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2024 International Poultry Congress

8-11 May 2024
BURSA-TURKEY

Strategic approaches for sustainable poultry meat and egg production

May 8-11, 2024

Congress Book

Editors

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FOREWORD

On the behalf of the Organising Committee, it is a great pleasure and honour for us to welcome you all to the International Poultry Congress 2024.

In this congress, the aim was to provide a platform for the exchange of new ideas, information and to build up and to strength professional relationships. We would like to express our sincere gratitude to the esteemed scientists who have made this congress more meaningful with their presentations and to the sponsors who made this congress possible.

We want to thank to the Rector of Bursa Uludağ University Prof. Dr. Ferudun Yılmaz, Dean of Agricultural Faculty Prof. Dr. İlhan Turgut, Scientific committee chaired by Prof. Dr. Sezen Özkan, and Organising committee chaired by Prof. Dr. İbrahim Ak, for their priceless help in the organisation of the congress.

We wish you all an enjoyable and productive time during the congress and a wonderful stay in this amazing cultural and historical centre of Turkiye, Bursa.

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ORAL PRESENTATIONS

Poultry Meat Industry in Türkiye

Naci Kaplan

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March 2024

If we look at the development of poultry meat industry in Türkiye, it showed significant structural change from the chicken meat production that started in the 1970s as family business to the increase in the integrated facilities in the 1980s and the start of contracted production model. In the 2000s, the investments continued, and European and World standards were achieved and even surpassed.

There are more than 15,000 broiler premises in our country. Owners of these establishments are able to continuously produce and acquire regular revenues with the successful "contracted breeding system" applied in the industry.

There are more than 20 integrated facilities for producing poultry meat in various regions of the country. All of these integrated companies continue production under registration and they have their own feed mills, parent stocks breeding facilities, hatcheries, contracted broiler farms, slaughterhouses, further-processing facilities and marketing departments.

Poultry production in our country is developed with a mindset based on science, and the entire production process starting from the farms is carried out in conformity with the principles of food safety, public health and welfare and within the framework of international codes.

According to the latest Agriculture Report published by the OECD and FAO, the total meat production in the world is around 350 million tons. About 40% of that, which corresponds to 140 million tons, is poultry. This report also emphasizes that poultry will be the most produced protein-based food among other animal food products within the next 10 years.

In the last 20 years, poultry production increased nearly four times in our country, and our country is placed 8th in the world with its poultry production of about 2.4 million tons. While the world average for per capita poultry consumption is 17.3 kg, this number is 21 kg in our country. However, in order to reach the consumption level of 35-40 kg like in the developed countries, we need to consume more.

Türkiye is located in the geography where 1/3 of the world poultry trade is carried out. Therefore, we have a geopolitically important position. With quality increasing ever year, the exports increased 16 times in the last 20 years. (While Poultry meat exports was nearly 30 thousand tons in 2005, it has reached 500 thousand tons by 2023, excluded chicken paws). Today, we export poultry to more than 90 countries. We have become one of the five largest exporters in the world.

The poultry industry of our country follows the highest level of national and international quality standards. Production is carried out by meticulously following the principles of food security. We can easily say that the poultry meat industry continues to develop rapidly, dedicating itself to the sustainable and environment friendly production applications which are the two of the most important issues of the new world order.

The slaughtering process in the industry is carried out by considering animal welfare within the framework of Islamic rules and by using an anesthetic/stunning method that would do the least harm to chicken. The member companies of our association have quality, food safety, environment and occupational safety management systems accepted worldwide as well as TSE Certificate of Halal Conformity.

The industry carries out studies with the government and universities for the research and use of scientific developments and production methods. Every stage of production is carried out according to the rules set out by the Ministry of Agriculture and Forestry. All such rules are in conformity with the European Union.

Sufficient and healthy nutrition is a requirement of a healthy life and healthy generation. One of the key steps set out by the World Health Organization for healthy nutrition is the consumption of white meat, i.e. poultry and fish, instead of red meat that has more fats.

Poultry meat, which has such important elements in terms of human health, must also be safe. Turkish poultry industry continues its works with the knowledge and works of a workforce qualified in the fields of veterinary medicine, agriculture, food, industry, environment and many others and continues its production in conformity with the legislation by protecting its quality based in the acquisition of qualified and safe food.

Our requests regarding our priority problems are provided below:

Hatcheries that operate in the field of poultry and have self-sufficient production become inactive due to their scales that remain under the rate of profitability or have difficulties benefiting from new hatcheries due to the support given to the locations that are far away from integrated facilities. Therefore, it is important for us to have the Ministry of Agriculture and Forestry take decisions within IPARD and rural development grants that will allow investments of new hatcheries that are in appropriate decisions.

Unfortunately, unscientific claims regarding our industry created misperceptions in the public. We need our Ministry's support regarding that. To correct the misleading information in public regarding the poultry meat industry, we are sure that the public service ads by our Ministry will contribute greatly for the recognition of the importance of poultry meat in balanced and healthy nutrition.

The number of certified biotechnology products is 577 in the world, 140 in the European Union and only 36 in Türkiye. This causes our costs to increase and makes it challenging for us to be competitive in exports. Our greatest wish is to make the Biosecurity Law and other regulations that regulate the biotechnology products conform with the European Union legislation.

Türkiye Feed Industry: Overviews

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The mixed feed sector processes the products obtained from plant production such as grains and oilseeds, and the food industry such as milling, starch, sugar by-products, oilseed meal, according to animal requirements, and mixes them with vitamins, minerals and premixes to make them available to livestock in the most appropriate form and cost. The mixed feed sector, that offers with this functioning, acts as a bridge between plant production and animal production, and also makes a significant contribution to the country's economy and employment by utilizing the waste and by-products generated during plant and animal production.

The increase in the world population causes an increment in demand for both protein and animal products. For this reason, the need for feed, which is the most important input of the livestock sector, also increases, and in this context, the mixed feed sector maintains its feature of being a dynamic sector that continues its development.

The mixed feed industry continues its development in our country as well as in the world, due to the increase in demand and technological developments. Although Türkiye started the feed industry later compared to developed countries in the field of animal husbandry, it has made significant progress both in terms of technology and feed usage awareness. Feed factories, which initially operated at low capacity using manpower-based systems, have made a rapid transition towards automation and even fully computer-controlled systems in recent years.

Although the development of the compound feed industry over 400% in the last twenty years draws attention, the same progress could not be made in plant production. This situation necessitates the supply of important raw materials such as grains, oilseeds, pulp and bran, which are used extensively in mixed feeds, through imports. However, this situation should not be seen as an obstacle to our mixed feed industry, which continues its production and development even under difficult conditions such as pandemics, war, and natural disasters. Our goal should be to transform our existing resources into value-added products and increase exports.

With its mixed feed production reaching 27.9 million tons as of last year, our country ranks first in the comparison of EU countries and seventh in the world in terms of mixed feed production.

We believe that our mixed feed industry, which has achieved many successes to date, will take its development to even higher levels and serve our country's animal husbandry in the best way, thanks to its high dynamism, strong technological infrastructure, knowledge and expert workforce.

Broiler and Layer Breeder Market and Consumption Trends

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Poultry is most efficient livestock for affordiable protein source both in respect to meat and egg. This not only mean less feed usage, it also means less waste more environmentally friendly. Scientific animal breeding studies, which started in the 1920s, have made serious progress since the early 1960s. As a result of using DNA technologies since the early 2000s, it has become common to obtain 160 chicks as hatched from a broiler PS breeder and 130 female chicks from a layer PS breeder. Today, a total of four companies, two broilers *(Aviagen, Cobb Genetics)* and two layer *(EW group and Hendrix Poultry Breeders)* dominate the world breeding poultry market. However, this number was more than 20 in the 1990s. Commercial breeds such as Hybro, Pilch, Hypeco, Scanbrid, Shaver, Peterson, Avian, Marshall, Pure breed, Isa vedette, which do not exist today. The number of broiler PS breeders is 600 million/year and sales value is approaching 4 billion dollars, and an annual growth of 3-5% is recorded worldwide. Layer PS breeding sector is more stable, with annual sales volumes of 45 million and a turnover of around 250 million dollars. While live broiler sales do not exist in some countries, they still have a share of around 20% worldwide. The share of whole bird is 22% while cut-up plus deboned further processed products in all chicken sales is 60%. Deboned and further processed product consumption has a tendency to go up related by the national income per capita. For instance, cut up and deboned-further processed portions are 40% and 10 % in Turkiye while it is 22% and 75% in USA. Egg shell color is one of the most important traits preference in consumption. White is a little bit more (%55). For instance, while brown is dominant in Australia, France and Spain, mostly white is preferred in the USA and the UK.

Keywords: Broiler breeder; layer breeder; parent stock; processing type

Introduction

Share of chicken meat consumption has been keeping its priority as more than 42% for all over the world because of the lowest production cost in all livestock animals. Annual growth rate of production, ranges 2-5 % by the regions and definitely will keep its number one position for the next decades.

World average egg consumption is 185 in spite of huge gap between different countries which ranges 75 – 350 eggs. In fact, without chicken in respect to meat and egg, it is not possible to meet affordable protein need of world population particularly for the poor countries.

Gallus gallus *(bankiva)* is the genetic origin, ancestor of today's modern commercial meat and layers types of breeds. It still exists in the wild in Asia-Pacific and based on some bone findings traced back to 8.000 BC. It was impossible to achieve having broilers 2.0 kg live weight with 1.60 feed conversion rate at 35 days and 320 eggs from a commercial layer in 365 days, if we kept the bird *(gallus gallus)* as it is. Which means, adult birds have about 1.0 kg live weight and seasonal 30-40 eggs.

Breeder genetic companies have made great improvements by implementing genomic (DNA) technology addition to classic - traditional breeding programs right after the year 2000. Today, two international broiler breeding *(*Aviagen & Cobb Genetics*)* and two layer breeding companies *(*EW group & Hendrix Poultry Breeders*)* are primarily dominating both world broiler and layer market. Significant progress has been made since the 1960s, although the first scientific breeding studies commenced at 1920. As pointed out above, remained a few ones while number of registered breeder companies was more than 20 in 1990s.

Breeding, selection of the best birds for the next generations is very hard task, needed extremly high qualified staff, collecting tens of millions data from individual birds about 35-40 different traits, and analaysing in a right direction plus disease risk (Figure 1). It takes 4 years at the earliest to see the positive or negative impact of any change have done at the top of genetic pyramid. R&D expenses has a significant share in budget (20%>).

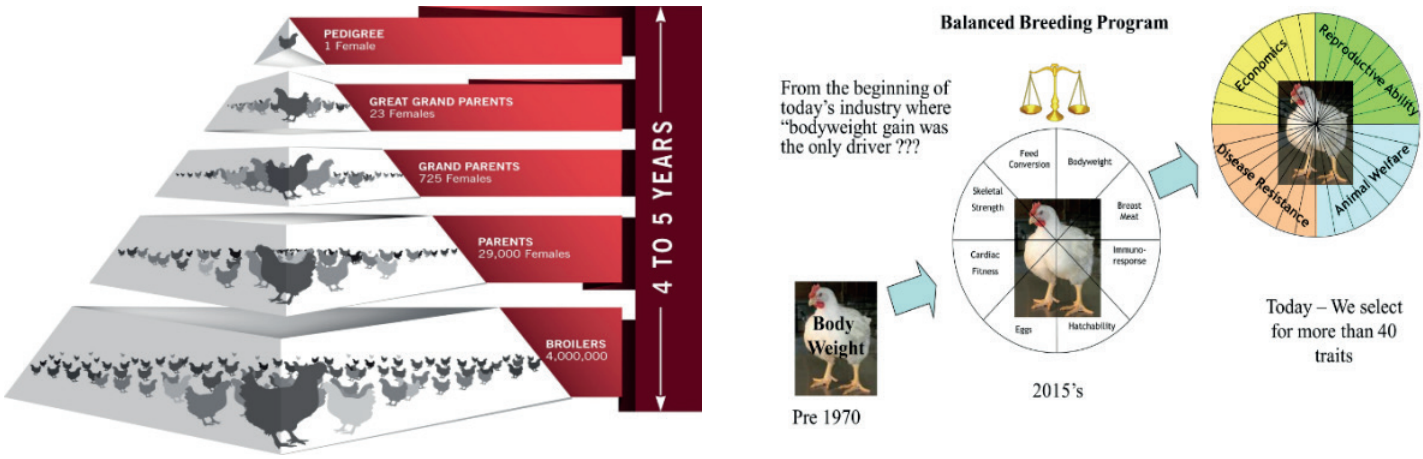


Figure 1. Breeding scheme of fast growing broilers

World broiler breeder market

EMEA and Asia regions are the fastest growing markets. World sales value of Parent Stock market is about 3.7 billon $ in 2023 (Figure 2).

Broiler Breeder Market (Million-Estimated)			
	2010	2018	2023
World	398	531	563
EMEA	121	165	175
N.America	98	110	116
S.America	75	76	82
Asia-pacific	106	180	190

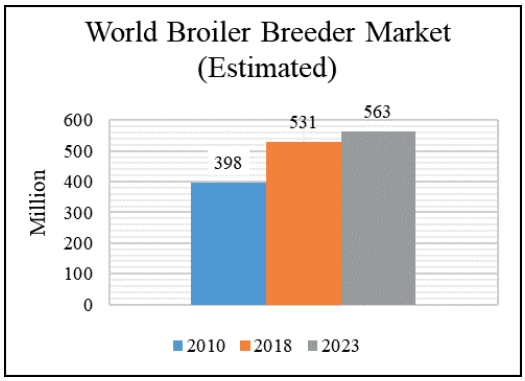


Figure 2. The World broiler breeder market

USA and Brazil is top two countries which have big numbers of parents therefore meat exporters and consume more per capita (Brazil>45 kg and USA>50 kg). China is far behind of those two countries in point of consumption (11.0 kg). But, PS numbers will be nearly 65 millions in next ten years by that annual growth rate (3%) (Figure 3).

Broiler Breeder Market(million-Estimated) (Selected Countries)			
	2010	2018	2023
USA	75	85	90
Brazil	47	50	55
China	27	30	47
Russia	16	19	22
Türkiye	8	12	15

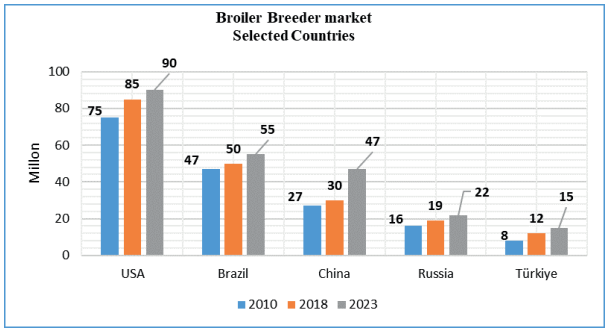


Figure 3. The broiler breeder market by selected countries (*Source: Cobb genetics)*

World layer breeder market

Layer PS sales volume is about 45 millions in 2022 and growth in volume mostly in the western countries. Total PS sales value is about 240 millions $. Whole asia, including China & japan, a big part of midle east and eastren part of CIS countries count for 58% of all PS placed in the world. Biggest counts in asia followed by Europe and North America (Figure 4).

World Layer PS Sales(Millions) (2022)	
China	14.450
Asia	7.897
Europe	5.359
N. America	3.894
S&C America	4.295
Russia(CIS)	2.767
Africa	2.227
Midle East	0.887
Oceania	0.235
Japan	1.240
TÜRKİYE	0.900
TOTAL	44.151

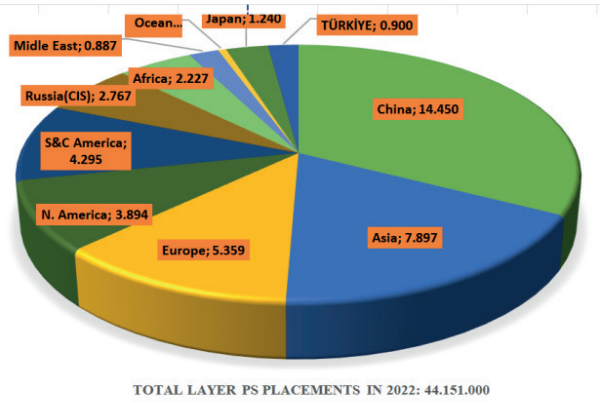


Figure 4. The World layer breeder market

China is clear number one with 33% of all PC placed in 2022 worldwide. Top 10 countries count for 62% of the total Layer PS sales value (Figure 5).

Top 10 countries in PS Sales Volume-2022 (million)	
China	14.450
USA	7.897
India	5.359
Russia	3.894
Indonesia	4.295
Benelux	2.767
Brasil	2.227
Mexico	0.887
Japan	1.240
Türkiye	0.900
Nigeria	0.800

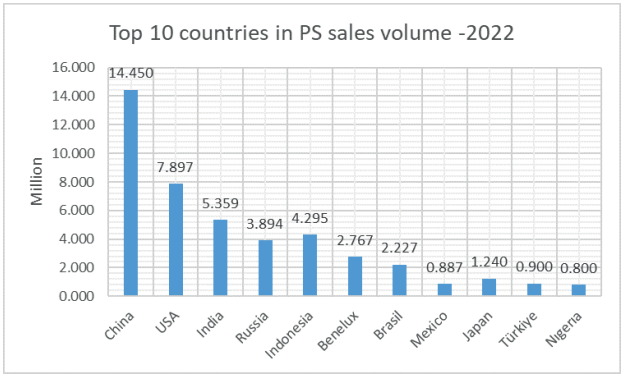
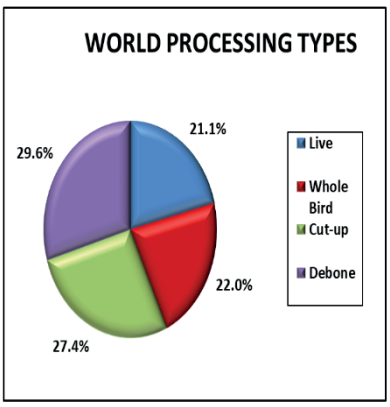


Figure 5. The top countries in layer parent stock sales (Source: Hy-Line international)

Processing trends

Processing type by the regions; Live bird sales is quite high in Asia while it is almost zero in some countries (USA, Turkiye; Figure 6). Although, cut up portion tends to increase almost by entire the world, deboned, ready to cook or precooked consumption is too high in some developed countries (USA, Western Europe and Japan), in relation to the level of per capita income (Figure 7).



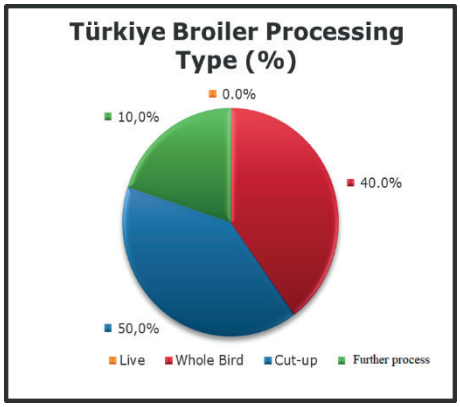


Figure 6. Processing type of the world and Türkiye

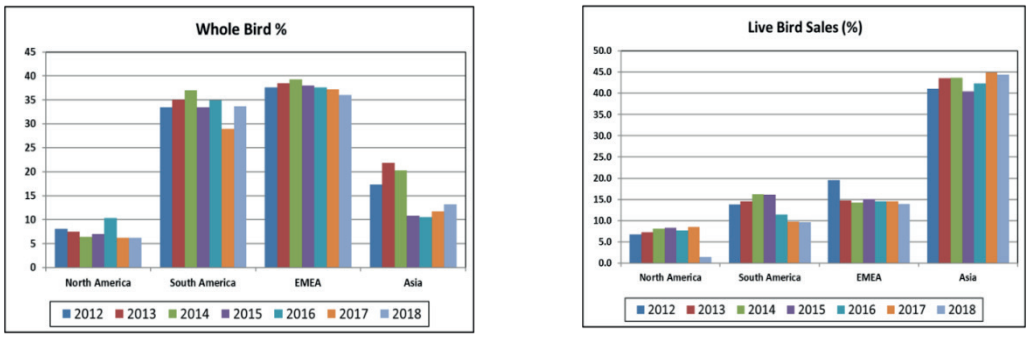


Figure 7. The processing trend by the regions (whole bird, live bird sales, %)

Just an example, cut up share in China is nearly 80% but deboned is about 10%. The same data for USA cut up 22% deboned 75% (Figure 8).

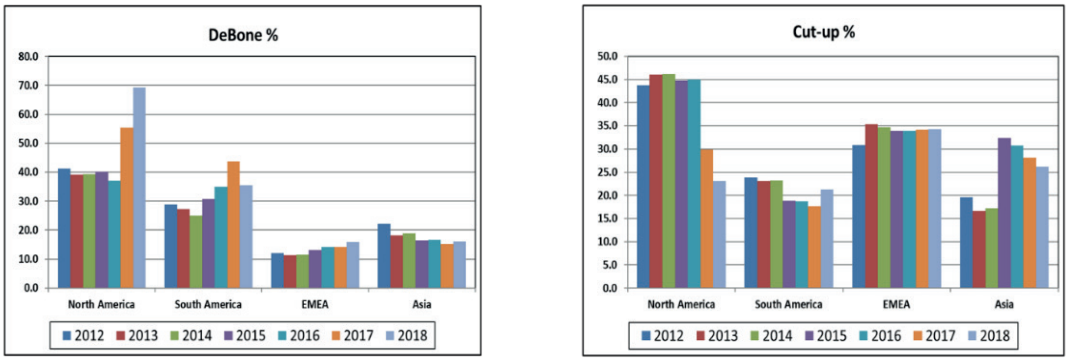


Figure 8. The processing trend by the regions (debone, cut-up, %)

Shell color is an important choice in table egg consumption. It is certain that egg shell color has no relationship with nutritional value (Figure 9). It is a culture, consumer perception. White shell color is more dominant in total although consumer perception varies from country to country. For example, while brown is dominant in Australia, France and Spain, mostly white is preferred in the USA and the UK. This ratio is 80% in favor of whites in Türkiye.

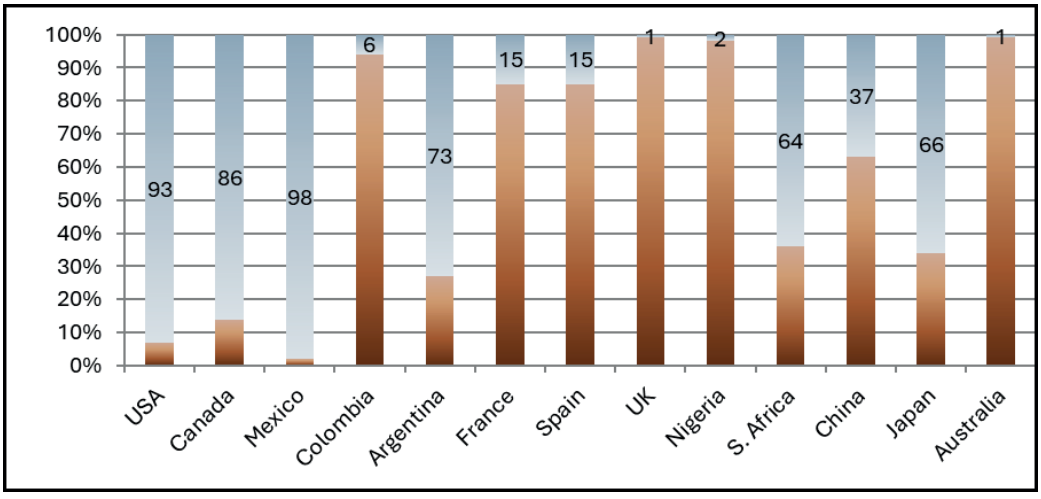


Figure 9. The eggshell color choice by countries

Conclusion

World population continous to grow. Most of the population growth will take place in developing countries (Asia and Africa). Today China and India already represent 40% of the population. Developing countries have high GDP (China&India:7-9%). Higher buying power means, increase in meat & egg consumption. In many countries chicken consumption is very low (0.5-2kg/annum) therefore potential is enormous. Poultry will keep its existing position to continue to be number one for cheapest protein source for meat & egg.

Consumers continue to ask for more and more meat & egg, therefore breeding-genetic companies will continue to produce more breeders. Breeding stock will continue to increase by 3-4% annually. Genetic improvements using DNA technology will support production by the super breeders.

Acknowledgement

Data regarding breeding numbers are estimated and are the closest to the actual figures. It is not possible to find the data in open literature or sources. It was taken from Hyline sources, which is leading layer breeder market and Cobb Tyson I am proud of a member.

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Hy-Line International; West Des Moines, Iowa, USA. https://www.hyline.com

Production/Consumption of Table Eggs and Hatching Eggs and Their Effects on the Environment

Müjdat Sezer

Istanbul Fishery and Animal Products Exporters Association, İstanbul, T**ürkiye**; Hastavuk Company, Bursa, T**ürkiye**
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According to FAO statistics, world fresh egg production in 2022 was 2,212,633,577,000 pieces. According to TÜİK ‘s 2022 data, there are 110 million laying hens in our country and a total of 20 billion chicken eggs have been produced.

Egg is one of the most cheapest and environment friendly form of animal protein for human food, as chickens convert feed into protein efficiently and do not need a large area to do this. The egg industry recognizes its role in helping prevent hunger worldwide.

Eggs are a sustainable affordable source of the highest quality of protein and amino acids that evey human needs.

It contains most of the 13 vitamins, minerals and antioxidants that the body needs. Additionally, eggs are a good source of commonly deficient micronutrients such as vitamins D3 and B12 and are one of the best sources of choline, a lesser-known but vital nutrient. It has been proven to be associated with better growth and supporter of brain cells, cognitive performance and motor development for children, also good for human eyes health at older ages.

Egg businesses constantly try to reduce the resources they use while maintaining the same level of production. With new technologies, significant productivity gains are achieved and environmental footprints such as water consumption and carbon footprints are less than all the other animal protein sources. These factors play an important role in trade between countries and make the product valuable.

Chicken manure wastes are converted into energy by utilizing them in biomass and biogas power plants. Biogas production aims to obtain quality energy, reduce odor, and reduce the amount of methane and ammonia in the atmosphere.

The Responsibility of Public Authorities and Academia in Preventing Misinformation in Foods

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Food misinformation can have harmful effects on the health, well-being of consumers and It may also cause loss in the country's economy.

In the last decades food misinformation has become increasingly widespread in Türkiye. Poultry industry is perhaps the group most affected by this situation.

Foods are the target of many chemical, biological and physical risks in the farm to fork pathways. The goal of food safety is to control and minimize these risks by using science-based regulations made by international consensus are followed. There is no zero risk in life. Every activity carries risk. The regulations that make up the food safety system are risk-based. The system operates within acceptable risk limits determined by scientific methodology.

In the international food safety system, some errors/harmful practices may occur over time. These errors/applications are examined with a scientific focus and the system is made safer with the corrections made.

Today, an unsustainable chaotic environment has emerged regarding misinformation in food. The solution depends on the development of a strategy with the participation of all stakeholders as public administration, universities, industry and consumer organisations taking into account the lessons learned from past mistakes regarding unscientific claims and the successful examples from various countries in the fight against misinformation in food.

Marketing of foods is subject to the authorisation of public authorities, based on regulations focused on protecting human health. At this point, trust in the responsible public authority is important. If this trust is not achieved, all kinds of unscientific claims can be found credible by consumers. In addition, if the food authority does not provide science-based explanations for the claims, as required by its responsibilities, these unscientific claims will gradually become beliefs in the society. What is happening in our country regarding GMO and some poultry products is an example of this situation

Another responsible for making food controversial is academia. Unscientific claims made by academicians who are not experts on the subject and have no knowledge of the world food safety network, science-based food regulations and food management systems play a major role in the spread of food-related misinformation. Unfortunately, these unscientific claims significantly affect consumers due to the academic titles these people hold. In the past events there has never been an institutional scientific and ethical response to the unscientific claims made non-expert academician in the media.

Nowadays, intense information is produced about the food-health relationship. There are an estimated 6.5-7.8 million researchers in the world. Their research results are published in 33,100 peer-reviewed journals in English and 9,400 in other languages. The number of articles published annually in these journals is 3 million per year. It can be estimated that at least 1-2% of these articles are related to the food/nutrition-health relationship. It is obvious that it is meaningless for a non-expert to take correct/incorrect information from this mountain of literature and without scientifically evaluate share it with the society.

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If published articles draw attention to the existence of a new risk in food, this is considered a signal by food/health regulation authorities and studies are started on it. First, the evidentiary strength of the data in question is systematically examined with using several scientific parameters. As a result of this review, if the information in

the article indicates a risk that should be taken into consideration based on reliable evidence, scientific institutions around the world intensify research on the subject. According to the results obtained, regulations are issued by the relevant organizations to control the risk, if necessary.

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SESSION 1

Sustainability in Poultry Production Chain: Environmental Impact – Economics – Information Technologies

Economics and Sustainable Poultry Production

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Global egg production showed a remarkable growth over the last 10 years. Egg production was 87 million ton in 2020 compared to 64 million ton in 2010 (+36%). In this period growth was limited in North America, Europe and Africa. Asia had a growth of almost 50%. In egg production China is by far the largest producer (38% of global egg production). China is followed by India, USA, EU-27 and Indonesia (each with a share of around 7%). Number 10 in this ranking is Türkiye with an egg production of 1.2 million tons (FAO, 2023). For housing of laying hens battery cages is the still the most common system in the world. According to data of International Egg Commission (IEC, 2023) alternative systems are used on a large scale in the EU, UK, USA, Canada, Australia and New Zealand. In all other countries the IEC is collecting data the share of cages is above 80%. Housing of layers is criticized in some parts of the world for animal welfare reasons. In terms of sustainability animal welfare is just one aspects to be considered. Social aspects as well as environmental and economic factors need to be included as well. Based on several indicators to quantify sustainability a comparison was made for cage, barn, free range and organic egg production (van Asselt et al, 2015). Cage production had the highest score on the environmental dimension, whereas free range production gave the highest score in the social dimension. In the economic dimension enriched cage had the highest sustainability score. However, using non equal weights for the indicators resulted in different score. The method discussed by van Asselt (2015) gives policy makers and stakeholders a tool to quantify sustainability and provides a weighted decision regarding future housing systems for layers. In literature many articles and papers cover the topic of sustainability in the layer sector. For example, on welfare all the aspects on alternative systems are covered by Rodenburg et al (2023). On economics and production costs a recent report is published by van Horne (2023). On environmental aspects the work of Leinonen (2014) and Blonk (2021) can be mentioned. In practice a country or company has to find a balance between the improvement on welfare versus the higher carbon footprint, more land use and higher production costs comparing cage and non-cage systems for laying hens. Also the market and consumer demand plays are crucial factor in any change in housing system.

Keywords: Economics; sustainability; housing systems; laying hens

Global Challenges for the Poultry and Egg Sector and Sustainability

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The interest of consumers for sustainable foods is evident and more prevalent in younger generations of consumers, often willing to pay a premium for products meeting their expectations. The growing demand of consumers for sustainable food value chains implies that the Poultry and egg sector addresses its current challenges under this premise. The rising cost of feeds will require the poultry and egg sector to identify ways to boost production efficiencies, either through diet formulation or improved management practices. Automation in processing along with the development of new products will further the economic sustainable of the sector. Feeds have the biggest impact on the environmental sustainability of poultry production while manure management represents the second largest contributor to emissions. Several options are available to mitigate the impact of production on the environment. Finally, the social sustainability of the sector depends on the solutions it will adopt to address concerns about worker safety, animal health and welfare, food safety, and food security. While many fields of research offer the sector new mitigation strategies to safeguard its sustainability, the acquisition of the latest knowledge still represent a challenge in the field. By providing continuing education opportunities to Poultry professionals, the World veterinary Education in Production Animal Health (WVEPAH) contributes to the sustainability of the Poultry and egg sector.

Keywords: Poultry, eggs, sustainability, challenges, continuing education, WVEPAH

Introduction

The Poultry and egg sector makes a significant contribution to nutrition and food security around the world. Between 2012 and 2022, the availability of broiler meat has increased by 3.7 kg and that of eggs by 41 eggs (+ 2.5 kg) for each person on the planet. The production of chicken meat (+31.1%) and eggs (+29.8%) recorded the fastest growth of all terrestrial animal productions during that period (FAOSTAT, 2024). However, we will need by 2050 to feed an additional 1 billion people, mainly living in Africa and Asia, while the rising levels of income will stimulate an estimated 73% increase in meat consumption with poultry meat as the preferred option. As these results must be achieved with only 5% more arable land available, raising more animals will not be sufficient and we will need also to be more efficient to preserve our limited natural resources (FAO, 2009). But the poultry and egg sector is also facing some immediate challenges. With the current war in Ukraine and high grain prices, producers are facing more and more pressure from retailers to produce more for less. The well-being and welfare of birds under its care is more and more challenged by NGOs and other vocal groups who have often little knowledge about poultry. Social pressure and ethical concerns are also forcing producers to change some management practices, often negatively affecting productivity. Consumers, non-governmental organizations (NGOs) and governments are also frequently challenging the impact of animal production on the environment. The sector must also continuously find ways to create more value within its value chain, develop new products and attract more consumers. Finally, and not the least, the sector must also adapt to the needs and desires of younger generations of consumers while improving its communication to an audience more and more removed from the rural environment and less likely to appreciate the challenges facing farmers.

Consumers and sustainability

Sustainability and sustainable development were defined by the United Nations as the development which meets the needs of current generations without compromising the ability of future generations to meet their own needs. When applied to the Poultry and Egg sector, sustainability is often divided into the following 3 pillars: social, economic and environmental. The intersect combining these 3 components is viewed as the key ecosystem in which a business or a sector will be the most sustainable.

As consumers are changing, communicating with them represents one of the challenges for the Poultry and

egg sector. By 2027, the Gen Z, people born between 1998 and 2016 will be the largest demographic segment, representing 28% of the global population. Combined with Millennials, these 2 generations will represent 52% of the global population and have clearly different needs and desires, including a strong interest in the sustainability of their food choices.

A survey of consumers was conducted in 2020 with 18,980 consumers from 28 different countries. When consumers were specifically asked about food and beverage purchases, the survey showed that 44% of the consumers were purpose-driven, that is willing to change their food purchasing habits to reduce their impact on the environment. Less consumers (35% of the respondents) were considered as value-driven consumers, that is primarily concerned about getting the best deal for their money. A further analysis of these purpose-driven consumers revealed that 57% were willing to change their purchasing habits to help reduce their impact on the environment. Likewise, 70% of them were willing to pay a premium, up to 35%, for brands that are sustainable and environmentally responsible (IBM, 2020). Since the sustainability of food choices is becoming an essential buying factor for younger generation of consumers, the poultry and egg sector must evaluate the sustainability of the different approaches it is considering to address the challenges it is currently facing.

Economic sustainability

The economic sustainability implies that producers, egg graders, and meat processors can balance price and profit to ensure both the long-term financial success of their companies as well as meeting the demands of consumers for affordable foods.

Poultry feeds: Globally, feeds represent the highest input cost (~ 65-75%) of poultry production (IPC, 2022). Therefore, the poultry and egg sector must either identify ways to produce more with the same amount of feeds or to formulate poultry rations to further reduce their cost. Various options are available to optimize gut health and maximize the conversion of feeds into poultry meat and eggs. The diet formulation used, the quality of grains incorporated into the ration, as well as the inclusion of various ingredients such as probiotics, prebiotics, bacteriophages, organic acids, or enzymes will have a positive impact on the overall health of the digestive system of birds, and therefore boost the absorption of nutrients and improve feed conversion. For instance, as birds digest and use only about 80-90% of grain-based feeds, enzymes are important tools to increase the nutritional value of feed ingredients, reduce production cost, and improve productivity. However, beyond this traditional use of enzymes, it is now recognized that enzymes play also a functional role. Proteases act on allergenic proteins in feeds, reducing oxidative stress and intestinal inflammation, and promote a healthy gut for optimal nutrient absorption and conversion (Bedford and Apajalahti, 2021).

Artificial intelligence: The Poultry and egg sector is typically rich in data offering some insight on ways to better manage birds and become more efficient, that is, to reduce the cost of production. The adoption of more sensors and probes on farms will greatly enhance our ability to gather data. By 2050, it is estimated that the average farm will generate 4.1 million data points using Internet of Things sensors and devices. Using Artificial Intelligence (AI), this wealth of data can then be used to train machines, define new algorithms and make predictions about production outcomes (Guyonnet, 2020). After collection on farms, digital data is transferred to a central location often using servers on the Cloud for safe storage and access to the analytical power of Super-Computers. Farmers are immediately provided with a summary of the results of their flock, with user-friendly interfaces allowing producers to see a summary of key parameters on one single screen. Data can also be plotted, with the current results compared to the standards for the genetic line used or to results from a previous flock.

The true power of AI is to optimize production by allowing poultry and egg producers to make better informed decisions based on predictions. For instance, Intelia Technologies (https://intelia.com/) in using field data to predict the performance of broilers on farms. Using data from a wide range of sensors measuring bird weight, temperature, feed and water consumption, humidity, and ammonia level, their algorithms can predict the performance of broilers, 7 to 10 days in advance. If the final weight is predicted below target, the producer can initiate a plan of action to boost feed intake and growth. Conversely, if the predicted final weight exceeds the target, feed intake and growth can be controlled. Overall, AI constitutes an excellent tool to mitigate or enhance

a particular outcome and therefore optimize production cost.

AI is also used to maximize operations and better connect farms with processing plants. For maximum efficiencies, plants prefer to deal with birds of similar size and weight. Currently, employees will work with farm production data, often outdated by a few days, to identify which poultry houses and birds to process. This scheduling process is both tedious, time-consuming and often inaccurate due to the time-lapse between the data supplied by the farms and the effective time of processing. With AI, this day-long scheduling exercise for the weekly activities of a processing plant can be accomplished in a few minutes, thus maximize efficiencies and reducing processing costs.

Smart automation: The efficiencies in meat processing is impeded by various factors, including the physically painful and tiring tasks performed by workers, the lack of real time data to reduce production losses and the difficulty to reward workers based on actual performance. In addition, the speed of human actions is also a limiting factor on a processing line. Smart automation, combining robotics to artificial vision and other components of AI have a great future in food plants and will further contribute to lower costs of production.

Product development: As consumers have many options in terms of animal-sourced foods and protein intake, the economic sustainability of the Poultry and egg sector is also linked to its ability to develop new products and offer more meal opportunities. Innovation will stimulate the development of new products and new meal concepts, allowing consumers to enjoy more poultry products and eggs at any time of the day and night. Among the main buying factors of consumers, addressing their needs for taste, convenience, authenticity and sustainability should represent the key foci of product development. Innovation will require the sector to adopt a more holistic approach towards research, combining the expertise of food scientists, culinary chefs, nutritionists and others.

In Western nations, convenience is certainly one of the most important features of new food items. In the future, the way consumers will eat chicken and eggs may be different from the current product offering. The sector must find many ways for consumers to eat more poultry and egg products, even if at times, they may not even know that their favorite snack food or prepared meal contains some chicken meat or eggs.

Developing new products may not always have to be a complex and expensive exercise. The success of hard-boiled eggs at retail in many countries is a good example of a very cost efficient way to develop a line of new products (regular eggs, eggs enriched with omega 3 and vitamins or eggs prepared in solutions for enhanced additional flavors). In other cases, the combination of existing foods, for instance a hardboiled egg, some nuts, and pieces of cheese, into a single package will appeal to consumers. The investment has been limited to the design of a package (Guyonnet, 2019).

Environmental sustainability

The impact of food production on the environment is often cited by consumers as an important consideration in their food choices. It is therefore essential for the poultry and egg sector to monitor its impact on the environment and to develop various mitigations strategies.

Environmental impact of the poultry and egg sector: Human-generated activities have a range of effects on the planet with the increased emissions of various gases impacting both the quality of the air we breathe, the composition and quality of soils on which we grow crops or raise animals and the quality and temperature of water in rivers, lakes and oceans.

Acidifying emissions are a natural phenomenon that has been accelerated by the recent human activities on the planet. The release of H+ ions contribute to the acidification of soils and water, destroying corral reefs and forests. Eutrophying emissions are linked to the presence in the environment and waterways of excessive amount of minerals and nutrients, due to runoff from fields after the use of fertilizers or the spreading of manure. Present in the water, these nutrients will greatly facilitate the growth of algae, leading to the depletion of the water in oxygen and some changes in water ecosystems.

Greenhouse gases are natural gases or produced by the actions of humans, absorbing and emitting radiation

within the thermal infrared range, process causing the greenhouse effect. The primary greenhouse gases in the atmosphere are carbon dioxide, methane, nitrous oxide and ozone. The effects of these different gases on climate change are compared to the effect of CO_2 and for this reason, the term of carbon footprint is often used. In 2012, it was estimated that the global animal production sector contributing to the emission of 7.1 Giga tonnes of CO_2 equivalent with the production of beef (41%) and milk (29%) responsible for most of these emissions. The Poultry and egg sector was responsible only for 8.4% of the total greenhouse gas emissions of the global livestock sector or an estimated 400 million CO_2 equivalent per year for poultry meat production (5.6% of total livestock sector) and 200 million CO_2 equivalent per year for egg production (2.8% of the total livestock sector). The production and processing of feeds is the main source of emissions, responsible for 86.7% of the emissions in broiler production and 74.5% in egg production. Manure management represents the second largest source of emissions, responsible for 6.4% and 20% of the total emissions by the poultry meat and egg sector, respectively. All Post-farm activities including the processing of meat, the packing of shell eggs or the processing of liquid eggs and distribution were responsible for less than 11% of total emissions (FAO, 2013a).

The challenge of feeding our growing population contributes also to more land use change (LUC) and deforestation in order produce more foods, an important element of the measure of the environmental impact of any production system.

Mitigation strategies for poultry feeds: Poultry feeds do not only play a key role in the economic sustainability of the sector but also in its environmental sustainability. The emissions from Poultry feeds occur primarily during crop production, with the use of fertilizers, the use of fuel in the vehicles used to care for and harvest the crops, as well as for the transportation of all raw materials and finished feeds. These are direct feed emissions, and most poultry farmers would have little control over the production of crops (Scope 3 emissions). The different grains used by the poultry and egg sector contribute differently in terms of CO_2 emissions. One avenue to mitigate the impact of Poultry feeds would be for nutritionists to incorporate the environmental impact of ingredients into the formulation process (Heidari et al., 2021). Another component of feed-related emissions is linked to LUC or the conversion of forest areas for crops, livestock production or urban development, affecting the capacity of soils and vegetation to store carbon. For example, soybean production in Brazil is more affected by LUC with deforestation creating new fields for cropping. Therefore, another mitigation strategy would be to select feed ingredients produced in regions with little or no deforestation. However, this strategy may be economically challenging and logistically complex to implement as a recent study in Brazil showed that the emission intensity of soy varies by more than 200-fold depending on its origin within that country (Escobar et al., 2020).

Indirect ways to improve feed efficiency and convert more feeds into products, such as better health and welfare, less mortality, better bone strength and improved genetics, will also contribute to the reduction in emissions of CO_2 equivalent per kilogram of product. A recent study showed that the adoption of the current best practices for nutrition and management of laying hens could reduce in Canada the total emissions of greenhouse gases by 47% (Pelletier, 2017).

Mitigation strategies through manure management: The second highest source of emissions of the poultry and eggs sector, occuring at farm level, is directly under the direct control of producers (Scope 1 emissions). Mitigation strategies will focus on the reduction of fermentation processes by anaerobic bacteria before the application of the manure on the fields. A decreased digestibility of nutrients in feeds increases the concentration of fermentable organic matters in manure, which in turn increases emissions. Mitigation strategies will typically focus in two areas: the composition of the manure including the presence of undigested organic substances and its content in nitrogen – and the storage of the manure with respect to the form and length of storage, the temperature and the time of application in the soil. For example, a timing of application of manure coinciding with the demand of crops for extra nutrients will effectively reduce, during field application, the emissions of greenhouse gases such as nitrous oxide (FAO, 2013b).

Poultry manure is typically stored in two forms: Dry manure storage, the more common form, consists in manure gathered in piles and left to dry for several months; Liquid manure storage, where manure mixed with wastewater is stored outside in tanks or lagoons. In uncovered lagoons, the anaerobic fermentation will typically

produce twice as much greenhouse gases than in dry manure. There are however some useful techniques that can minimize emissions from liquid manure storage, the preferred form for its ease of application as a crop fertilizer. Studies have shown a reduction up to 55% in greenhouse gas emissions when slurry tanks are completely emptied. As any "aged" manure left inside the tank will accelerate the spread of bacteria and emissions in the next batch of liquid manure stored, it is recommended that storage tanks be emptied completely. Acid treatment of liquid manure may achieve similar results although it may make its use as a fertilizer more difficult (Wood et al., 2014).

Impact of housing systems: The choice made for housing birds has some consequences on the environment and the overall sustainability of the sector. In the United Kingdom, researchers using national data from the egg sector demonstrated that the production of eggs in any cage-free system will contribute between 15% and 18% more emissions of CO_2 equivalent per kilogram of eggs produced (Leinonen et al., 2012a). Likewise, the production of broilers under free-range or organic systems in the UK contributed to an increase in emissions of CO_2 per kilogram of chicken carcass by 16.3% and 28.3%, respectively. Higher feed consumption in free-range and organic production systems, both giving birds access to the outdoors, were the main cause of this higher impact on the environment (Leinonen et al., 2012b).

Bird density has also an effect on the environmental sustainability. Compared to the normal density in Europe of 20 broilers per square meter, a lower density with 16 birds per square meter contributed to a 1.6% increase in greenhouse gas emissions per kilogram of carcass. Bird density must be carefully selected as it impacts differently the welfare of birds and that of our planet (Leinonen et al., 2014).

Mitigation through housing design: With increasing pressure from customers and consumers to reduce the impact of the livestock sector on the environment, it is important to consider a holistic approach and the manner we design and build poultry houses has also an impact on the environmental sustainability of the poultry and egg sector.

Net Zero Energy Buildings (or NZEs) are energy efficient structures with net zero energy consumption, meaning that the total amount of energy used by the building annually is equal to the amount of renewable energy generated. By design, these buildings are based on three types of approaches: structural considerations to reduce energy use, adoption of energy efficient systems, and on-site generation of renewable energy. In a recent study, researchers in Canada demonstrated that in an NZE house, energy use was reduced by 36% per tonne of eggs produced. Depending on the origin of the electricity used-whether it is fossil fuel, gas, coal, or hydroelectricity, investing in an NZE barn will also provide significant benefits in reducing CO_2 emissions and other impact categories (Scope 2 emissions). NZE technology is a new option for the poultry and egg sector along its journey towards greater sustainability (Li et al., 2021).

Creating value from waste materials: Greater environmental sustainability of the sector can also be achieved through innovation to monetize waste materials. For instance, the Hubei Shendi Group in China (http://www.hbsd.cn) launched in 2019 EggBio Food Cleanser, a product made from eggshells, a typical waste product of the egg processing sector. The matrix of this ingredient allows the capture of heavy metals and pesticides and is used to clean fruits, vegetables, and other foods. They have also launched Eggbio Collagen Peptide of Egg Membrane, a bone and joint health product made from peptides extracted from eggshell membranes, another waste material of egg processing. Through innovation, this company has created added-value from waste materials, with one product also improving food safety, therefore having an impact on the 3 pillars of sustainability: environmental, economic, and social.

Social sustainability

The social sustainability of the poultry and egg sector relates to diverse aspects of production and trade, including worker health and safety, animal health and welfare, food safety, and food security.

Worker health and safety: It is important to consider the effects of production systems and management practices on the health and welfare of poultry workers. For instance, it was shown in the USA that the change from conventional cages to enriched cage systems and a cage-free system to produce eggs would impact air quality and

the level of particulate matter (PM) in poultry houses. In the cage-free system, the PM 2.5 level was 6.7 times higher than in both cage systems (Shepherd et al., 2015). Therefore, a decision to switch to a cage-free housing system to produce eggs can potentially reduce the air quality for both the birds and the workers caring for them.

In addition to the beneficial effects of enzymes on feed conversion previously mentioned (economic and environmental), the use of enzymes will contribute to less CO_2 emissions, less PM 2.5 and better quality of soil and air, all having a positive impact on the health of poultry workers and the general population.

Animal welfare and the sustainability image of the sector: Some media-savvy, vocal NGOs have developed very effective campaigns to force large global retailers to switch their supply of eggs. They often target retailers by associating the production of eggs in a cage system to cruelty to animals and accusing retailers to cruelty for selling eggs produced in a cage system. In North America, this tactic, potentially threatening the stock market value and corporate image of large companies, has been extremely successfully in obtain their commitment to supply only eggs from cage-free systems. Most retailers, food service companies and food processing giants in the USA have committed to using and selling only eggs produced in cage-free systems by 2025. In Europe, the French government banned in 2022 the euthanasia of male layer chickens and it is now mandatory to raise male chicks for meat, a very expensive and inefficient way to produce poultry meat that consumers do not really desire.

The poultry and egg sectors must adopt a proactive role in the animal welfare debate to maintain the trust of its clients and consumers. While scientific data will demonstrate the benefits of certain practices such as beak treatment or the culling of male layer chicks, it is evident that decisions, especially with regards to animal welfare, are made based on emotions rather than science. There is therefore a need for the sector to change its approach towards communication with consumers and focus more on emotions and less on science.

Fortunately, new technologies will greatly assist the sector in monitoring and safeguarding the welfare of birds under its care. The continuous presence of robots inside the houses can improve the quality of the litter and prevent footpad and breast burns. The use of video cameras can assist with the monitoring of bird welfare and detect quickly any unusual or abnormal behaviours. Finally, the use of radio-frequency identification devices allows to better understand the motion of birds inside poultry barns as well as their preference in terms of the positioning of feeders and waterers. Adopting Poultry 4.0 with the latest AI technologies will not only allow the poultry and egg sector to improve its profitability but also clearly demonstrate to consumers its commitment to using the best available tools to safeguard the welfare of birds (Guyonnet, 2021).

Animal health: Avian Influenza continues to have a huge impact on Poultry and egg production around the world. Since 2020, highly pathogenic avian influenza (HPAI) viruses have spread from Asia to Europe, then North America, and finally, for the first time, Latin America in October 2022. Since early 2020, we have experienced globally over 7,000 outbreaks, 14 million birds died of the disease but also over 250 million were euthanized as a preventative control method. This massive culling of birds (stamping out) is no longer sustainable and is questioned for ethical and animal welfare reasons. Some countries in Europe are now considering vaccination as an option, with France initiating the vaccination of ducks in 2023. In February 2024, Colombia also endorsed the use of vaccines as one of the tools to control the spread of HPAI.

Food safety: The provision of safe foods to consumers is essential for the sustainability of the Poultry and egg sector. Despite its best efforts, products from the sector are still incriminated in outbreaks of foodborne diseases (ECDC, 2023). While these outbreaks always create a very negative image of the sector and significantly reduce consumption, at least temporarily, they also provide further ammunitions to groups opposed to animal production.

In addition to good management practices, one of the ways to control and / or prevent *Salmonella* and other pathogens has typically rely on antibiotics. Unfortunately, their extensive use has created another challenge, the rise of antimicrobial resistance (AMR), affecting both animals and people. The multi-resistance of bacteria to antibiotics is concerning and has led the World Health Organization, The Food and Agriculture Organization, the World Organisation for Animal Health and the UN Environment Programme to join forces under the concept of One Health.

We have some new tools at our disposal to fight bacteria and safeguard the safety of poultry products. For example, bacteriophages are viruses that can specifically attack and kill bacteria such as *Salmonella*, *Campylobacter* or *Escherichia coli*. They offer some real opportunities to protect the health of animals, safeguard their welfare without any fear to develop resistance to a treatment used for humans (Pelyuntha et al., 2024). However, few veterinarians, animal production professionals and producers are aware of these new alternatives.

The role of continuing education

Acquiring the latest knowledge in terms of management practices, feed formulations, housing design or disease diagnosis and prevention is an essential step to assist the poultry and egg sector along its sustainability journey. The development of a Poultry AI chatbot by Intelia Technologies makes it now easier for farmers and field service to obtain almost instantly excellent responses to their queries. The possibility to access relevant and accurate information at any time is indeed of great benefit to the overall sustainability of the sector (Guyonnet, 2024).

By advising on ways to protect the health of birds, by ensuring optimal feed formulation and conversion of feeds into meat or eggs, by providing some guidance and oversight in terms of animal welfare, and by ensuring food safety, the daily tasks of animal production specialists and veterinarians have a huge impact on the sustainability of poultry production. But there is a need towards a more constructed approach to train them on the latest research findings, ingredients, and products available and upscale their core competencies.

The World Veterinary Education in Animal Production Health (WVEPAH), established in 2010 at the request of the World Organisation for Animal Health (WOAH), is a not-for-profit organization with the goal to provide continuing education to veterinarians and animal production specialists in the field (https://wvepah.org/). With a vision of Food Security for all, WVEPAH brings a concrete One Health approach to animal production and health. It empowers, through training and certification, professionals to contribute to the sustainability of human nutrition. WVEPAH is partnering with the university of Montreal in Canada to deliver academic degrees validated by WOAH. WVEPAH has also developed partnerships with key poultry organizations, including the World's Poultry Science Association (WPSA), the World Veterinary Poultry Association (WVPA) and the Latin America Poultry Association (ALA). The Poultry curriculum includes two modules: Module 1 (Key Disciplines in Poultry Health/ Regulation Module OIE-WOAH), offered exclusively online, addresses the general field of Poultry production and diseases as well as various aspects related to regulations, zoonoses and disease control measures; Module 2, combining online lectures and a 5-day onsite session, offers specializations in the key poultry species raised worldwide (broilers and breeder birds, commercial layers, turkeys, and waterfowls). The lectures are provided by a team of global poultry experts from the private sector and the host universities partnering with WVEPAH and located around the world (Guyonnet and Cadot, 2023).

Conclusion

While the Poultry and egg sector is facing numerous challenges, the increasing demand of consumers for sustainable food products, especially younger generations of consumers, is offering many opportunities. Although feeds and manure have the greatest impact on the environment, it is extremely fortunate that there are many tools available to further reduce the impact of poultry production on the environment. Many of these sustainable initiatives will also translate into higher productivity and economic returns, making them a real win-win situation for producers, consumers, and the planet. New technologies and tools such as artificial intelligence have the potential to assist the sector address a wide range of global challenges. However, acquiring the latest knowledge in many different fields is time consuming and complex. In that respect, the World Veterinary Education in Animal Production Health is an excellent partner to assist the poultry and egg sector along its sustainability journey.

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Utilizing Information Technologies in the Poultry Industry: Application Examples

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Producers in the poultry industry face numerous challenges, with new ones emerging daily. Chief among these difficulties is cost pressure, compelling manufacturers to produce more at a lower cost. Additionally, heightened awareness of the environmental impact of poultry production, greenhouse gas emissions, and animal welfare exerts diverse pressures on producers. Misinformation, such as the misconception that "poultry are constantly given hormones and antibiotics," sometimes influences consumer preferences, making antibiotic-free production popular and placing producers under pressure. Apart from these primary challenges, it is a recognized fact that producers, who must care for thousands of chickens, cannot dedicate enough time to them due to their other workloads. At this juncture, digital technologies (such as cameras and sensors) should serve as the eyes and ears of the producers, empowering them to address current issues and enabling the sector to derive greater benefits from information technologies. The integration of information technologies into the poultry industry will bring significant advantages to the sector. Automation and robotic applications optimize daily farm processes, reducing labour costs and increasing efficiency. For instance, automatic feeding and watering systems precisely control the nutritional and water needs of animals, supporting environmental sustainability by optimizing energy and resource use. Robotic applications are employed in incubation and egg incubation processes to enhance egg hatching rates and reduce errors related to labour. Cleaning robots play crucial roles in maintaining animal health by elevating hygiene standards on farms. Moreover, data analytics and monitoring systems integrated into robots offer farm owners real-time information on the health status, growth trends, and overall performance of animals. These data enable early disease diagnosis and expedite treatment processes. Additionally, with these robots developed in recent years, besides monitoring animal health and welfare, it is possible to measure ammonia, carbon monoxide, temperature, humidity, and litter condition from thousands of points inside the poultry house, create poultry house mapping, and inform the producer in real-time. Smart farm management systems integrated with Internet of Things (IoT) applications can enhance business processes by providing remote access and control to farm owners. All these technological innovations represent significant strides in terms of sustainability, efficiency, and animal health and welfare in the poultry industry. Nevertheless, to support the poultry industry by advancing these innovations and technologies, veterinarians, zootechnicians, engineers, and producers must collaborate more closely.

Keywords: Precision poultry farming; health and welfare; sustainable production; robotics

Siam Chicken Bioresource Project: Balancing Food Security and Biodiversity

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Indigenous and local chicken breeds are widely employed in rural development and backyard farming globally, owing to their cost-effectiveness, adept scavenging abilities, and resilience in challenging environmental conditions. These breeds play a crucial role in addressing nutritional needs within communities. These breeds, exemplified by the Mae Hong Son chicken, Chee Fah, and Fah Luang chicken, have their origins in the crossbreeding of domestic chickens with the red junglefowl. Thriving in highland environments, they hold significant socio-cultural importance in Thai communities. Economically, indigenous and local breeds, preferred in remote areas, are maintained for local consumption and supplementary income, presenting an economical choice due to their lower maintenance costs. Crossbreeding practices have yielded breeds with favorable traits, making it imperative to preserve their genetic diversity. These chickens not only ensure food security for farmers and local communities but also play a crucial role in adapting to future environmental challenges, contributing valuable traits to the poultry industry. These traits encompass enhanced egg and meat production, quality, environmental stress tolerance, and disease resistance. This study delves into the genetic history of indigenous and local chickens, identifying breeds/ecotypes resulting from red junglefowl and Thai domestic chicken crosses, showcasing their adaptation to diverse local environments. Habitat suitability analysis evaluates their distribution across Thailand, encompassing past, present, and future suitable habitats, with a focus on their response to temperature variations. The research aims to deepen our understanding of their adaptation mechanisms, facilitating the genetic improvement of commercial chicken breeds and contributing to the conservation of indigenous and local chickens. Insights into habitat distribution guide effective management and conservation planning. The prioritization of nutritional and genomic scans is crucial for identifying new alleles and genes of agronomic significance. Furthermore, the study aligns with the food bank management protocol framework, particularly within specific border regions of Thailand, emphasizing the role of nutrition in tandem with genetic diversity conservation and rural development.

Keywords: Indigenous chicken; genetic diversity; food security; rural development; adaptation

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SESSION 2

Sustainability in Poultry Industry, Biotechnology, Feed Additives and Antibiotic-Free Production

Poultry Meat and Human Health

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Everyone eats. That makes diet probably the most common exposure concerning health and disease, underlying the importance of nutrition research. The latter faces numerous unique challenges such as collecting reliable nutritional data, baseline nutritional status and blinding of participants, as well as potential bias regarding inclusion of them. Dietary patterns cannot be isolated from behaviors and lifestyle. Furthermore, there is a large day-to-day variability in what is eaten, and the food in question always includes a wide variety of intended and unintended chemicals. Bearing these limitations in mind, available research unequivocally points out at the health benefits of a plant-based vs an animal-based diet. However, as the vast majority of humans will not convert to veganism in any forseeble future, converting them from less healthy animal protein sources into healthier ones could potentially be a critical tool for improving public health. As a relatively less expensive protein source which is also easier on the environment, with a modest calorie density, higher protein/fat ratio, lower saturated fat, rich vitamin and mineral content, poultry meat has numerous advantages which still remain to be publicized to accomplish this task.

Keywords: Poultry meat; red meat; human nutrition; saturated fat

Sustainability in the Poultry Sector: Biotechnology and Feed

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The world population has grown from less than two billion at the beginning of the last century to more than 8 billion today. After the second World War, there was a mobilization for development all over the world and an accompanying increase in prosperity. This rapid development has brought along changing eating habits and agricultural technologies that were able feed the increasing world population. Today, dizzying developments in science and technology are rapidly finding application in almost every branch and stage of agricultural production and transforming agricultural production. However, the negative impacts of agricultural production on the environment, regardless of how it is carried out, disrupt the ecological balance of nature as well as depleting natural resources. Although the poultry sector has more sustainable values compared to red meat production, the yield obtained from unit area, including plant protein sources to meet poultry feed needs requires an increase by 50% in the coming years. It is important to remember that this increase in production will be possible through the widespread cultivation of modern biotechnology crops that reduce the use of pesticides and chemical fertilizers, which have proven to be harmful to the environment. We should also remember that modern biotechnology products are helping to reduce carbon dioxide and methane emissions from agriculture to net zero.

Keywords: Modern biotechnology; sustainable intensification; plant proteins; greenhouse gases

Investigation of the Efficacy of Thermostable Phytase Enzyme Produced from Newly Isolated Bacillus megaterium EBD 9-1 Used in Broiler Chicken Rations

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This study was carried out to determine the efficiency of thermostable phytase enzyme produced from the new local isolate Bacillus megaterium EBD 9-1 in broiler rations. In this study, the effects of various biological wastes, nutrients and some metal ions on phytase production were investigated. As a result, a new breeding medium was developed, resulting in a 2.34-fold increase in enzyme production. Subsequently, large-scale production and lyophilization of the enzyme was carried out. It was determined that the lyophilized enzyme preserved its activity at high temperatures. A total of 486 1-day old Ross-308 genotype male chicks were randomly distributed into 9 groups, with 9 replicates in each group (6 animals in each replica group). Standard Ca (SCa) and standard phosphorus (SP) without enzyme were used as positive (+) controls (SCaSP-) in broiler experimental groups; They were divided into three main groups as enzyme-free SCa and low P negative (-) control I (SCaDP-) and enzyme-free low Ca and low P negative (-) control II (DCaDP-). And each main group was divided into 2 subgroups containing microbial (SCaSP+MF, SCaDP+MF, DCaDP+MF) and commercial phytase (SCaSP+TF, SCaDP+TF, DCaDP+TF) at the level of 300 FTU/kg. When the performance parameters obtained were evaluated, the live weight gain increased in the SCaSP+TF, SCaDP+TF, SCaDP+MF, DCaDP+TF groups compared to the SCaSP-, SCaDP- and DCaDP- groups; European production efficiency factor values were found to be significantly higher in the SCaSP+TF group and in the groups in which phytase was added to the diet containing low P compared to the SCaDP- and DCaDP- groups. Compared with the SCaDP- and DCaDP-, the best feed conversion was in SCaSP+MF and DCaDP+TF ($P<0.001$); the highest carcass weight was obtained in the SCaSP+TF ($P<0.05$) compared to DCaDP- group. In terms of the incidence of tibial dyschondroplasia (TD), the SCaSP-, CaSP+MF and SCaDP+MF groups were found to have a significantly lower TD incidence than the DCaDP- group. As a result, it was concluded that it would be beneficial to produce the phytase enzyme produced from Bacillus megaterium EBD-9 in granule form in order to be commercialized, and to continue Research-Development studies with different doses in order to reveal the most effective dose.

Keywords: Broiler; animal feed; phytase

Probiotic Bacillus Coagulans DSM 32016 Mitigates Clostridium Perfringens-Induced Performance Drop in Broiler by Beneficial Intestinal Microbiota Modulation and Histomorphological Improvements

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Probiotics are a sustainable tool to influence gut health and performance. Apart from their potential to improve zootechnical performance under unchallenged conditions, certain strains may also have protective abilities under pathogen pressure. In line with strategies aiming to reduce antibiotic usage, this study investigates the efficacy of a novel probiotic feed additive *Bacillus coagulans* DSM 32016, in enhancing broiler performance as well as mitigating negative effects of *Clostridium perfringens* challenge. A total of 144 day-old chicks (ROSS 308, ♂♀) were randomly assigned to four groups (n=6, 6 chicks per pen). Groups, pathogen-challenge and probiotic dosage for entire trial period were: Group 1. NC, Negative control (no pathogen challenge, no probiotic supplementation); Group 2. NCTS, Treatment I (no pathogen challenge, probiotic supplementation [1.0 x 10^9 CFU/kg feed]); Group 3. PC, Positive control (pathogen challenge, no probiotic supplementation); Group 4. PCTS, Treatment II (pathogen challenge, probiotic supplementation [1.0 x 10^9 CFU/kg feed]). Group 3 and 4 received a 10-fold dose of anticoccidial vaccine (Coccivac-D) on day 5 and were orally challenged with *C. perfringens* (4 x 10^8 CFU/ml) on days 5, 6, and 7. Broilers were fed ad libitum with a starter diet (Day 1 – 21) and a finisher diet (Day 22 – 35). Weekly documentation included feed intake (FI), body weight (BW), body weight gain (BWG), and feed conversion ratio (FCR). Intestinal *C. perfringens* and *Lactobacilli* counts were quantified via common CFU analysis, and intestinal samples were taken for histomorphological analysis at end of trial (Day 35). Statistical analysis employed ANOVA if data were suitable or non-parametric tests (Kruskal Wallis) using IBM SPSS software. Mean values were assessed for significance using Duncan›s multiple range test with significance set at $p \leq 0.05$. PC birds exhibited reduced BWG and increased FCR compared to NC, indicating a successful pathogen challenge. Both probiotic groups, NCTS and PCTS showed improved performance parameters compared to NC and PC, respectively, with significantly enhanced BWG in the finisher phase. FCR was significantly reduced in PCTS compared to PC in both feeding phases. Histomorphological parameters such as villi width of birds in PCTS group were significantly improved compared to PC. PC displayed highest intestinal *C. perfringens* counts and significantly decreased *Lactobacilli* counts compared to NCTS. Dietary supplementation with *B. coagulans* DSM 32016 resulted in significantly increased broiler performance with and without pathogen challenge, revealing additionally improved histomorphological parameters as well as a beneficial modulation of the gut microbiota under pathogen challenge. Hereby, the findings demonstrate the efficacy of *B. coagulans* DSM 32016 in mitigating the negative impacts of *C. perfringens* infections in broiler chicken.

Keywords: Probiotic; poultry production; pathogen infection; feed efficiency

Effects of Using Pomegranate Peel Extract and Prebiotics together on Fattening Performance and Some Blood Parameters in Quails

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The purpose of this research; The use of prebiotic (1 g/kg) and low (7.5% mg/kg) and high (17.5% mg/kg) doses of pomegranate peel extract separately and together with prebiotics in quail rations; performance parameters (Body Weight; BW, Body Weight Gain; BWG, Feed Consumption; FI, Feed Conversion Ratio; FCR hot-cold carcass weight and yields), meat quality (L*, a*, b* and pH values of breast and thigh meat), the activity of some antioxidant enzymes in blood serum (Superoxide Dismutase; SOD and Total Antioxidant Capacity; TAC), fatty liver and hydropic degeneration, small intestine villus height (VH), crypt depth (CD), villus height/crypt depth (VH/CD).), to determine its effects on villus width (VW). A total of 240 newly hatched quails were used. Quails were equally distributed into six groups according to their CA (7.68 ± 0.63) and gender. Rations; 0 (Control), 1 mg/kg prebiotic (Pr), 7.5 mg/kg pomegranate peel extract (PPE1), 7.5 mg/kg pomegranate peel extract + 1 g/kg prebiotic (PPE1+Pr), 17, 5 mg/kg pomegranate peel extract (PPE2) and 17.5 mg pomegranate peel extract/kg + 1 g/kg prebiotic (PPE2+Pr) were added. Quails were weighed at 7-day intervals; highest BW value; In PPE1, the highest FI was observed in C, and the best FI was observed in PPE2+Pr ($p<0.05$). The a* and b* values of leg meat were high in PPE2+Pr, the lowest pH value of breast meat was observed in PPE1, and the highest TAC value was observed in PPE2 ($p<0.05$). It was observed that fatty liver was lowest in PPE1, VH was highest in PPE2, CD was lowest in PPE2+Pr, and VH/CD and VW values were highest in PPE2+Pr. As a result, PPE at a dose of 17.5 mg/kg added to quail rations; It positively affected performance parameters, meat quality, blood serum TAC value, liver-intestinal histomorphology.

Keywords: Antioxidant; performance; pomegranate peel extract; quail

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SESSION 3

Alternative Feed Sources and Sustainability in Poultry Nutrition

Insects in Poultry Nutrition: The Oportunity of the Whole Larva

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A wide range of insects are being considered as potential candidate sources of dietary protein; however, it was only recently that the European Union, with Regulation (EU) 2017/893 of May 24, first allowed the use of the black soldier fly (Hermetia illucens), the common housefly (Muscadomestica), the yellow mealworm (Tenebrio molitor), the lesser mealworm (Alphitobius diaperinus), the house cricket (Acheta domesticus), the banded cricket (Gryllodes sigillatus) and the field cricket (Gryllus assimilis) as feed in aquaculture. With Regulation (EU) 2021/1372 of August 17, their use was extended to poultry and pig feed. Most of the studies on the use of insects in poultry feeding have focused on the benefits of insect meals. However, live insects are part of the natural diet of poultry, so more effort should be directed at evaluating their use further, not only in relation to their effect on poultry performance and product quality, but also from the perspective of bird welfare. No adverse effects have been observed with the dietary inclusion of live larvae at up to 10% of the daily feed intake. However, further research is needed to establish the inclusion levels that are most advantageous for the bird's health, economically sustainable for the breeder and without the unnecessary waste of resources. Live larvae provide fresh, unaltered nutrients and they stimulate birds to express innate behaviours which may improve the birds' welfare. The production and distribution of live larvae may be laborious and expensive, especially for large-scale production systems. Dehydrated larvae are easier to handle, and no complex protocols need to be implemented prior to offering to the bird. By contrast, dehydrated larvae are potentially less attractive to birds.

Keywords: Poultry; whole insect larvae; live insect larvae; dehydrated insect larvae; frozen insect larvae; black soldier fly; mealworm; housefly

Introduction

Over the last 70 years, innovations in intensive poultry production have made poultry farming highly efficient and relatively inexpensive. However, consumer perception of poultry products is negatively affected by the widespread belief that broiler chickens and laying hens are raised in poor welfare conditions and fed 'artificial feeds' containing hormones and antibiotics. Furthermore, the negative impact of poultry feeds upon the environment is great due to the substantial use of soybean (the main protein source in poultry feeds), now inextricably linked with deforestation (Le Poulaine de Warouz *et al.*, 2019). Western society is currently facing a crucial juncture in animal production, as the models developed in the 1960s to ensure high-quality protein for the human population have become 'socially obsolete'. Therefore, it is the responsibility of scientists to develop more socially responsible models that can sustain food security while addressing the evolving needs of society. Insects have been recognized as a crucial component of the solution to finding alternative protein sources for animal nutrition, either in the form of meal which can replace soybean or other conventional dietary protein sources (Martinez-Marin *et al*., 2023). Additionally, whole insects have the potential to serve as environmental enrichment to enhance poultry welfare, whether in both free-range and intensive farming conditions (Van Huis, 2013). The attraction of using insects in livestock feeds is centred on their low-impact production, which involves lower energy costs and less land area utilization, and a lower environmental footprint compared with other protein sources (Martinez-Marin *et al*., 2023; Van Huis, 2013). Insects are naturally consumed by free-range chickens and provide valuable nutrients (Appleby *et al*., 2004).

EU regulation and research on insects

In the last 10 years, the potential use of insects in animal feed has experienced significant development in Europe, in terms of EU Regulation evolution, research outcome and potential practical application. In 2012 the International Platform of Insects for Food and Feed (IPIFF) was created as an EU non-profit organisation to represent the interests of the insect production sector towards EU policymakers, stakeholders and citizens. Most IPIFF members are EU small and medium-sized enterprises who produce insects for the European market (https://

ipiff.org). In 2014, the first international conference 'Insects to feed the world' (organized by the Wageningen University in collaboration with the FAO) brought over 450 participants from 45 countries. The conference was a milestone in the recognition of the professional insect industry, involving feed industry leaders, insect breeders, universities, NGOs and other stakeholders who gathered for the first time. Since then, that conference has been held every two years. In 2015 the European Food Safety Authority (EFSA) provided the first positive opinion about the use of insects as food and feed, suggesting the need of data and research reports about the potential biological and chemical hazards associated with farmed insects used as food and feed (EFSA, 2015). In 2017 the European Commission (EC) published the Regulation (EU) n. 2017/893 thereby authorised the use of processed animal proteins (PAPs) derived from insects and compound feed containing such processed animal protein for feeding aquaculture animals. This authorisation covered seven insect species, namely: black soldier fly (*Hermetia illucens*), house fly (*Musca domestica*), yellow mealworm (*Tenebrio molitor)*, lesser mealworm (*Alphitobius diaperinus*), house cricket (*Acheta domesticus*), banded cricket (*Gryllodes sigillatus*) and field cricket (*Gryllus assimilis*). Subsequently, in 2021 the EC, with the Regulation (EU) n. 2021/1372, expanded the authorised use of processed animal proteins (PAPs) derived from the insects included in Reg. 2017/893 to also poultry and pig nutrition. Presently, killed whole insects (with or without any further treatment, according to Regulation (EC) No 1069/2009) are not allowed as feed for food-producing animals.

On the research side the the EU has recently increased their funding of research projects in order to provide original data to support the use of insect as feed. In this context the PROteINSECT (https://www.proteinsect.eu) project (2013-2016) focused on house fly and black soldier fly for evaluation of their potential as protein source in animal nutrition. The SUSINCHAIN (https://susinchain.eu) project (2019-2023) aims to contribute to novel protein provision for feed and food in Europe and wants to overcome the barriers for increasing the economic viability of the insect value chain and opening new markets. Both projects were funded by the EU under the umbrella of Horizon2020 program. The Poultrynsect (https://poultrynsect.eu) project (2021-2023) promotes the use of live larvae in organic chicken farming (H2020 ERA-NETs SUSFOOD2 and CORE Organic). The SUSTAvianFEED (https://www.sustavianfeed.eu) project (2021-2025) seeks to showcase pioneering poultry farming systems through the integration of sustainable animal feeding, with insects playing a pivotal role. The ADVAGROMED (https://www.advagromed.com) project (2022-2025) aims to develop, evaluate and promote an innovative farming system adapted to the unique Mediterranean conditions by exploiting the advantages of insect production in conjunction with basic agroecological principles, even in poultry farming. Both SUSTAvianFEED and ADVAGROMED are funded by the PRIMA programme, supported by the EU.

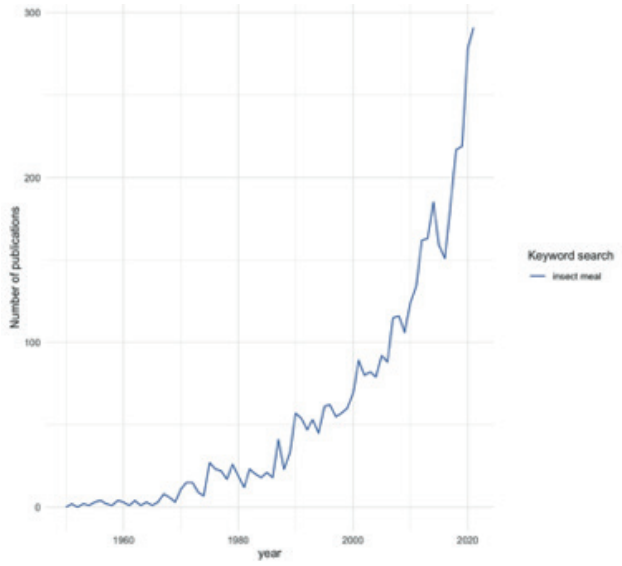

Figure 1. Scientific articles using insect meal as a keywords (Kieronczyk et al., 2022)

Following the evolution of EU regulations, policymaker inputs and research projects, there has been a dramatic increase in publications that feature 'insect meal' as their main topic (Figure 1). This paper's focus is mainly related to the use of insect meal (full-fat and/or defatted) as potential substitution of standard feed protein source (i.e. soyabean and/or fish meal) in poultry, fish and swine production, considering aspect such as growth performance, digestibility, gut health and product quality (Kieronczyk et al., 2022). A very limited number of studies investigated the effect of administering whole insect larvae (live, frozen or dehydrated) in poultry farming practice, thus pointing the way to new research frontiers. In fact the whole larve may be considered both as source of nutrient and as a tool for environmental enrichment to promote poultry welfare. In this comprehensive vision, utilizing whole insect larvae (whether live, defrosted, or dehydrated) holds the potential to enhance the sustainability of poultry farms in terms of feed quality and animal welfare. However, this novel approach is still relatively underexplored and

presents new opportunities for research and practical applications. A wide review about this topic has been recently publishe by Schiavone and Castillo (2023).

Insect in poultry nutrition

The avian feeding behaviour is a vast and complex issue, which farmers, breeders, and all individuals dealing with poultry breeding and production should deepen their knowledge about, thus design and organise the feed distribution according to the bird's needs. Wild and feral poultry dedicate a great part of the day to foraging for food (Appleby *et al*., 2004). Domestic birds would also be capable of choosing proper food items to fulfil their nutritive requirements, if they would be given the opportunity to do so. Concerning the use of whole insects' larvae, this might bring additional benefits to birds, by stimulating them to become more active, evoking part of the foraging activity, thus their welfare. Furthermore, the EC recently committed to banning caged farming in Europe by 2027 and a legislative proposal is expected by the end of 2023. Few studies have focused on testing the bird's response and beneficial effects the dietary inclusion of live and/or dehydrated or frozen whole insects larvae may produce, as well as practical aspects of the supplementation. Studies on dietary live insect larvae supplementation have been focused on broiler chickens, slow growing chickens and laying hens (table 1), evaluating quantities offered, insect species, modality of supply and welfare benefits caused by their use. The insect larvae used in these poultry trials were black soldier fly (BSFL), yellow mealworm (YML) and house fly larvae (HFL). Live BSFL or YML are apparently a very appreciated food item, as demonstrated by the time needed to eat it (Bellezza Oddon *et al*., 2021). Scattering the larvae throughout the litter gives the bird the chance to look for them, stimulating the bird to accomplish the foraging behavior (Ipema *et al*., 2020a; Ipema *et al*., 2020b; Ipema *et al*., 2022; Pichova *et al*., 2016). Certainly, from the point of view of the bird, this supplementation modality might provide the bird with a higher state of welfare. On the other hand, implementing logistic supplementation could be quite demanding. Providing the larvae only once daily may not offer the bird a prolonged stimulus, but choosing a desirable moment of the day for this supplementation can still contribute to the bird's welfare.

Table 1: Live insects larvae inclusion in poultry diets: species, inclusion rate and distribution method

Insect sp.	Bird	Age (d)	Quantity	Freq.	Method	Reference
BSFL	broilers	0-35	8%[a]	4 times	scattered	Ipema *et al*., 2022
BSFL	broilers	0-42	5-10%[a]	4 -7 times	scattered	Ipema *et al*., 2020b
			10%[a]	all day	tubes holes	
BSFL	broilers	0-42	5-10%[a]	2-4 times	scattered	Ipema *et al*., 2020a
YML	broilers	6-18	10 g/ bird/d	once	scattered	**Errore. Il segnalibro non è definito.**
BSFL/YML	broilers	4-38	5%[a]	once	2 plates	Bellezza Oddon et al., 2021, Biasato *et a*l., 2022
BSFL	slow growing chickens	28-81	10%[a]	once	plate	Bongiorno *et al*., 2022
BSFL	slow growing chickens	39-174	4%[a]	once	plate	Fiorilla *et a*l., 2023
HF	slow-grow. chicken	14d-adult	30-50g/ bird/d	once		Dankwa *et al*., 2002
BSFL	turkey	0-35	12%[b]	once	plate	Veldkamp *et a*l., 2022
BSFL	laying hen	469-546	10% [a]	6 hours/d	dispenser	Star *et al*., 2020
BSFL	laying hen	126-210	10-20% andad lib.	once	bowels	Tahamtani *et al*., 2021

[a]estimated on dry matter feed daily feed intake; [b]estimated on fresh feed daily feed intake.

The use of defrozen BSF larvae in poultry diets was tested in broilers (Moula *et al.*, 2018a) and slow growing chickens (Moula *et al.*, 2018b). The bird's feed interest was stimulated and no effects on the feed conversion ratio were observed with up to 20% dietary inclusion (Seyedalmoosavi et al. 2022).

Studies on the use of dietary whole dehydrated larvae in poultry are also very limited (table 2). Compared to a diet without BSFL, scattering dehydrated or live larvae through the pen increased active behaviors (Ipema *et al*.,

2022). In authocthonous slow growing chickens, the acceptability of live or dehydrated BSF larve was the same at any bird's age (from 39 to 174 days of age) (Fiorilla *et al*., 2023).

Table 2: Dehydrated insects larvae inclusion in poultry diets: species, inclusion rate and distribution method

Insect sp.	Bird	Age (d)	Quantity	Frequence	Method	Refererence
BSFL	broilers	0-35	8%[a]	4 times	feeder/scattered	Ipema et al., 2022
HF	broilers	1-35	5-10-15-20%[b]	once	with feed	Hwangbo *et al*., 2009
BSFL	slow-grow. chickens	39-174	4%[a]	once	plate	Fiorilla *et al*., 2023
HF	slow-grow. chickens	126-168	3 times/day	cafeteria (30')	cafeteria	Traore *et al*., 2020
HF	guinea fowl	308-357	3 times/day	cafeteria (30')	cafeteria	Traore *et al*., 2020

[a]estimated on dry matter feed daily feed intake; [b]estimated on fresh feed daily feed intake.

Actually, in guinea fowl, dehydrated HFL offered as cafeteria was not considered and cereal grains were preferred, while in slow growing chickens HFL were appreciated (Traore *et al*., 2020), suggesting a different response to the same stimuli, dependinding on the poultry species. Regarding the quantity to be included in the diet, more information is needed to individualize the appropriate level. Advantages the use of dehydrated larvae may offer, are however to be considered. For instance, dehydrated larvae are easy to handle and no expensive and/or complex protocols are needed to be applied prior to offer these to the bird.

Common problems observed in broilers are linked to the legs' health due to the progressive increase of the bird's body weight. Supplementing live BSFL decreased the incidence of leg problems in broiler chickens (Ipema *et al*., 2020b; Ipema *et al*., 2022). Feather pecking is another problem which poultry farmers must deal with. In laying hens, by delivering dehydrated BSFL through a special dispenser a decrease in the feather damage was observed (Star *et al*., 2020). In 4-5-week-old turkeys, a reduction in the back and tail aggressive pecking was observed (Veldkamp *et al*., 2022). In broilers, no effect was observed (Biasato *et al*., 2022). Also, for this aspect, further studies are needed to have a clear picture of the real effect the dietary insects may have on the feather pecking behaviour.

Conclusions and future perspectives

Basic and applied research on the use of whole dehydrated insect larvae in poultry is still in its early stages, and several questions remain unanswered. In this context, the following issues need to be investigated in avian biology to promote this innovative feeding practice in poultry farming, such as the impact of insect dehydrated larvae on: 1) feed intake; 2) digestibility; 3) gut health; 4) behavioral patterns; 5) product quality. Despite the potentially lower attractiveness of dehydrated larvae compared to live ones, the application of dehydrated larvae in farming practices is more promising than the use of live larvae, despite the cost of the drying process. The main reasons for this statement can be summarized as follows: 1) the production of dehydrated larvae is independent of the moment of use; 2) dehydrated larvae can be easily stored; 3) dehydrated larvae are transported more efficiently (as live larvae contain around 70% water); 4) the microbiological composition of dehydrated larvae can be easily monitored and stabilized before being fed to birds (no live animals are introduced to the poultry farm, enhancing biosecurity protocols); 5) the automatic distribution of dehydrated larvae on the farm can be easier than with live ones, without causing stress to the larvae. At the moment, unfortunately, the dehidrated larvae remain unauthorized in the EU due to the lack of investigation in this area. Therefore, further research is needed to study the effect of dehydrated insect on poultry welfare and, consequently, to improve consumer acceptability of standard poultry products.

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The Quality Parameters of Soybean and Alternative Protein Feedstuffs in Poultry Nutrition

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The aim of this study was to determine the changes in crude protein and crude oil values of imported soybeans according to their origin, and also to investigate the alternative feedstuffs of soybean in poultry nutrition. A total of 227 soybean samples obtained from six origin countries (Ukraine, Argentina, Brazil, USA, Paraguay, and Uruguay) were analyzed for the crude protein and fat content. The crude protein and fat content of soybean showed difference between a range of 30.7 and 38.8% and 17.7 and 23.0% respectively, according to the origin countries. The lowest content of crude protein with a value of 33.9% was observed in soybean imported from Ukraine, whereas the highest content with a value 35.6% was found in soybean imported from USA. The highest and lowest of fat content were observed in soybean imported from Paraguay (21.3%) and USA (19.2%, $P<0.05$). Current findings clearly indicated that the nutritional value of soybean showed variations according to the origin country, and also depends on climatic conditions and soil characteristics of origin countries. At that point, it should be emphasized that the cost of soybean consider with nutritional content. On the other hands, soybean meal is the major source of protein added to the poultry diet with approximately of 30% inclusion rate to satisfy protein and amino acid requirements of the chicken. In recent years a huge interest has been focused on alternative protein sources, for example oilseed by- and co-products, distillers' dried grain with soluble, microalgae, insects, and single-cell organisms to replace soybean in poultry nutrition. As a conclusion, it is important to consider some criteria's in selecting of soybean and other protein alternatives according to the chickens' nutritional requirements, balancing of amino acids in diet, avoid anti-nutritional or toxic compounds in alternative protein feedstuffs, and also cost and availability of feedstuff by geographical areas.

Keywords: Soybean; alternative protein sources; microalgae; poultry nutrition

Introduction

The global population is increasing day by day, which results in a significant increment for global demand of food and feed (Parrini et al., 2023). By 2050, it is estimated that the world population will be more than 9 billion people; subsequently agricultural production is expected to show an increment by 50% (Lombardi et al., 2021). In poultry nutrition, protein feeds are one of the most expensive and limiting ingredient in diet formulations (Parisi et al., 2020) and one of the most important protein sources for poultry is soybean. For this reason, the need for soybean is increasing day by day and soya bean production is becoming more and more important especially in animal nutrition with a usage amount as 67% of the animal feed market (Pettigrew et al., 2002).

Soybean (*Glycine max L.*) is a high quality protein source due to its favorable attributes such as relatively high protein content and suitable amino acid profile except methionine, minimal variation in nutrient content, ready availability year-round, and relative freedom from intractable anti-nutritive factors if properly processed. The most important quality criteria's for soybean are crude protein, moisture, KOH and crude oil contents. These criteria vary greatly depending on the origin of the soybean. In addition to these analyses, physical analyses such as seed size, color and seed shape are also important in soybeans. It has been reported that geographical location of soybean production, soybean variety, and processing methods affects the crude protein and amino acid composition of soybean meal (Parsons et al., 1991, 2000; de Coca-Sinova, 2008, 2010; Baker et al., 2011). In poultry nutrition, soybean is not used directly in feed formulation due to its higher oil content and cellulose in the hull. Therefore, the by-products of soybean as soybean meal and soybean oil is used in poultry nutrition, with an average value of 30% of diet.

The leader countries as soybean producer in the world are Brazil and the USA. In worldwide the soybean production amount by 2023 is explained as 398,210 (1000 metric tons) by USDA (USDA Reports, 2023 at: https://ipad.fas.usda.gov/cropexplorer/cropview/commodity View.aspx?cropid=2222000). The leading soybean producing countries worldwide between 2012 and 2023 is shown on Figure 1.

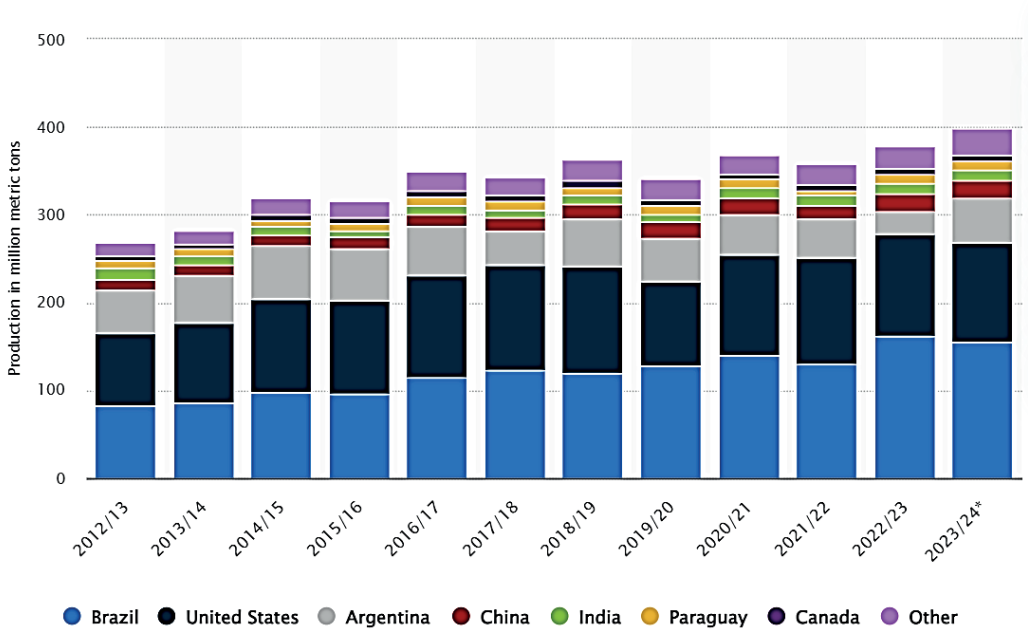

Figure 1. Leading soybean producing countries worldwide (in million metric tons, Statista, 2004; Accessible at: https://www.statista.com/statistics/263926/soybean-production-in-selected-countries-since-1980/)

The aim of this study is to compare the crude protein, crude fat and moisture contents of soybeans according to their origins, and also to give information about alternative feedstuffs as a protein source instead of soybean in poultry nutrition.

Materials and Methods

A total of 227 soybean samples obtained from six origin countries (Ukraine, Argentina, Brazil, USA, Paraguay, and Uruguay) were analyzed for the crude protein and fat content. The crude protein and crude fat content of the soybeans samples was determined according to AACC Method (46-11.02, 30-25.01, International, 2010a, 2010b).

The obtained data were analyzed using the GLM procedures of statistical software (Minitab, 2013). Significant differences among the means were compared using the Tukey test and were considered statistically different at a level of $P < 0.05$.

Results and Discussion

The crude protein content of soybean by different countries is shown on Figure 2. As seen in the figure, the protein content was found to be the lower in Argentine (34.3%) and Ukraine (33.9%) compared to the other countries ($P<0.001$).

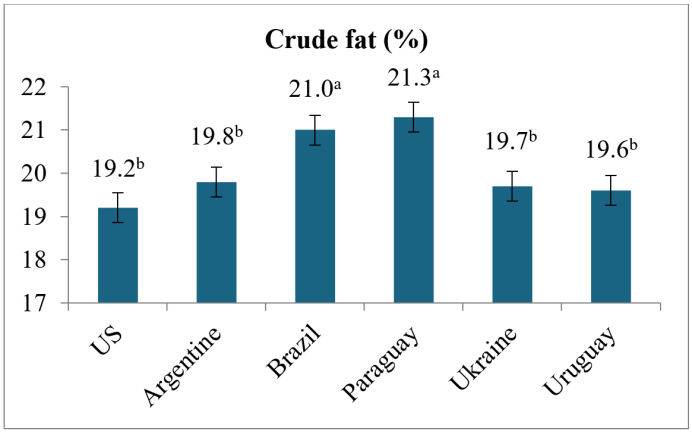

Figure 2. The crude protein content of soybean by different countries

The crude fat content of soybean by different countries is shown on Figure 3. As seen in the figure, the highest mean value of fat content was observed in soybean produced by Brazil (21.0%) and Paraguay (21.3%, P<0.001).

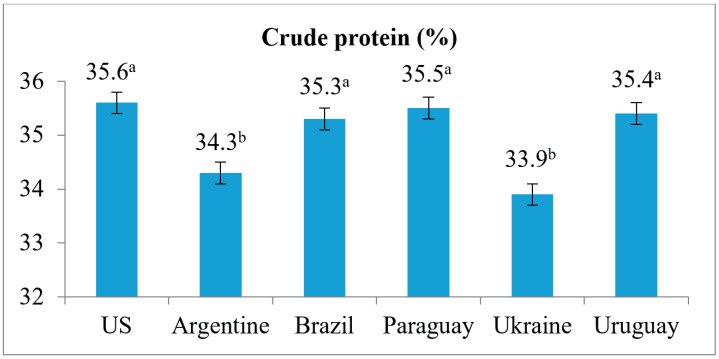

Figure 3. The crude protein content of soybean by different countries

The soybean meal is a primary source of protein in diets; therefore any factors affecting the protein content of soybean could have major interest for feed industry. On the other hand, fat content of soybean has also crucial importance to the industry because of its high economic value. It is well known that the soybeans grown in different environmental conditions and agricultural practices cause huge variations in quality parameters. Besides, the meal processing conditions, e.g. processing temperature, moisture and drying time, cause differences in both chemical composition and quality of soybean meal (Thakur and Hurburgh, 2007). According to Zhang et al. (2024), soybeans with a moisture content of less than 13% and a crude fat content of more than 20% are accepted as high-oil soybeans. In a previous study performed by Grieshop and Fahey (2001), soybeans from China had a higher crude protein (42.1%) and a lower fat content (17.3%) than those from Brazil (40.9% and 18.7%) and US (41.6% and 18.7%) on a dry matter basis. Grieshop and Fahey (2001) reported that the fat content of soybeans from both Brazil (range between 18.0 and 19.8%) and the U.S. (17.89-19.65%) were quite stable, however fat content of soybeans from China showed many variations from 14.5% to 18.0%.

Although the high nutritional value of soybean as a plant protein source provides an efficient usage in poultry nutrition, both the social and environmental impact of the soybean industry and genetically modified soybean production has led to a growth in demand for more sustainable alternative protein sources (Gkarane et al., 2020). At that point, recent scientific studies have focused on the usage possibilities of *Hermetia illucens* (black soldier fly) larvae and the microalga spirulina (*Arthrospira platensis*) in nutrition (Schiavone et al., 2017; Park et al., 2018; Kawasaki et al., 2019; Smetana et al., 2019).

Conclusions

The current findings demonstrated that nutritional composition of soybean showed differences according to the origin. As a protein source, the soybean from US, Brazil, Paraguay, Uruguay had the highest protein content.

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The Effect of Essential Amino Acid-Balanced Low-Protein Diet on Performance and Meat Quality in Broiler Chickens

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The aim of the study was to investigate the effects of low-protein and essential amino acid-balanced diets that would reduce feed cost on performance parameters such as body weight gain, feed consumption, feed conversion ratio, and meat quality. A total of 1050 one day old male chicks of Ross 308 genotype at one day of age were divided into 3 groups, each consisting of 350 chicks and further subdivided into 10 subgroups, each comprising 35 animals. From days 1 to 10, all groups were fed a diet containing 22.5% crude protein (CP) without changing the protein content. All groups' diets have been balanced with essential amino acids lysine, methionine, threonine, tryptophan, isoleucine, leucine, arginine and valine according to the data in the Ross 308 user guide. From days 11 to 22, the first group was fed a diet with 20.60% CP (LP1), the second group with 19.5%CP(LP2), and the third group with 18.5% CP (LP3). Between days 23 to 37, the first group was fed a diet containing 20.00% CP, the second group with 19%CP, and the third group with 18% CP. At the 22nd and 37th days of the trial, the body weights of broiler chickens were individually measured. On the same days, feed weighing was conducted to calculate individual feed consumption and feed conversion ratio of the broiler chickens. At day 22, the body weights of the first and second groups were found to be close to each other and were not statistically significant. However, the body weight of the third group (18.5% CP) was statistically significantly ($P \leq 0.05$) lower compared to the first (20.60% CP) and second (19.50%CP) groups. When considering the feed consumption at day 22, the first and second groups showed similar values with no statistical difference between them. However, the third group consumed less feed in parallel with body weight and this decrease was found to be statistically ($P \leq 0.05$) significant compared to the first and second groups. Regarding the 37th day, there was no statistically significant difference in body weight between the first and second groups, whereas the body weight of the third group was found to be lower compared to the first and second groups, and this difference was statistically ($P \leq 0.05$) significant. In the 37-day, feed consumption and feed conversion ratio showed similar results among the groups and were not statistically significant. Similarly, in the samples taken from the breast meat at day 37, while there were no statistically significant differences in protein content, cooking loss, pH, moisture analysis results. As a result of the decrease in feed protein content, the fat content in breast meat has increased ($P \leq 0.05$) significantly. The results are generally evaluated, considering body weight, feed consumption, feed conversion ratio, and meat quality, the most favorable diet protein content was achieved with the 2nd group, with a rate of 19.60% during the growth period (11-22days) and a rate of 18.08% during the finishing period (23-37days).

Keywords: Broiler; low protein diet; body weight; feed conversion ratio; meat quality

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2024 International Poultry Congress

8-11 May 2024
BURSA-TURKEY

SESSION 4

Poultry Welfare, Different Rearing Systems and Sustainability

State of the Art Broiler Breeder Management and Nutrition for Optimal Sustainability and Welfare

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Poultry meat is the most important protein source in human diet and to meet the increasing global demand. The discrepancy between a healthy and reproductive life and impaired behaviour and welfare is known as 'the broiler breeder paradox'. Managing broiler breeders is very challenging, particularly with the ongoing genetic alterations in both broilers and their parent stock. State of the art management for nutrition, housing, equipment, and health are necessary to optimize reproduction of breeders for a maximum number of healthy offspring. Contrary to expectations, implementing a twice-daily feeding regimen for breeder pullets has shown potential to enhance body weight uniformity. Nevertheless, the development of a novel system for optimal feed distribution is necessary to fully realize its benefits. In several EU countries, feeding on the litter is commonly practiced in rearing farms due to its associated advantages, including reduced clean-up time, improved litter quality, fewer leg issues, and enhanced body weight uniformity. During the laying phase, adopting a regimen of feeding twice daily or splitting feedings (particularly morning and afternoon diets) has demonstrated benefits in terms of egg production, behaviour, and egg fertility. It's noteworthy that water stands as the most crucial nutrient, with unrestricted access playing a pivotal role in behaviour, welfare, reproduction, and overall health. Male-to-female ratio is a key factor to maximizing egg fertility and hatchability.

Keywords: Broiler breeders, management, nutrition, sustainability, welfare

Introduction

Since some years, poultry meat is the most important protein source in human diet and to meet the increasing global demand, poultry production increased annually with approx. 3% to more than 100 million tons in 2020 (USDA, 2021). The majority of poultry meat is produced by more than 70 billion broilers originating from approximately 600 million broiler breeders. This implicates that a relatively small number of broiler breeders (or parent stock) has a substantial impact on the poultry meat chain. The main task of broiler breeders is to produce first class hatching eggs and healthy chicks and appropriate management is therefore essential (van Emous, 2015). During the last decades this is becoming more and more challenging, because the continuing increase in the genetic growth potential of the offspring and the parent stock as well (Zuidhof et al., 2014).

During the last six decades, broilers have been successfully selected for maximum growth and feed efficiency (Zuidhof et al., 2014). Modern fast-growing broilers reach a BW of 2.0 to 2.5 kg in 35 to 45 days (Augère-Granier, 2019). The high growth rate and efficiency is advantageous in broilers, but it may lead to welfare and reproduction problems in parent stock during the rearing and laying period. Feeding breeder pullets ad libitum, as is standard practice in broilers, results in a very high BW with negative effects on reproductive performance, mortality and health (Heck et al., 2004). To prevent these negative effects, feed restriction is necessary to promote breeder welfare and health reasons, whereas feed restriction simultaneously creates another welfare problem (D'Eath et al., 2009). Breeders show abnormal behaviour like stereotypical pecking behaviour towards objects such as walls, empty feed systems, empty water systems and other parts in the house, sometimes in combination with excessive water intake (spoiling) is observed (Savory and Kostal, 1996; de Jong et al., 2002). The discrepancy between a healthy and reproductive life and impaired behaviour and welfare is known as 'the broiler breeder paradox' (Decuypere et al., 2010). In other words, feeding broiler breeders ad libitum has negative consequences for health, welfare, and production, but on the other hand, feed restriction has negative effects on behaviour and welfare. EFSA (2010), however, states that insufficient research has been done in this field to conclude whether feed restriction impairs the welfare of broiler breeders.

Given the aforementioned challenges, managing broiler breeders is very challenging, particularly with the ongoing genetic alterations in both broilers and their parent stock. State of the art management for nutrition,

housing, equipment, and health are necessary to optimize reproduction of breeders for a maximum number of healthy offspring. Besides these mentioned factors, diet composition and feeding strategies are important factors to reach this goal. Therefore, this paper describes the state of the art scientific knowledge on nutrition in broiler breeders.

Feeding programmes – rearing phase

During the rearing phase, feed provision occurs either daily or through various feeding programs incorporating feed-less days (EFSA, 2010). These programs may adopt skip-a-day (alternating between feeding and fasting days), 6/1, 5/2, or 4/3 feeding regimens (indicating 1, 2, or 3 days without feed per week, with higher feed portions on feeding days). In Europe, legislative restrictions prohibit feeding programs with feed-less days, leading most farmers to adopt daily feeding systems. Conversely, in North America, feeding programs with feed-less days remain prevalent (de Jong and van Emous, 2017). The rationale behind employing feeding programs revolves around achieving uniform body weight in feed-restricted pullets (Leeson and Summers, 2009). Pullets typically receive between 25 to 33% of the feed quantity compared to ad libitum-fed counterparts (de Jong et al., 2002), with the most severe feed restriction observed between 6 and 16 weeks of age (de Jong and Jones, 2006). This regimen necessitates a feed cleanup window of 15 to 30 minutes in daily-fed birds, potentially leading to heightened competition and aggressive behaviour during feeding (de Jong et al., 2002), particularly in instances of inadequate feeder space and slow feed distribution (de Jong and Swalander, 2013).

Modern pullet housing facilities are outfitted with adequate feeder space and rapid chain feeders (up to 30 m per minute or more) or pan feeders, ensuring uniform feed distribution within three minutes across the entire rearing house (Aviagen, 2018; Cobb, 2018). Additional management measures such as elevating the feeder system during filling or conducting feed system filling in darkness further enhance feed distribution (Abad, 2020).

Research indicates that daily-fed pullets experience lower stress levels compared to those on skip-a-day feeding programs, as evidenced by reduced plasma levels of corticosterone and insulin-like factors (Ekmay et al., 2010). Moreover, daily feeding demonstrates 5 to 10% greater efficiency in terms of feed intake for achieving target weight at the end of the rearing period compared to feeding programs (Vaughters et al., 1987; Bennett and Leeson, 1989; de Beer and Coon, 2007; Montiel, 2016). This disparity in efficiency arises from the necessity for birds on feeding programs to store nutrients (such as fat and protein) on feeding days for utilization during feed-less days, a process that is not 100% efficient and results in decreased efficiency and higher feed requirements (de Beer and Coon, 2007; Leeson and Summers, 2009). De Beer and Coon (2007) compared four feeding programs (skip-a-day, 4/3, 5/2, and daily) and found that breeder pullets fed daily during rearing consumed 8% less feed to achieve the same body weight with comparable uniformity. Improved feed efficiency and comparable uniformity were observed with daily feeding (Zuidhof et al., 2015). During the laying phase, De Beer and Coon (2007) noted earlier peak egg production and higher settable egg production in pullets fed daily compared to those on feeding programs. Additionally, Montiel (2016) reported a 9% decrease in feed allowance during rearing with daily feeding compared to skip-a-day feeding.

In contrast to feeding programs with feed-less days, van Emous et al. (2021) investigated feeding once or twice a day in combination with control and diluted diets. Pullets fed twice a day exhibited lower body weight coefficient of variation (indicative of higher body weight uniformity) at 10 weeks of age, although no significant effect was observed at 20 weeks of age. Furthermore, pullets fed twice a day tended to display earlier onset of lay, higher total egg production at 30 weeks of age, and improved fertility.

Twice-a-day feeding / split feeding – laying phase

Despite efforts to increase calcium levels in the breeder diet and supplement with additional calcium sources such as oyster shell or large limestone, eggshell quality has declined (Leeson and Summers, 2009). This decline can be attributed to the feeding regimen practiced in breeders, wherein a limited feed allowance is provided in the morning and consumed within 2 to 6 hours (Ronald and Farmer, 1984; Backhouse and Gous, 2005). This practice fails to adequately meet the optimal nutrient requirements for egg production (Backhouse and Gous, 2006). The

majority of egg laying in females occurs in the morning, typically between two and seven hours after lights-on (Zakaria and Omar, 2013). Following ovulation, albumen formation takes place over the subsequent six hours, necessitating protein, followed by eggshell formation over the ensuing 18 hours, primarily requiring calcium (Leeson and Summers, 2005). Feeding breeders twice a day may enhance the availability of nutrients during egg and eggshell formation, potentially resulting in improved eggshell quality (Backhouse and Gous, 2006). Various studies have also shown that broiler breeder hens fed twice a day produced more eggs compared to those fed once a day (e.g. Moradi et al., 2013; Soltanmoradi et al., 2014). However, contradictory findings have been reported by other authors (de Avila et al., 2003; Backhouse and Gous, 2005; Londero et al., 2015, 2016).

Feeding specially formulated morning and afternoon diets, known as 'split feeding,' can help meet the varied nutritional requirements during egg formation in both layers (de Los Mozos and Sanchez, 2014; Molnár et al., 2018) and breeders (Anonymous, 2021; van Emous and Mens, 2021; van Emous, 2023). De Los Mozos and Sanchez (2014) investigated split feeding in older laying hens (aged between 95 and 98 weeks) and observed higher eggshell weight, thicker eggshell, and a 30% reduction in cracked and shell-less eggs. A study by Anonymous (2021) reported higher chick production (+1.9 DOC/hh) in breeders fed via split feeding, along with 9% lower feed costs and improved feather cover due to reduced pecking. In the study by van Emous and Mens (2021), it was concluded that twice-a-day feeding (with the same diets) improved behaviour, while split feeding improved both egg production and behaviour in broiler breeders. However, no significant effects were observed on eggshell quality and incubation traits. In the second study of van Emous (2023) a tendency to higher egg production was observed between 45 and 65 week of age. They also found a lower water intake and water-to-feed ratio and a higher activity at the end of the day what potential can improve hatching egg fertility.

Unrestricted access to water

Unrestricted access to water can lead to over drinking in restricted-fed broiler breeders, potentially resulting in wet litter and, in severe cases, polydipsia (Hocking et al., 1993). Maintaining high-quality litter is crucial for optimal foot health in pullets and breeders (Kaukonen et al., 2016), as well as for preventing nest and egg contamination (EFSA, 2010). Hence, water restriction is commonly implemented in most broiler breeder facilities (both rearing and breeding farms) through either a fixed water-to-feed ratio or a predetermined duration of water access during the day (de Jong et al., 2016). A water-to-feed ratio of approximately 1.8 is typically recommended under commercial conditions, with adjustments based on house temperature (Aviagen-EPI, 2017; Cobb, 2018; Hubbard, 2015). When employing the fixed-hours-of-water method, farmers often close off access to water two hours after the cleanup time (R. van Oosten, 2020, personal communication). During hot days (above 25°C), many breeder farmers provide birds with an additional period of water access in the late afternoon, typically ranging from 30 minutes to 1 hour. Regardless of the method of water restriction, daily crop assessment of at least 20 birds per house is recommended a few hours after feeding to monitor crop firmness throughout the bird's lifecycle (Aviagen, 2018; Cobb, 2018).

Experts suggest that water restriction may have negative implications for breeder welfare (de Jong et al., 2016). However, the sole experiment conducted on water restriction in breeders did not observe any adverse effects on welfare indicators (Hocking et al., 1993). In a study by van Emous et al. (2021), breeder pullets were provided with access to water for 7¼ hours per day, resulting in an average water-to-feed ratio of 2.3. The stocking density in the experiment was slightly lower (8 vs. 10 birds/m^2) than common practice. Interestingly, the study found that increased water intake did not necessarily lead to wet litter, a finding supported by several studies conducted by Aviagen at their research facilities in the Netherlands (J. Lesuisse, 2020, personal communication). In previous studies reporting over drinking and litter problems, open water systems were often used, sometimes in conjunction with much longer access periods (up to 14 hours) due to extended day length (Kostal et al., 1992; Savory et al., 1993; Hocking et al., 1996, 2001). However, over drinking behaviour was not observed in the study by van Emous et al. (2021), leading to the speculation that this could be attributed to the use of nipple drinkers and the shorter duration of water access.

In the aforementioned study by van Emous et al. (2021), half of the pullets were fed control diets, while the

other half received diets diluted to an average of 16%. Surprisingly, no difference in water intake was observed between the two treatments, resulting in a lower water-to-feed ratio for pullets fed diluted diets. The authors hypothesized that water intake may be limited by the capacity of the crop (Wehner and Harrold, 1982) rather than solely by the amount of feed consumed. Overall, it is concluded that severe water restriction may not be necessary when pullets have extended access to water and exhibit calm water intake behaviour. It has been previously proposed that 'over-drinkers' may not inherently possess this behaviour but may develop it over time (O. van Tuijl, 2018, personal communication).

Importantly, the pattern of water intake can evolve during the first 10 weeks of laying due to reduced severity of feed restriction (J. Lemmens, 2020, personal communication). Birds in practical conditions tend to prioritize rapid feeding followed by quick drinking to avoid running out of feed and water, respectively. This behaviour is also observed in the production house during the initial approximately five weeks, after which feed allowance increases rapidly to approximately 90% of the maximum daily amount (Aviagen, 2018). This results in a peak in water intake one to two hours after feed distribution, underscoring the importance of calculating water system capacity to accommodate peak demand. Failure to do so may result in insufficient water availability at the rear of the breeder house and uneven water distribution across the flock.

Male to female ratio

Breeder companies recommend starting the production period with 8 to 11% males (Aviagen, 2018, Cobb, 2018). Moreover, it is recommended by Cobb (2018) to use a male-to-female ratio of 8 to 9% in houses with slats, and 9 to 10% in houses without slats. Male percentage, however, decreases during the laying phase due to grading (e.g. leg problems, BW loss) and mortality (de Jong and van Emous, 2017). Around 24 weeks of age mostly 9% good developed and active males are necessary for good initial fertility, resulting in 8 to 8.5% first-grade males around 30 weeks of age (Aviagen, 2018, Cobb, 2018). When males show aggressive and dominant behaviour, male-to-female ratio must be reduced to 5% and the 3 to 4% in a separated male compartment (van Emous et al., 2020; Cobb, 2018). About 15 to 25% of the males are graded during the laying phase and replaced by so called 'spiking' males (Casanovas, 2000, 2002). From 40 to 45 weeks of age, spiking of mature young males (around 25 weeks of age) is often applied. Spiking is replacing of approx. 1 to 2% inactive males by mature young males, which is commonly applied in practice to maintain fertility of hatching eggs (Leeson and Summers, 2009). Spiking males however, involves the risk of introduction of pathogens and it may be stressful to the birds because male aggression may increase (EFSA, 2010). Sometimes intra-spiking (swapping older males at the same farm from one house to the next) is used as a method to increase male activity and thus fertility, which has a much lower biosecurity risk (Casanovas, 2000).

The last decade, research in the Netherlands focussed on adjusted male and female management to influence and improve mating behaviour in breeders (van Emous, 2010; van Emous and Gunnink, 2011; van Emous, 2020). A decade ago, an innovative housing system for broiler breeders, called the Quality Time® (QT 1.0), has been developed (van Emous, 2010). After a successful pilot experiment, two on-farm experiments were carried out in a commercial broiler breeder house with 15,000 birds. Males were separated from females during five hours per day, using a sex separate feeding system and a vertical moving fence lengthwise the house. In the QT compartments more voluntary and successful matings were observed which resulted in an improved feather cover between 37 and 48 weeks of age (van Emous and Gunnink, 2011). Separating males from females did not increase aggressive behaviour between the males (van Emous, 2010). In the first flock no effect on fertility was found, however in the second flock average fertility was improved with 1.5%. The first version (QT 1.0) was followed by an on-farm experiment (QT 2.0) with 9,900 breeders with a separated male compartment at the rear of the house (R.A. van Emous, unpublished data). It was concluded that this system results in a very good separation of the females (less than 0.1% females in the male compartment) and increased hatchability with approx. 2%. An additional advantage of the QT house is that males can be easily locked up in the male pen during the first two to three weeks after transfer for excellent separated sex feeding. Besides this, grading of low quality males is much easier when sexes are separated and depletion at end of lay is easier (van Emous, 2010).

An experiment was carried out to study the effects of the Quality Time 3.0 or so called 'skip-a-day male-female contact' system (van Emous, 2020). In this system, males and females were mixed every other day followed by a day without mixing. The study showed that skip-a-day male-female contact gives hardly any effects on reproduction results and behaviour. However, when this system is applicable in practice, it gives a 5 to 10% higher economical result due to the higher number of females and lower number of males.

Despite of spiking, the overall male percentage declined roughly from 9% at the start to 7% males at the end of the laying phase (van Emous, 2010). From an objective perspective, this is a surprisingly method because physical and physiological characteristics of the breeder males are also decreasing (van Emous, 2010). Research showed that mating activity (Duncan et al., 1990; Cassonovas, 2000), percentage of successful matings (Duncan et al., 1990), ejaculates quality (e.g. Casanovas, 2002; Zhang et al., 1999), sperm penetration ability (e.g. Bramwell et al., 1996) and testicular size (Sarabia Fragoso et al., 2013) decreased as males are aging.

Therefore, an adjusted male to female ratio management is suggested by van Emous (2010). Starting with a low male to female ratio (4-5%) and increase this by 3 times spiking to around 8% at 50 weeks of age. He advised to transfer 8 to 9% male to female ratio to the breeder farm and place 4% in a separated male house and use these males as reserve males and place them in a four to five week period in the main flock after 30 weeks of age. Recently, an on-farm experiment in a Veranda cage system was performed to investigate the effect of two different male to female ratios. In two cages, breeders are kept with a decreasing male to female ratio (from 7.2% to 6.4%) and in two cages the experiment started with 4% males which increased three times: 5% at 30, 6% at 40 and 7% at 50 weeks of age by adding spiking males. The results shows no difference in general behaviour, however feather cover and mating behaviour was improved in cages with the adjusted male to female ratio (R.A. van Emous, unpublished data). Moreover, fertility and hatchability was approx. 3% higher from 49 weeks of age onwards in the cages with increased male to female ratio.

Conclusion

Poultry meat serves as a paramount protein source in the human diet, with its global demand witnessing annual growth. Broiler breeders, the parent stock of broilers, wield significant influence over the poultry meat supply chain by yielding premium hatching eggs and robust chicks. However, this task is progressively daunting due to the relentless rise in the genetic growth potential of both offspring and parent stock. To optimize breeder reproduction and ensure the highest number of healthy offspring, advanced management practices encompassing housing, equipment, and health are indispensable.

Contrary to expectations, implementing a twice-daily feeding regimen for breeder pullets has shown potential to enhance body weight uniformity. Nevertheless, the development of a novel system for optimal feed distribution is necessary to fully realize its benefits. In several EU countries, feeding on the litter is commonly practiced in rearing farms due to its associated advantages, including reduced clean-up time, improved litter quality, fewer leg issues, and enhanced body weight uniformity.

During the laying phase, adopting a regimen of feeding twice daily or splitting feedings (particularly morning and afternoon diets) has demonstrated benefits in terms of egg production, behaviour, and egg fertility. It's noteworthy that water stands as the most crucial nutrient, with unrestricted access playing a pivotal role in behaviour, welfare, reproduction, and overall health.

Male-to-female ratio is a key factor to maximizing egg fertility and hatchability.

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Effects of Plumage Quality on Egg Production, Sperm Penetration, Fertility Rate and Hatchability in Broiler Parent Hens

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In this study, the effects of feather scores of broiler parent hens on egg production, sperm penetration, fertility rate and hatchability were investigated. A total of 225 hens with the same body weight were taken from a flock of 4000 hens at the age of 45 weeks, reared in a commercial house. On the same day, each body part of each hen, including head, neck, breast, back, wing and tail, was scored (1-4 points). The average plumage quality of the hens were calculated and divided into 3 group: 1.79 (min1.33-max2.00), 2.26 (min2.01-max2.67) and 3.10 (min2.68-max3.83) in the Featherless (FS), Medium Feathered (MF) and Full Feathered (FF) groups, respectively. After, hens were placed in individual cages and monitored for 14 days. The eggs of 75 hens (same score as total) were broken for 9 days and sperm penetration numbers were determined microscopically, while the eggs obtained from 150 hens were incubated weekly and did not hatching eggs were also examined macroscopically. A total of 2836 eggs were used to determine the averages. When the study results are examined FS, MF and FF groups, 1-7 d; 8-14 d and total egg yields were calculated as 72.3, 76.5 and 76.9% ($p<0.05$); 73.6, 75.2, 76.7% ($p>0.05$) and 72.9, 75.8 and 76.8 ($p<0.05$), respectively. 1-7 d; 8-14 d and total fertility rates were determined as 88.5, 94.0 and 95.2%; 49.8, 51.0 and 63.5% and 69.1, 72.9 and 79.7% in the same order ($p<0.05$). The average numbers for sperm penetration according to groups were determined as 70.9, 55.9 and 39.1, respectively ($p<0.05$). In FS, sperm penetration and fertility rates from day 1 to day 9 were detected between 214-17 and 93-68%; 149-11 and 94-62% in MF and 93-23 and 100-80% in FF, respectively. In terms of hatchability, the averages were found to be 74.9, 73.6 and 72.23% ($p>0.05$) and 45.5, 51.8 and 50.5% ($p<0.05$) in the first and second incubation, respectively. While there was no difference between embryo deaths in the first incubation, in the second incubation, early; middle and late stage embryo mortality rates were determined as 9.8, 6.1 and 17.9%; 1.1, 0.0 and 0.0% and 4.7, 4.6 and 1.8% ($p<0.05$). When the findings were examined, it was determined that as featheriness increased, egg production increased and the fertility rates of FF were higher. While higher sperm penetration numbers were detected in the eggs of FS in the first days, it was determined that this number decreased rapidly day by day, reducing the fertility rate. But, maintained a high level of fertility for a longer time as closer sperm penetration numbers in FF. While the lowest value in terms of hatchability was in FS, the highest early embryo death rate and the lowest late death rate were detected in FF. As a result, feather score can be used as an indicator in n terms of egg production. It has been determined that sperm is stored better in the sperm storage tubules of FF hens, sperm is released from there in a more balanced manner, and as a result, they have higher fertility rates.

Keywords: Feather score; egg production; sperm penetration; fertility; embryo death; hatchability

Animal Welfare Level of Slow and Fast Growing Broiler Chickens

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By means of the improvement of animal breeding and environmental conditions in broiler chickens, slaughter age is now reached within 5-6 weeks. However, with rapid growth at this level, some metabolic problems and deteriorations in some parameters related to animal welfare arise. This study was conducted to compare the animal welfare levels of slow and fast growing broiler chickens reared on a slatted floor. In the study, 70 fast-growing (Ross 308) and 70 slow-growing (Hubbard JA57) genotypes were used. Animals were raised on a plastic slatted floor for a total of 6 weeks. At the end of the production period, animal welfare parameters were measured by scoring Foot Pad Dermatitis, Hock Joint Dermatitis, Breast and Abdomen Feather Cover Level, Breast and Abdomen Dirtiness Level, and Gait. The results obtained at the end of the measurement were compared with the Mann-Whitney-U Test. In statistical analysis, SPSS 23.0 package program was used. Among the parameters examined, the difference between the groups in terms of all parameters except Foot Pad Dermatitis was found to be significant at the 0.05 level. In terms of Hock Joint Dermatitis, Breast Dirtiness, Breast Plumage and Gait scores, better results were obtained from slow-growing genotypes.

Keywords: Broiler; growth; housing; welfare

Effects of Different Feeding Strategies on Performance, Carcass Parameters, Digestive Tract and Meat Quality in Native Turkish Geese

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This study was conducted to determine the effects of different feeding methods on fattening performance, carcass characteristics, digestive tract development and meat quality in domestic geese. The study was carried out with 180 1day old domestic geese (mixed male-femaleThe experiment was conducted in a 2x3 factorial design and the animals were randomly divided into two groups, the first group was given starter diets prepared according to their nutrient needs for 4 weeks and the second group for 6 weeks. At the end of the starter periods (day 28 and day 42), 90 animals (45 animals for each group) were selected and randomly distributed into 3 subgroups. The first sub-group was fed with grazing, the second sub-group was fed with growth ration in addition to grazing and the third sub-group was fed with growth ration only. Each subgroup was divided into three replicates and each replicate was set to contain 5 animals. Animals were fed until 10 weeks of age and slaughtered at 70 days of age and evaluated for performance, carcass parameters, digestive tract weights and intestinal lengths, pH, leaching water loss, cooking water loss and color analysis of breast and thigh meat and liver enzyme parameters were evaluated. When the overall data of the experiment were analyzed, the effect of age group was not significant ($P>0.05$) in terms of performance, but the effect of feeding method was significant ($P<0.05$) in terms of body weight (BW) and feed conversion ratio (FCR), and the best values in terms of these two traits were observed in the concentrated feed group. While no direct effect of age group was observed, age X feeding system interaction was found to have a significant effect on both BW and FCR ($P<0.05$). In terms of slaughter and carcass parameters, it was determined that age had an effect only on liver weight ($P<0.05$). It was observed that feeding system influenced all parameters except feather amount and the result was generally in favor of concentrate feed ($P<0.05$). In terms of meat quality characteristics, it was observed that breast meat color was affected by both age, feeding system and their interactions, while this interaction was not significant for thigh meat. No statistically significant effect of treatment groups on brisket pH was observed ($P>0.05$), while a significant effect of feeding system was observed on thigh meat pH ($P<0.05$). While the effect of feeding pattern was observed on leaching and cooking water losses in breast meat, this effect was observed only on cooking loss in rump meat ($P<0.05$). The effect of feeding model on jejunum, ileum and total small intestine lengths was significant ($P<0.05$) and the highest values were observed in the grazing group; a similar effect was observed in jejunum and secum weights; the effect of feeding model on almost all relative intestinal weights was significant ($P<0.05$). There was no effect of treatment groups on liver enzyme activity ($P>0.05$).

Keywords: Goose; performance; digestive tract; meat quality

Interspiking Technics and Hatchery Results in Broiler Breeders

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The introduction of new male broiler breeders into a flock is known as “spiking.” The flock fertility naturally declines in broiler breeders. However, this can be compensated by the implementation of effective spiking program. The study was designed to examine how varying levels of single and double inter-spiking affects the fertility and hatchability in same age broiler breeders in the same house. The study included 4224 (3840 females and 384 males) Ross 308 broiler breeders and flock was monitored from 28 to 59 weeks of age throughout the experiment. The trial part of the commercial broiler breeder house was divided into eight equal compartments each containing randomly 480 females and 48 males. The single inter-spiking was introduced at 45 weeks and double inter-spiking was introduced at 53 weeks of age, by replacing the males with the ratios of 75%, 50%, and 25%. For the hatchery parameters a total of 12,000 eggs were used in each age period. Eggs were incubated at 37.7 °C, 50–55% RH for 18 day and then transferred to hatcher for incubated at 36.6 °C and 60% RH until hatch. In the study, for the single inter-spiking program; the interaction between age and spiking ratio on fertility and hatchability was found to be statistically significant ($P<0.0001$). In case of double inter-spiking program, the interaction between age and spiking ratio on fertility and hatchability was found to be statistically significant ($P<0.01$). It is recommended to implement inter-spiking program in broiler breeders when the herd management is inadequate and fertility and hatchability parameters are low.

Keywords: Spiking; broiler breeders; fertility; hatchability

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SESSION 5

Poultry Health and Biosecurity

Current Viral Infections of Chickens in Türkiye: Solution Suggestions

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In this talk, the most frequently observed viral infections of chickens in Türkiye, which cause significant losses and problems, will be introduced and evaluated based on current literature and our data. After this general introduction and data analysis, possible sources of the problems, and solution suggestions will be discussed. When an evaluation is made by looking at the serological (ELISA; Enzyme Linked Immunosorbent Assay) and virological (Genome detection and gene sequencing) data obtained from samples taken from the broiler breeders and commercial broilers we have, we could say that the most important losses in chickens, and therefore the most important productivity losses in poultry farming, are primarily caused by five important viral infections. We can list the agents of these infections as Avian Coronavirus Infectious Bronchitis Virus (IBV), Avian Avulavirus-1 (Newcastle Disease Virus; NDV), Avian Influenza Virus (AIV), Infectious Bursal Disease Virus (IBDV) and Fowl Adenovirus (FAdV). IBV is an avian coronavirus, and exists on all continents of the world. Although its only host is chickens, its control through vaccination has become difficult due to immunologically non-logical control strategies. The protective antigenic epitopes of IBV is primarily found in the S1 protein. IBVs have 7 genotypes, and 36 genetic lineages. NDV is a virus, which can cause infection in almost all bird species, its meso/velogenic pathotypes cause significant losses in chickens, and it has 2 classes, 18 genotypes and 33 sub-genotypes. Protective antigenic structures of NDV are F and HN structures. ND is a notifiable disease. Another notifiable disease is 'Avian Plague' caused by AIVs H5 and H7 (Highly Pathogenic AIVs). The protective antigens of AIVs are H proteins. LPAIV (Low Pathogenic AIVs) infections are widespread in poultry all over the world. Apart from these three primary respiratory tract infections (IBV, NDV and AIV), IBDV infection, one of other two infections frequently observed in Türkiye, is the most powerful immunosuppressive and lethal birnavirus infection in the world. Protection from IBDV infection is related to VP2 protein. Different pathotypes and variants of this virus cause problems all over the world, despite vaccinations. The fifth current infection in Türkiye, which is observed as a problem in broilers and broiler breeders is due to FAdVs. The protective proteins of FADVs are hexon proteins, and genotypes of the virus are determined using this structure.

As with all infectious diseases, the path to be followed in the fight against or management of these five infections in chickens in our country is based on good establishment and supervision of biosecurity concept in the companies. Apart from the structural part within the biosecurity concept, supervision of the success of operational or applied biosecurity should be carried out by the companies by the use of epidemiological studies. In this context, characterization of the infectious agents causing the diseases, determination of the prevalence of the infectious disease, as well as the transmission routes of the agents and evaluation of the immunological potential of the flocks would guide poultry companies to design their specific vaccination strategies, and determination of the types of vaccine viruses.

The strategies mentioned above are only possible with accurate epidemiological testing approaches. In other words, it is necessary to know that correct results will be obtained with the correct laboratory tests, and to know where each test will be performed more appropriately. These five viral infections in the field, which continue to constitute a significant portion of the economic losses of businesses, is related to: (1) inappropriate implementation of epidemiological testing strategies, (2) insufficient application and evaluation of vaccination, and (3) irrational other biosecurity procedures. Sustainable management to minimize these viral infections in the companies is only possible with fundamentally applied and tested control and protection strategies, from breeder stocks to commercial productions, and monitoring of the outcomes with the most appropriate tests.

In recent years, both vaccine production technologies, and diagnostic methods have shown extraordinary progress in a highly qualified manner with the opportunities provided by modern genetic methods. For example, while the commercialization of biotechnological vaccines enabled flocks to reach immunological protection thresholds much more quickly through vaccinations, molecular diagnostic methods have paved the way for them to become ultrasensitive and rapid, easily evaluated with bioinformatic applications. On the other hand, immunologically

meaningful evaluation of the strategies of existing conventional inactivated, and live vaccines is a critical issue in terms of obtaining appropriate protective protection. Therefore, feasible use of existing conventional vaccines, modern vaccines and genetic diagnosis methods in the poultry industry has brought scientific convenience to the control of all infectious diseases, and enabled companies to maximize their profitability. At the end of this speech, critical modern infectious disease control and protection strategies for poultry companies will be discussed and I believe that the results will be guiding for the sector.

Keywords: Chicken; viral infection; vaccination; molecular methods; epidemiology

Butyric Acid and Medium-Chain Fatty Acids Improve Vaccine Efficacy in Broiler Chickens by Modulating the Adaptive Immune System

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Medium chain fatty acids (MCFAs) and butyric acid may contribute to better disease resistance of broiler chickens by modulating immune cells, thereby leading to increased vaccine efficacy. To check our hypothesis, first we tested immunomodulatory effects of a specific blend of butyric acid and MCFA (C-prove 80) on primary cultured peripheral blood mononuclear cells (PBMCs). PBMCs were isolated according to Larsberg et al. (2021) and seeded in RPMI with 5% of the test component. Flow cytometry analyses showed an increase in cytotoxic T cells after treatment with C-prove 80. Activation by CD25-FITC fluorescence and proliferation was measured with a Incucyte S3 live cell imaging device. Treatment with C-prove 80 led to a higher proliferation capacity and an increased activation rate of PBMCs. Thus, a faster and more efficient immune response towards infectious diseases could be assumed. Next, we investigated whether the observed immunomodulatory effects could result in an induced vaccination efficiency against Newcastle Disease virus (NDV) and Infectious Bursal Disease virus (IBDV) in broiler chickens. A total of 380 male Ross 308 birds was used for this study and divided in two treatment groups, each consisting of 10 repetitions of 19 birds. Animals received drinking water and a standard commercial feed ad libitum throughout the entire study. Birds were vaccinated against NDV (Clone 30) and IBDV (Bursa Plus) on D7, respectively D17. C-prove 80 was added to the drinking water of half the birds (T02) at 1L/1000L (corresponding to 265 ppm acids) from D0-D10 and D18-D21, while chickens from group T01 received unsupplemented water. On D34 the humoral immune response against IBV was quantified with ELISA by taking 2 blood samples per pen. IBDV antibody titers were significantly ($p < 0.05$) increased in birds receiving C-prove 80 in the drinking water (9176 vs 7814), while NDV titers were only increased numerically (4155 vs 1948). To conclude, this study shows that adding a combination of butyric acid and MCFA in the drinking water of broilers may induce vaccine efficiency through an immunomodulatory effect on lymphocytes. An increased cytotoxic T cell count may further increase the bird's disease resistance through an increased clearance capacity of virus-infected cells. We hypothesize that these effects are mediated through a direct binding and activation of free fatty acid receptor 2 (FFAR2) - known to be expressed on PBMCs - as we observed in a receptor activation assay using HEK293 cells.

Keywords: Butyric acid; medium chain fatty acids; broiler chicken; PBMC; vaccination

Protective Effect of Pomegranate Peel Powder Against Fatty Liver Syndrome in Laying Hens

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The project aimed to determine the effects of pomegranate peel powder added to laying hen feeds as a protective against fatty liver on some performance, egg quality characteristics, blood and liver parameters. For this purpose, a total of 216 ATAK-S hybrid Brown egg chickens, 24 weeks old, located in the Poultry Research Institute Directorate, were used as animal material. The trial was conducted for 38 weeks. Study groups: It was formed as a group of 1: control group; 2: 1% pomegranate peel powder (PPP) group, 3: 2% PPP group, 4: 4% PPP group. In our study, pomegranate peel powder did not have a negative effect on live weight gain. There was less live weight gain in the groups fed with PPP added feeds compared to the group without PPP added to the diet. The lowest live weight gain was in the group supplemented with 4% PPP. Feed consumption, feed utilization and egg production values improved in the groups receiving pomegranate peel. Feed consumption and feed conversion values were evaluated as the best in the 2% PPP group. In addition, adding increasing amounts of pomegranate peel to the diet increased egg production in the same way. In our study, when the internal and external quality characteristics of the eggs were evaluated in general, positive results were obtained in terms of yolk index, shell thickness and shell breakage resistance, especially in the group adding 4% pomegranate peel powder. More egg yolk weight was detected in the groups to which pomegranate peel powder was added than in the control group. According to the results of the biochemical analyses, a decrease in glucose level, ALT and ALP enzyme activities, and an increase in SOD enzyme activity were detected in the 1% PPP group. A decrease in glucose level, AST enzyme activity and MDA level was detected in the 2% PPP group. In the comparisons made between the groups that included pomegranate peel and the control group, no differences were found in terms of cholesterol, triglyceride, albumin and total protein. In general, pomegranate peel caused a decrease in liver enzyme activities and an increase in SOD and GPx enzyme activities. A decrease in relative abdominal fat weight was determined in direct proportion to the amount of PPP added. There was less loss in relative liver weight in the group that participated in 4% PPP compared to the other groups. In addition, according to histopathological evaluations, less fat was detected in the group that added 4% pomegranate peel. Biochemical parameters and pathological findings are in harmony with each other. The results of the evaluations showed that it is appropriate to add 4% PPP to the diet as a hepatoprotective and performance enhancing product. New studies are needed to better understand the bioavailability of pomegranate fruit and pomegranate by-products.

Keywords: Pomegranate; antioxidant; poultry; biochemistry; histopatology

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SESSION 6

Genetics and Breeding Strategies for Sustainable Poultry Production

Reviewing the Achievements of Broiler Breeding for Rapid Growth, and the Genetic Mitigation of Negative Consequences

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Since the 1950s, higher growth rate has been the main broiler breeding objective, being essential for efficient meat production, due to better utilization of feed, facilities and labor. The breeding for more rapid growth has been very successful, with broilers growing faster and faster every year, continuously reaching higher body weights at earlier ages.

Over the years, several growth-related 'defects' have emerged, related to the continuously increasing growth rate of broilers. Most important among them were excessive fat deposition, leg problems, and ascites. Due to their association with elevated growth rate, initially each defect was considered a biological limit to selection for further higher growth rate. Therefore when the elevating prevalence and severity of these rapid-growth related defects started to reduce the overall economic efficiency of broiler meat production, growth-reducing diets had been suggested by the breeding companies to mitigate the negative effects of the emerging defects.

Eventually it has been shown that the tendency to develop these defects are heritable, and although rapid growth is required for the defect's expression, genetically it is independent of growth rate. Thus, identification of the genotypes prone to develop each defect allowed the breeding companies to select against it, while continuing to select for more rapid growth rate, along with other economically-important traits.

In recent years, new defects - breast muscle myopathies - have been showing up: White Stripes (WS, first reported in 2007), Wooden Breast (WB, 2011), and Spaghetti Meat (SM, 2015). As with earlier defects, the emergence of these breast muscle myopathies were considered by many as indications of a biological limit to further selection for fast-growing and high-yield broilers. Consequently, the use of growth-reducing management strategies (i.e., lower-density diets) and slow-growing breeds, have been suggested to reduce the prevalence and severity of the breast muscle myopathies.

However, upon the emergence of each myopathy, broiler breeders have amended their programs with selection against the tendency to develop it. Indeed, the prevalence and severity of WS has been decreasing and currently it is very rare. Similarly, a decline is observed in the prevalence and severity of WB, with low incidence and low severity, and only among males reared to high body weights.

It appears that the prevalence and severity of Spaghetti Meat (SM) are not declining yet. In part this could be attributed to the later emergence of SM compared to WS and WB. Moreover, the different biological nature of SM compare to WB further complicates management and genetic mitigation of this defect. Whereas the prevalence and severity of WB clearly increase with higher body weight and higher breast yield (hence rarely found in females), the prevalence and severity of SM are higher in females than in males, and within sex they are only lowly associated with body weight and breast size.

Moreover, the WB phenotypes observed at the slaughterhouse are those developed in the broilers during rearing, and they can be detected on live broilers. In contrast, although also SM develops in 'high-tendency' broilers during their rearing, it cannot (so far…) be measured or assessed on live broilers. The SM observed in the slaughterhouses -- where this myopathy cause significant economic losses due to downgraded breast meat quality -- reflect not only the inherent tendency of each broiler, but also random or non-random effects of processing. Full comprehension of the processing effects, mainly defeathering, can reduce the prevalence and severity of SM in commercial broiler operations at present and in the near future. For the long run, the breeding companies are expected to develop tools for accurate phenotyping the inherent tendency of broilers to develop SM. Such tools are expected to lead to a successful genetic reduction in SM, similar to the already observed reduction in WS and WB.

Finally, the observed and expected genetically reduced prevalence and severity of breast muscle myopathies indicate that the breeding of fast-growing high-yielding broilers has not reached yet a biological limit.

Keywords: Broilers rapid growth; genetics and breeding; breast muscle myopathies; spaghetti meat; defeathering

Genetic Diversity and Sustainability

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Sustainability is a complex concept which has various definitions. Here, it will be defined as a social goal for people to co-exist on Earth now and in the future. The challenge is to manage short term and long term objectives, for example ensure short-term profitability without exhaust natural resources that are needed on the long term to maintain good conditions for human life on Earth. In short, the aim is to keep options available for future generations and not to limit their choices from now on.

Actually, genetic diversity exhibits similar issues: intense selection is decreasing genetic variability whereas genetic variability is needed for future selection. So, managing short term and long term objectives is a key issue for sustainable breeding. Furthermore, breeding objectives have to take into account societal demands as well as environmental constraints, which may exhibit some paradox. For instance, free range housing is considered to be good for animal welfare in western societies but leads to higher green-house-gas emissions because of lower feed efficiency. Sustainability requires to manage trade-offs, which also applies to manage genetic diversity for sustainable breeding.

Genetic diversity can be described by several indicators to assess diversity between breeds or lines or within a breed or a line. Both components are important to get a full picture of the genetic diversity of a species such as the chicken. The main indicators will be reviewed with a focus on molecular data which can be routinely produced thanks to the use of SNP panels, up to the obtention of the whole genome sequence. SNP panels make possible to compare populations on a standard set of molecular markers, but whole genome sequence makes possible to discover new variants which may be specific to a breed and become important for future breeding objectives. Molecular markers also make possible to assess inbreeding without any pedigree information, which is very useful for local breeds. The use of Runs of Homozygosity (RoHs) is a powerful tool to distinguish ancient from recent inbreeding and take appropriate management decisions of the breed.

In order to mitigate the loss of diversity generated by selection, one can think of the ‘avoid-reduce-compensate’ approach proposed for the preservation of biodiversity in environmental policies.

Loss of diversity within a population corresponds to increased inbreeding. Avoiding inbreeding depends on population size and on selection intensity. The onset of genomic selection has increased the efficiency of selection and accelerated genetic progress, as well as the loss of genetic diversity at the same time. The situation is different in local breeds where there are simple methods to avoid inbreeding for a number of generations provided that population size is not too small.

At some stage of a breeding program it becomes impossible to avoid inbreeding, then the next step is to limit its increase and there are methods designed for that aim : maintain a number of breeding families, take into account inbreeding in the process of ranking candidates to selection, as performed for example with the optimal contribution selection (OCS) method that can be implemented with routine programs. Yet, genetic diversity will decrease, more slowly than without OCS, but it will.

The last step is to compensate for the loss of diversity, by keeping germplasm in gene banks, through frozen semen or primordial germ cells. This makes possible to preserve those genotypes which are not needed at a certain time and would become useful again for future production systems. There are no published example of such a re-use in chickens, but there is one in cattle (Jacques et al., Genet.Sel.Evol, 2023). Yet, cryopreservation methods in birds are not yet fully operational, so that keeping live populations is still recommended to avoid loosing original genotypes.

Another way to compensate for the loss would be to re-create genetic diversity by technologies such as gene editing. This tool is far from being routine in chickens and it raises new questions regarding which gene to modify

and which modification to introduce. It could be as harmful as beneficial since we do not know yet how newly modified gene(s) may interact with the rest of the genome.

In conclusion, balancing genetic diversity and selection response is possible but any technological progress call for an increased sense of responsability in order to remain sustainable.

Incomplete Impact of Thermal Selection on *HSP70* and *HSP90* Genes Polymorphism in Thai Indigenous and Local Chicken Breeds and Red Junglefowls

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Increased temperatures from climate change threaten farm animal welfare and productivity, including chickens, causing economic losses. However, understanding the genetic basis of indigenous chicken adaptation to high temperatures is limited. To address this, we investigated polymorphisms in heat shock protein genes *HSP70* and *HSP90*, which are involved in cellular defense against thermal stress, in indigenous and local Thai chicken breeds and red junglefowls. Through metabarcoding and genetic diversity analyses, we found seven *HSP70* alleles: two unique to red junglefowls, one in Thai breeds, one specific to Lao Pa Koi chickens, and three shared between red junglefowls and Thai breeds. We identified 20 novel *HSP90* alleles: eight exclusives to red junglefowls, seven shared, two found in multiple breeds, and three unique to Fah Luang, Decoy, and Dong Tao chickens. Despite this level of diversity, no distinct population structures were found for *HSP70* or *HSP90*, suggesting incomplete impact of domestication and selection. The low genetic diversity and shared alleles between red junglefowls and Thai breeds supports the selection of these alleles in tropical regions like Thailand. Selection signature analysis suggests purifying selection on *HSP70* for thermotolerance. This study provides valuable insights into the genetic basis of thermotolerance in chickens and highlights the importance of preserving genetic resources with thermotolerance traits. These findings have implications for developing breeding programs to enhance poultry production under the pressures of climate change.

Keywords: Allele; chicken breed; heat; purifying selection; tropical

Population Genetic Structure and Efficiency of Microsatellite Markers for Individualization and Paternity Testing in Chickens

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Chicken (*Gallus gallus*) is one of the important future food sources. Breeding improvement is necessary in purpose of preparing for climate change and food crises, especially in indigenous chickens, which contain potentially useful genetic traits. Therefore, it is essential to investigate suitable microsatellite markers in order to develop the high-quality breeder by establishing individual identification and paternity testing methods. In this study, a total of 889 chickens from "The Siam Chicken Bioresource Project" were used to evaluate the efficiency of a set of 28 microsatellite markers recommended by FAO and a set of 12 markers selected by the Ant Colony Optimization (ACO) algorithm. Matching probability (MP) in chickens was low in both marker sets, ranging from 7.1E-06 to 7.1E-89 by using a combination of 28 microsatellite loci, while using 12 microsatellite loci showed a range from 3.8E-02 to 1.5E-42. The low probability of identity was also observed by the use of the two marker sets at 1.4E-43 and 1.2E-22, respectively. In terms of paternity testing, the probability of exclusion (PE) for one candidate parent when the genotype of the other parent is not known was at a high level in both marker sets, with 0.999999999993 and 0.999999418106, respectively. These findings indicated that the combination of 12 microsatellite markers could be useful for efficient and reliable individual identification and parentage testing in chickens as same as using 28 microsatellite markers.

Keywords: Chicken; individualization; paternity testing; microsatellite marker; marker efficiency

Current Situation and Recommendations in Broiler Breeding Studies in Türkiye (Pure line studies at Transitional Zone Agricultural Research Institute)

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Today, the majority of chicken meat production is provided by fast-growing broilers. These broilers, which reach slaughter weight at the 5-6 weeks and are produced through breeding studies lasting approximately 100 generations, make a significant contribution to animal protein production in the world with the effect of appropriate management and feeding conditions. Türkiye, which is among the top 10-15 countries in the world in chicken meat production, is completely dependent on foreign countries for broiler parent production. Despite some breeding studies carried out since the 1950s, imports have continuously increased. Although significant successes were achieved at Erbeyli Poultry Research Institute in 1980-1990, the studies were completely stopped in time.

Between 2008 and 2010, our study on the development of slow-growing broiler parents was a step towards the resumption of breeding studies. In 2011, it was decided to start breeding studies at EGKTAE with slow-growing broiler broilers in a well-attended meeting at TAGEM. For this purpose, a quest for a broiler pure dam line was started. During these quests, the studies were changed to the development of fast-growing broiler parents with the provision of 3 fast-growing dam and 2 sire lines from a breeding company. In 2015, the pure lines received as hatching eggs were multiplied and selection and parent production studies with grandparent were started in 2016. A selection strategy was applied for live weight, breast meat and individual feed efficiency in the sire lines, and a balanced selection strategy was applied for growth characteristics and egg production in the dam lines. Performance tests were carried out on the parents and progeny and the material was registered under the name ANADOLU-T. Since 2018, parent material has been given to the private sector for trial purposes. In 2022, a 30-35% reduction in the breeder material imported by our country has again revealed the importance of the broiler breeding studies.

While ANADOLU-T broilers are largely similar to commercial genotypes at 5 weeks of age, a 150-200 g body weight difference occurs at 6 weeks, and a decrease of 0.1-0.15 points is observed in feed conversion ratio (FCR) (1.55-1.65). For this reason, new strategies have been made to concentrate the studies on FCR and breast meat in all sire lines. Infrastructure is being established for life-time feed conversion tests in males of sire lines. Starting from sire lines, pedigree production has started to be applied and it is aimed to start genomic selection in time. According to the current performance data and numerical values, it is possible to meet 15-25% of the broiler breeder need of our country with an appropriate multiplication plan. (EGKTAE: Eskişehir Transitional Zone Agricultural Research Institute; TAGEM: General Directorate of Agricultural Research and Policies)

Keywords: Breeding; selection; performance; ANADOLU-T; hybrid; parent

Age-Related Changes in Slaughter and Carcass Traits of ANADOLU-T and ROSS-308 Broiler Chickens

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The aim of this study was to determine the age-related changes in slaughter, organ and carcass characteristics of ANADOLU-T broiler pure lines and its hybrid in comparison with ROSS-308. In the study, four-way ANADOLU-T hybrids, two dam (A1, A2) and two sire lines (B1, B2) from which these hybrids were produced and ROSS-308 hybrids were used. Between 1 and 6 weeks of age, 4 female and 4 male broilers were slaughtered weekly from each genotype. Body weight (g), carcass and edible internal organ weight (heart, liver, gizzard) (g), abdominal fat (g), breast and thigh weight (g) were determined weekly, and expressed as a percentage of slaughter weight. Differences among genotypes were evaluated weekly by one-way ANOVA procedure and Tukey test was used for multiple comparisons. ANADOLU-T sire lines and hybrid had similar body weights to ROSS-308 until 4 weeks. However, ROSS-308 showed higher values in the 5 and 6 weeks ($P<0.05$) and was determined as 2123, 2132, 2110, 2277 g and 2819, 2809, 2743 and 3051 g for B1, B2, ANADOLU-T hybrid and ROSS-308, respectively. Carcass yield was similar between ANADOLU-T sire lines and hybrid and ROSS-308 at all weeks. The heart ratio among genotypes were different in the first 3 weeks and were highest in A2 line ($P<0.05$), and similar between 4-6 weeks. The liver ratio among genotypes were not significant until the 5 weeks, ROSS-308 hybrid had the lowest value (2.08%) at the 6 weeks ($P<0.05$). ANADOLU-T hybrid had the lowest gizzard ratio at 3 weeks (1.61%) and the highest at 6 weeks (1.28%). The edible organ ratio tended to decrease with age. It was significantly different between the genotypes at 1, 3, 5 and 6 weeks ($P<0.05$), and it was the lowest in ANADOLU-T and ROSS-308 hybrid at 5 weeks and in B1 line at 6 weeks ($P<0.05$). Abdominal fat ratio showed an increasing trend with age. Abdominal fat ratio was similar between genotypes in the first week, but in the following weeks, ROSS-308 had the lowest and ANADOLU-T hybrid had the highest value ($P<0.05$). The breast ratio of ROSS-308 hybrid was similar to B1 and B2 lines but higher than ANADOLU-T hybrid at 3, 4 and 6 weeks ($P<0.05$). At 6 weeks, breast ratio of B1, B2, ANADOLU-T hybrid and ROSS-308 were 28.8%, 29.9%, 27.6% and 31.8%, respectively. While thigh ratio was significantly higher in ROSS-308 only at 2 weeks ($P<0.05$), it was similar in all genotypes at other ages. In conclusion, ANADOLU-T pure sire lines and hybrid had similar growth trend and carcass yield with ROSS-308 until 4 weeks. However, the high abdominal fat and low breast ratio of ANADOLU-T hybrid restrict its meat production efficiency. This suggests that multi-trait selection strategies targeting higher body weight and breast ratio and lower abdominal fatness should be adopted in ANADOLU-T pure lines. However, under current conditions, a slaughter age between 4-5 weeks seems more favorable for a more competitive, economical and sustainable meat production with ANADOLU-T hybrids.

Keywords: Breast ratio; broiler; carcass yield; hybrid; performance; pure line

Determination of Performance Values of Anadolu-T Line Broiler Breeder Hens

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The aim of this study is to determine the breeding performance of the Anatolian-T line broiler-oriented breeding chickens, which is conducted under the auspices of the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry. A breeder house, that is located in the Kayışlar neighborhood of the Akhisar district in the Manisa province, with a total of 6,877 breeding materials, including 5,867 females and 1,010 males, were included in this study. Data on various parameters for all animals in the breeder house between weeks 1 and 58 were recorded on a weekly basis. The 64 week period could not be evaluated because the breeder chickens were sent to slaughter at week 59 due to low productivity. In a breeding period, it was determined that the average weekly mortality rate of breeding hens is 0,69 %, at the end of the production period between the 25th and 58th weeks female body weight averaged 3,143.21 ± 41.02 grams and rooster body weight averaged 4,097.41 ± 44.30 grams. By the 57th week, a total of 693,163 eggs were produced in the poultry house, with an average egg weight of 58,8 ± 0,80 grams (per egg), out of these, 663,632 eggs were transferred to the hatchery, with 662,400 eggs were hatched, as a result of the hatching process, a total of 525,680 day-old broiler chicks were obtained, with an average weight of 39.00 grams, it was found that an average of 110.2 chicks were obtained per breeding chicken, when evaluated in terms of hatchability, an average value of 79.89% was obtained, and the infertility rate of the eggs was found to be 12.35%. Female and male body weight averages, egg weight averages and standard error of the mean were calculated using SPSS 20.01 package program. In this study, the Anadolu-T line breeders did not maintain stable values after the 50th week and showed some fluctuations. The low fertility rate obtained in this study is thought to be due to the genetic capacities of the breeders as well as the care and feeding conditions. However, when values between the 26th and 50th weeks were examined, it was observed that they were comparable to other hybrids used worldwide. It is suggested that these values can be further improved through breeding efforts, emphasizing the importance of focusing on achieving stable values for the Anadolu-T line throughout the 64 weeks. Particularly, investigation of sudden declines after the 50th week is deemed necessary. There is a need for future research to explore performance data in different breeder houses under varying conditions throughout the entire 64-week period. Anadolu-T line is a brand value of Türkiye in terms of broiler chicken production and therefore it should be researched and developed. It is thought to be a good alternative against any negative situation that may occur in the world in terms of broiler breeder chicken supply.

Keywords: Anadolu-T; breeder hen; breeding; broiler breeder; performance

Allelic Diversity of the *ADSL* Gene in Indigenous and Local Chicken Breeds and Red Junglefowl in Thailand Exhibits Weak Purifying Selection

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Elevated levels of purine and uric acid in chicken meat, associated with health concerns like gout and cardiovascular diseases, have raised alarms regarding the meat's quality and its impact on consumers' health. Commercial broiler chickens, due to intensive inbreeding, display high genetic uniformity, particularly in genes influencing inosine monophosphate (IMP) synthesis—a crucial aspect of meat quality. Adenosine succinate lyase (ADSL) gene polymorphisms significantly impact IMP metabolism and purine content, pivotal factors in meat quality. This study investigates ADSL gene polymorphism across indigenous, local chicken breeds, and red junglefowl in Thailand, using metabarcoding and genetic diversity analyses. We identified five ADSL alleles, encompassing 73 single nucleotide polymorphisms in exon 2, including both missense and silent mutations, likely affecting IMP synthesis efficiency. Structural analyses revealed alterations in amino acid composition potentially influencing ADSL enzyme activity. In Chinese indigenous and broiler chicken breeds, certain SNPs have been associated with specific genotypes and inosine monophosphate (IMP) content. These SNPs are also identified in the ADSL alleles of Thai indigenous and local chicken breeds, along with red junglefowl in the present study. Previous research underscores the significance of SNPs within exon 2 of ADSL, highlighting their importance in the genetic diversity of chickens. While commercial broiler chickens exhibit high genetic homogeneity, indigenous and local breeds show substantial genetic variation. The use of ADSL as a genetic marker holds potential for improving productivity and meat quality through crossbreeding with diverse indigenous and local breeds. Additionally, assessments of purine content in the meat of Thai indigenous chicken breeds, such as Pradu Hang Dam, Korat, and Chee, consistently reveal lower levels compared to broiler chickens. This aligns with our observations of potential ADSL gene variations in Mae Hong Son chickens correlating with potentially lower purine content, indicating a possible link between genetic markers and meat quality. While these findings have promising implications for commercial broiler chickens, additional investigations are essential to determine the practical utility of the ADSL gene as a reliable genetic marker for selecting traits beneficial to both chicken health and the overall well-being of consumers in the context of commercial poultry production.

Keywords: Indigenous chicken; selection; meat quality; polymorphism; pürine

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8-11 May 2024
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SESSION 7

Incubation Management and Embryo Development

Modern Technologies and Innovative Approaches in Incubation Management

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Hatchery management is a dynamic field continually evolving forward by technological developments and innovative methods. These methods and solutions not only improve the efficiency and effectiveness of the hatching process but also elevate the quality of hatching eggs and chicks. At every stage of incubation, the goal is to optimize embryonic development and achieve maximum productivity. Some of the modern technologies and methods influencing hatchery management are given below.

Keywords: Egg quality; UV light; hatchery automation; in-ovo vaccination; sex determination in poultry

Ultraviolet Lights

Ultraviolet (UV) lights serve as essential tools for egg inspection of hatching eggs. By illuminating the eggshell with UV light, it is possible to expose defects, residues, and potential issues such as acid etching, organic matter contamination, abrasions, and watermarks. The use of UV lamps is key for enhancing hatching success by facilitating the selection of problem-free eggs and lowering contamination risks. However, achieving a successful investigation requires the correct UV light wavelength and filtration. Optimal wavelengths, such as 365nm, coupled with black filters (minimizing reflected light from the environment), deliver detailed and easily visible results when compared to 395nm lights.

Transfer Automation Systems

Transfer automation systems represent innovative technologies that simplify and update the incubation process. These systems are equipped with various cutting-edge technologies, including advanced infrared and laser sensors, heartbeat detectors, thermal cameras, and loading/transferring automation systems. They automate the transfer of eggs from trays to baskets or facilitate the removal of eggs from trolleys, separating viable embryos and transferring them to baskets placed on hatcher trolleys. These automation systems reduce labour costs, minimize damages, and accelerate the speed of the transfer process especially when used with integrated robots. Moreover, these systems are evolving to combine automated candling processes between days 8 and 12 of incubation, enabling differentiation between viable eggs and infertile or early mortality.

In-ovo Vaccination Technology

In-ovo vaccination technology automates vaccine administration into eggs between the 18th and 19th days of embryonic development by creating a small hole in the eggshell. This method ensures that chicks are vaccinated pre-hatch, offering a good protection against diseases. In-ovo vaccination presents a feasible solution, particularly in hatcheries with high labour costs, as it saves time and labour. Moreover, when integrated with transfer automation, it targets live embryos only. Shortening the vaccination period by 2.5 days potentially brings better immunization. However, skilled technicians are required for these processes, and there is a great risk of mortality for upside-down eggs. While commercial broiler chick production faces similar vaccine costs, breeder or layer production, requiring sex separation, may face doubled expenses. Users have reported additional losses ranging from 0.5 to 3%, with challenges in determining the correct vaccination timing in mixed flocks or egg ages.

Sex Determination Automation

Sex determination automation systems use various techniques, including spectral-based, acoustic-based, morphology-based, and volatile organic compound (VOC)-based methods, to rapidly and accurately determine chick sex during incubation. These technologies have huge potential for single-sex production in laying hen operations and male-female line separation in broiler breeder production. Particularly in laying hen production, sex determination automation makes a significant improvement in animal welfare by eliminating the need to euthanize male chicks. These advancements not only improve the efficiency of the hatching process but also

support ethical standards positioning sexing automation as a vital component of modern hatchery management.

Conclusion

The integration of these cutting-edge technologies and innovative methods into hatchery management not only enhances efficiency and effectiveness but also reduces risks and improves quality. Moreover, these advancements support animal welfare standards. As hatchery technologies continue to evolve, they offer a promising roadmap for the future of hatchery equipment and chick production.

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Alternative Application for Fumigation: Ozone Treatment during Incubation

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This study was conducted to investigate effects of ozone treatment during incubation of broiler eggs as an alternative application for fumigation. A total of 240 eggs obtained from 45-week old Ross 308 broiler breeder flocks were used in the study. The eggs were weighed and randomly divided into two groups: the group without ozone (control group) and the group with ozone (n: 3 trays, 40 eggs/tray). The eggs were placed into two incubators with the same features, which were calibrated before the experiment. A commercial ozone generator placed in the incubator and ozone gas activated for 1 minute per hour and provide ozone gas at the level of 0.050 ppm. Ozone gas was applied in 3-day cycles during the 18-day incubation period. During this period, a temperature of 37.2-37.5ºC and 55% of relative humidity were applied in incubators. On the 18th day of incubation, randomly selected six eggs from each experimental group were taken into sterile bags to determine the microbial load of the egg shell. Besides, six eggs were randomly sampled from each experimental group for determination of embryo development. The total aerobic bacteria count was found higher in control group than ozone group (5.74 versus 5.25 cfu/mL respectively; $P < 0.01$). The number of Coliform sp. was found higher in control group than ozone group (5.63 versus 5.09 cfu/mL respectively; $P < 0.01$). The yeast mold count was found similar between the groups ($P > 0.05$). The egg weight, embryo weight and embryo yolk sac weight were found to be similar betwen the groups ($P > 0.05$). It can be concluded that ozone application as an alternative to fumigation during incubation in broiler chicken eggs is effective in reducing of egg shell microbial load.

Keywords: Ozone; incubation; fumigation; egg shell microbial load; broiler

Effects of Green and Red LED Light during Incubation on Hatch Characteristics of Anadolu–T Broiler Breeders

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The current practice in commercial hatcheries is to hatch eggs completely in darkness. However, in nature, most developing avian embryos are regularly exposed to daylight for short periods of time when the chicken leaves the nest to eat and drink and when she rotates the eggs several times in a day. It is known that light exposure during incubation affects chicken embryo development, because broilers have a light-sensitive pineal gland, producing melatonin, which is one of the most important hormones in chickens affecting physiology, immunity and behaviour. In addition to light itself, the color of light might be an important factor, since chickens have special extraretinal photoreceptors in their eyes and brains. Therefore, the aim of this study is to investigate the effects of green and red LED light during incubation on hatchability, chick weight, chick length, yolk weight, yolk-free body weight and tona score of male and female Anadolu-T® broiler breeder chicks. A total of 1200 eggs (A1 female × A2 male = dam line of Anadolu-T® broiler breeders) and a total of 1200 eggs (B1 female × B2 male = sire line of Anadolu-T® broiler breeders) from a 48-week-old grandparent flock were obtained, 60-65 grams eggs were selected, stored, randomly distributed into three groups (green, red, darkness; 800 eggs per group; two incubators; 400 eggs per group per incubator) and incubated. Plastic-covered and water-resistant green and red LED strips were attached underneath hatching trays. Green and red LED light was applied with a 16L:8D light schedule throughout incubation (incubators and hatchers). Data of hatchability of all chicks; chick weight, chick length, yolk weight, yolk-free body weight and tona score of 180 chicks per group were collected and subjected to mixed model analysis, using the PROC MIXED procedure in SAS Studio. Results showed that red LED light increased the hatchability when compared to the green and dark incubated eggs ($P<0.001$). Chick quality (tona score) was improved by exposing eggs to red and green light during incubation compared to dark incubated eggs, while chick quality was found similar between chicks of red and green LED light groups ($P<0.05$). Green LED light during incubation resulted in higher chick weight and chick length compared to red and dark incubated eggs, while chick weight and length were found similar between chicks of red LED light and darkness groups ($P<0.05$). These results indicate that (1) the light during incubation is important for developing chicken embryo, (2) red LED light during incubation could be the most beneficial light spectrum to improve hatchability, (3) whereas green LED light did not affect the hatchability but improve the chick weight and length, which is desired for especially broilers to start a life with a high weight and length.

Keywords: Green LED light; red LED light; incubation; Anadolu-T; broiler; breeder

Effects of Dietary Supplementation of Organic Chromium on Live Weight, Hatching Results, Sperm and Biochemical Parameters of Roosters

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Parent stocks are flocks both genders are kept together to obtain fertile eggs. These flocks are more sensitive to rearing techniques and environmental conditions than commercial layer hens. The oxidation and antioxidant systems of birds are in balance under normal conditions. However, the increase in both egg production and feed efficiency with the breeding studies carried out in parent stocks has made the flocks especially sensitive to oxidative stress. Oxidative stress can cause significant economic losses by affecting hatching results and chick performance in breeder flocks. In this case, while the feed intake of poultry decreases, the need for mineral substances of breeding flocks increases. Chromium a module of tolerance factor, helps insulin, burns fat for energy in the cell (mitochondria) and improves performance by reducing blood glucose and cholesterol concentration, improves egg production, shell thickness, hatchability, reduces embryo mortality and has antioxidant properties that help reduce the negative effects of oxidative stress. This study was carried out to determine the effects of chromium-picolinate to male parents stock diets on hatching results, sperm, biochemical and pathological parameters. The present study was performed in Directorate of Poultry Research Institute (Ankara, Türkiye). The experiments were conducted in completely randomized desing with five replications. A total of 54 white male parent stocks. (at 25 wk old) were used in the experiment. The roosters were placed in individual cages. They were divided into three treatment groups (control, 400 and 800 ppb chromium) at week 25. When the roosters were 35 weeks old, they were distributed to cages enriched with layer hens. The trial period lasted 25 weeks. The results were analyzed statistically by analysis of variance and Tukey's test using Minitab package program. The data obtained in the experiment were subjected to one-way analysis of variance. Mean differences were considered significant at $p < 0.05$. At the end of the research, the hatching results hatching results(fertile hatchability, hatching performance, early, middle and late period mortality, newly hatched chick weight, sex ration), sperm (volume, concentration, motility, dead and anormal sperm ratio) biochemical (glucose, total protein, cholesterol, triglyceride, albumin, globulin, creatinine, uric acid, Ca, P, Mg, Cr, Zn, Na, K, Fe in blood), oxidant/antioxidant status (TAS, TOS ve OSI in liver) and pathological parameters (liver, testis and small intestine) were evaluated. Results showed that sperm motility, dead sperm ratio, anormal sperm ratio, chromium and calcium concentration in blood, OSI values in liver were statistically affected in roosters.

Keywords: Layer breeder roosters; organic chromium; hatching results; sperm parameters; serum biochemistry; oxidative status

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2024 International Poultry Congress

8-11 May 2024
BURSA-TURKEY

SESSION 8

Poultry Egg and Meat Quality

Impact of Changes in Production Practices on Chicken Meat Quality and Possible Improvement Prospects

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For many years, demand for poultry meat, and in particular for cut and processed products, has grown considerably. As a result, the poultry industry has adapted with high-performance animals, whose growth rates and meat yields (especially breast) have continued to increase. But the industry has also had to face up to new meat quality problems, which seriously affect not only its taste and nutritional qualities, but also its processing capacity. As in pork, technological and sensory defects are often linked to variations in energy metabolism, which influence the post-mortem pH drop. This variability mainly concerns the pectoral muscle, whose metabolism is entirely glycolytic, and affects the color, water retention capacity and texture of cooked meat. In the last ten years or so, several degenerative muscle anomalies, known as myopathies, have also appeared, initially in countries using high-yielding strains with high slaughter weights, but today most countries are affected. The main ones are white striping, wooden breast and spaghetti meat, which mainly affect the pectoral muscle of broilers. The consequences of these quality anomalies are dramatic, affecting not only the visual appearance of the meat (to the point of rejection by the consumer), but also its nutritional composition and processing capacity. The poultry industry is actively seeking solutions in terms of genetics, nutrition and management practices. Research carried out to date has improved our understanding of the biological processes involved in the appearance of meat defects, but to date, no miracle solution has been identified to systematically reduce these defects. Nevertheless, we can assume that part of the solution will lie in genetic improvement, but also (and certainly additionally) in nutritional strategies or adaptations in terms of breeding practices. In concrete terms, the implementation of these solutions will be facilitated by the development of predictive tools that could enable more in-depth phenotyping of meat defects, ideally on live poultry, but also a more general reflection on what the “poultry farming of tomorrow” should be, taking into account current concerns about animal welfare, environmental impact and product quality.

Physical and Antimicrobial Protection of the Hen's Egg throughout the Extended Laying Cycle.

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Birds are oviparous, and produce a cleidoic egg with its internal environment almost totally isolated from the outside. This reproductive cell is composed of an oocyte filled with nutritional reserves (yolk) and surrounded by several specific layers (eggshell, egg white, vitelline membrane) providing natural protections, water and additional essential proteins and minerals to the developing avian embryo (Nys and Guyot, 2011). The unfertilized egg is consumed worldwide because of its low price and high nutritional value. It contains a large diversity of nutrients (protein, lipid, vitamins, and minerals) and possess an ideal profile of balanced amino acids and large amounts of unsaturated fatty acids. The egg can supply all the required nutrients for the human diet except for calcium and vitamin C (Réhault-Godbert et al., 2019). Its hygienic quality is crucial for consumers especially when it is consumed as a raw material. The structure and content of the egg have been optimized to combat microbes from a potential contamination by oviduct secretion during egg formation (vertical transmission) and to impede potential contamination by pathogens from the environment after laying (horizontal contamination) (Réhault-Godbert et al., 2022). The egg has several complementary levels of protective systems: the eggshell (cuticle, calcified layer and eggshell membranes), the egg white and the vitelline membrane. These egg structures protect, thanks to physical, physico-chemical and chemical mechanisms, the nutrient-rich egg yolk, which composition is very favorable to bacterial growth. Chemical protections are ensured by a myriad of antimicrobial proteins and peptides present in all part of the egg, especially in the egg white where they are particularly abundant and in a solubilized form (Réhault-Godbert et al., 2022). The yolk contains high amounts of specific immunoglobulins (IgY), but these molecules are not assumed to exhibit direct antimicrobial activities against pathogens. In fact, they are part of the adaptive specific immunity (antibodies) of the chick and are functional only after hatching. Therefore, tThe protection of the unfertilized table egg therefore relies largely on the innate defense system. The physical protection of the egg first is based on the eggshell and eggshell membranes outside of the liquid egg, and internally to the perivitelline membrane which separate the yolk from the egg white. In addition, chalazae physically maintain the yolk in the middle of the egg. These twisted filaments connect yolk to each pole of the egg and keep it at a distance from potential bacterial contamination arriving through the eggshell. Viscosity, alkaline pH, and iron restriction of egg white reduces the survival capacity and migration of bacteria toward the yolk (Baron et al., 2015). Finally, the egg white but also the vitelline membrane and even the eggshell contain numerous antimicrobial proteins which are very efficient to prevent microbial contamination of the egg. Lysozyme and ovotransferrin are among the most abundant and well-characterized egg antimicrobial proteins but a number of novel antimicrobial proteins and peptides have been identified more recently using high-throughput technologies (proteomics, transcriptomics) and innovative purification approaches. The egg protective systems are very efficient since only a few bacteria including Salmonella Enteritidis are able to cope with these mechanisms and can survive,and even multiply in this unfavorable environment (Baron et al., 2016). However, it is well established that the properties of the physical barriers (eggshell and vitelline membrane) and the quality of the thick egg white are weakened by hen age during the laying cycle. Over the past decade, breeding companies have selected hens that can produce 500 eggs in a laying cycle lasting 100 weeks by improving persistency in lay and by stabilizing egg quality beyond 80 weeks of lay. This genetic improvement can be realized only if matched by better knowledge of the birds' physiology and its nutritional requirements (Nys, 2017). However, the alterations in eggshell quality and in egg white properties remain the limiting factors of extension of the laying period as an egg is unsuitable for human consumption if the eggshell is fragile or cracked, or if the thick egg white and the vitelline membrane are of poor quality. In this context, a better understanding of the bird's physiology and nutrition is essential to update the knowledge on egg protective system and to explore how far this system is affected by hen age. During the last 15 years, proteomic and transcriptomic approaches (Gautron et al., 2011) have allowed to identify proteins putatively involved in the antimicrobial properties of eggs and those controlling the formation of the physical barriers (eggshell, egg membranes) or involved in the supply of mineral to form the eggshell (intestinal and uterine ionic transport) and in the regulation of Ca and P metabolism (Nys et al., 2021).

All these data contribute to a better understanding of the origin of the defect induced by hen age.

Keywords: Egg; hen, innate; immunity; egg white; eggshell

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Effects of Slaughter Age, Strain, Gender and Body Weight on White Striping and Wooden Breast Myopathies and Carcass Parts of Broiler Breast Muscle

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This study evaluated how strain, gender, and days of slaughter may affect the occurrence of white striping (WS) and wooden breast (WB) in broiler breast muscle. Furthermore, this study examined the correlation between BW, carcass part percentages, and degree of WS and WB. The chicks were obtained from four strains so called A, B, C, and D and were placed into the experimental 80 floor pens (50 birds per pen) after sex sorted with free access to feed and water. A total of 200 birds in each were processed at 35, 42, and 44 d of age in each. On each processing day, five male and five female chickens each of five pens from each strain were randomly selected and sent to the slaughterhouse. Birds had individually marked and weighed before carotid artery and jugular vein were manually severed with a knife. Carcasses were manually eviscerated and hot carcass and abdominal fat weights were collected before carcasses were washed in and cold water tank for 20 min and transferred to air chiller at 4°C for approximately 24 h. Cold carcass and carcass part weights, which included wing, drumstick plus thigh, butterfly skinless breast, *P. major* and *P. minor* were determined. WS and WB scoring system were developed for the *P. major* on a 1 to 4-point ordinal scale using a single trained and experienced technician. The data was analyzed as a 3x4x2 factorial design with independent variables of age, strain, and gender. Pearson correlation analysis was used to evaluate the correlation coefficients between all collected traits. Regression analyses were also performed to examine effects of BW on carcass yield and butterfly skinless breast percentage. It was clear that WS and WB scores were correlated to BW in females ($r=0.316$; $P<0.001$ and $r=0.306$; $P<0.001$) and males ($r=0.296$; $P<0.001$ and $r=0.426$; $P<0.001$) besides the WS scores were significantly correlated to WB myopathy ($r=0.469$;$P<0.001$). The abdominal fat, carcass yield, drumstick plus thigh, butterfly skinless breast and *P. major* weight percentages, BW and WS-WB scores reduced in 35 d when compared to 42 and 44 days, but the wing percentage were increased in 35 d as well as there was no significant difference in *P. minor* percentages of the slaughter ages. The BW ranked from highest to lowest were strains A, D, B, and C ($P<0.001$). The carcass yield and breast meat percentage has been increased 2.05% ($R^2=0.347$) and 1.73% ($R^2=0.236$) by a-1 kg BW, respectively ($P<0.05$). The WS-WB scores had been affected by the strains and gender of the birds ($P<0.05$). Moreover, an interaction effect between slaughter age and gender was significant for WB myopathy score($P<0.05$).The intensity of WB and WS incidence in strain D was two and four times greater than in strain C, respectively ($P<0.05$). It can be concluded that lower BW would reduce WB and WS myopathies because of not only slaughter day and gender but also the strain of the chickens. Moreover, increased BW has increased carcass yield and breast meat percentages.

Keywords: Broiler; myopathy; white striping; wooden breast; strain

Effect of Stocking Density on Egg Production and Egg Quality Characteristics in a Commercial Laying Hen House

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The study was conducted to examine the effects of stocking density on characteristics related to egg production and quality in a naturally ventilated commercial laying hen house. Density groups were created by placing 5, 6, 7 and 8 hens in cages, each with dimensions of 55x45x40 cm. For each group, 12 cages were used as replicates and the animals were randomly distributed, with 3 replicates on each floor of the 4-storey cage. As material, 9496 eggs collected for 32 days from a total of 312 layer hybrids of the Lohmann Brown genotype at 34 weeks of age were used. The eggs obtained from each replicate were weighed daily and their numbers were recorded, and egg yields per chicken/day, average egg weights and egg amounts produced were calculated. On the 14th and 28th days of the experiment, a total of 240 eggs, 60 (30 + 30) per group, were used to determine the quality characteristics. Egg weights according to 5, 6, 7 and 8 density groups, 61.3a, 60.7b, 60.6b ve 59.6c g; hen/day egg yield as 99.8a, 98.8a, 92.9b and 91.9b%, respectively. The amount of eggs produced per day per pen was 305.9d, 359.4c, 393.5b and 437.8a g, while the amount of eggs produced per hen per day ((egg yield x egg weight)/100) is 61.2a, 59.9a, 56.21b and 54.7c g in the same order. The total amount of eggs produced per hen in the 32-day period was determined as 1957.4a, 1916.8a, 1798.9b and 1751.2c g ($p<0.05$). Egg shape index averages were determined as 77.6b, 78.0ab, 77.8ab and 79.0a%; yellow weight: 15.8a, 15.8a, 15.6ab and 15.1b g; albumen rate: 62.6b, 63.5ab, 63.8a and 64.2a%; yellow ratio: 26.8a, 25.9ab, 25.6b and 25.1b% and flesh-blood spotted: 8.3b, 10.0b, 8.3b and 16.7a%, respectively ($p<0.05$). Among the quality characteristics, no difference was detected between the groups in terms of albumen height, yolk height, albumen width, albumen length, yolk diameter, albumen weight, shell weight, shell ratio, albumen index, yolk index, haugh unit and shell thickness ($p>0.05$). It is seen that egg production and quantity are higher when 5-6 hens were placed in the cage compared to 7-8 hens. It can be said that as the number of animals in the pen increases, the size of the yolk formed in the ovary decreases and as a result, egg yield and quantity decreases. Although 7-8 animals produce more when the amount of eggs produced per unit area is considered in commercial production, when the efficiency of production per hen is examined, 5-6 chickens have higher productivity. Meat-blood stain, an undesirable quality criterion in table eggs, reached the highest rate in cages with 8 hens. As a result, when factors such as egg production, egg quantity, egg quality characteristics and more effective use of unit area are evaluated together, it is recommended to place 5-6 hens in each cage.

Keywords: Stocking density; layer; egg yield; egg quality; egg quantity

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2024 International Poultry Congress

8-11 May 2024
BURSA-TURKEY

SESSION 9

Poultry Products: Relations with Human Health, Food Safety

The Heart Adventure of the Egg

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"Dr. Mr. Bingür is a good heart surgeon, let him mind his business. "If there is something useful for the public, we will say it."

2nd President of the Cardiology Association at the time

While I was performing my heart surgeries, I suddenly found myself in the egg world with a question from my friend Balçiçek İlter, an esteemed television presenter, after an interview on Haber Türk Television. The question was very simple:

- Do you suggest eggs to your patients?

- Yes, two eggs a week.

- The 'Scientific Poultry Congress' will be held in Istanbul, the president of the association Prof. Dr. Rüveyde Akbay would like to meet with you.

I accepted without objection. After a phone call with the lecturer, I realised the seriousness of the matter and asked for the latest publications on the subject. In the meantime, I accessed some medical publications and saw that the message 'Egg consumption should be reduced to four per week' given by cardiologists to the Americans who ate 3-4 eggs a day in the nineteen sixties was perceived as 'it should not be eaten at all' until it came to our country.

I made a very simple plan. As I had promised, I would come to the congress as a guest and share my thoughts in a few sentences. When I arrived at the congress hotel in the morning after an intensive surgery programme, I was very embarrassed to be greeted at the door by Rüveyde Hoca and all the faculty members, but I experienced the real shock when I entered the hall. There were at least 7-8 television cameras and as many journalists. Suddenly I realised that I was one of the two speakers. When I was offered to speak first, I very politely suggested that our American guest speak first. I watched with admiration the speech of Prof. Donald J. McNamara, who devoted 25 years of his professional life to egg research.

When it was my turn, I had no written text or slide preparation. At the beginning of my speech, I said, 'After the presentation of this esteemed scientist, I would like to start my speech by apologising to my patients for the fact that for years we forbade our patients to eat even the yolk of the egg on the cake' and then I brought together my knowledge of the last one or two weeks and the information I had received from the visiting professor and explained that even people with coronary heart disease can eat 3 to 4 eggs a week and that healthy people should eat one egg a day.

When I left the meeting and came back to my hospital, I jokingly explained the incident to our press communication director, dear Esra Aydemir. Dear Esra, who is a very experienced journalist, said, 'This sentence (I apologise to my patients for banning eggs) will fly.' I never took it seriously, but I couldn't manage to give interviews on television or appear on live broadcasts in the news. It was as if I gave the good news that society needed.

Just as some cardiologists contributed to these statements, which were widely covered in all written and visual media, by saying 'I have already said this before', and some cardiologists expressed their discomfort not whether the news was true or false, but the fact that it was declared by a cardiac surgeon and created a great public opinion. In the meantime, some of the colleagues' language even reached insulting levels.

We presented our research on "Blood lipids and atherosclerosis risk factors in subjects given one egg a day and two eggs a day", which we conducted together with the Scientific Poultry Association, at an international

congress. In order not to lose the momentum and to maintain media interest, we carried out public activities and even distributed eggs in the squares.

I declared in all press releases that I had not discovered anything new, but that I had dared to loudly announce a fact that had been spoken on scientific platforms since 1990. On this occasion, cholesterolomania, which had been created against eggs for years, was very successfully destroyed.

I would like to thank the discretion shown by the visual and print media during this process.

Exploring the Influence of Eggshell Calcium Powder, Low Methoxyl Pectin, and Acorn Extract as Phosphate Replacers on the Quality Properties of Restructured Turkey Fillets

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This study was carried out to investigate the effects of eggshell calcium powder (ECP), low methoxyl pectin (LMP), and acorn extract (AE) as phosphate replacers on the chemical composition, quality parameters, microstructural properties, and microbiological quality of restructured turkey steaks. The control group was produced using 0.50% sodium tripolyphosphate. In order to replace phosphate, group E was produced using only 0.50% eggshell calcium powder, while in group EP, 0.50% eggshell calcium powder was combined with 0.25% LMP. In the EPA group, 0.50% eggshell calcium powder was combined with 0.25% LMP and 200 mg GAE (Gallic Acid Equivalent) acorn extract. The addition of LMP to the formulation has led to an increase in the moisture and fat content of the samples, while a decrease in protein values has been observed. On the other hand, there have been no significant differences between the ash contents of the turkey steaks. When ECP is used alone, no significant differences were observed in the water holding capacity of turkey steaks compared to the control group. However, it has been determined that the addition of LMP to the formulation increased the water holding capacity. When LMP was added to the formulation in a manner similar to water holding capacity, an increase in cooking yield was observed, with the lowest cooking yield value being identified in the control group. During the 21-day storage period at +4°C, Total Aerobic Mesophilic Bacteria (TAMB), yeast, and mold counts were conducted on the samples. A significant increase was observed in the TAMB counts of the samples, and until the 10th day of storage, the TAMB of the experimental groups was found to be lower than those of the control group. At the end of storage, it was determined that the TAMB of the EP and EPA groups were significantly lower than those of the control group. Additionally, it was found that the amount of phosphate used in the control samples did not prevent yeast-mold development throughout storage, and the count exceeded the microbiologically safe limit. The E group exhibited a microstructure similar to the C, however, reductions were observed in the cavities of the experimental groups with the addition of LMP. On the other hand, the use of AE in the EPA group resulted in a more porous appearance compared to other groups. Results from this study have shown that the use of ECP alone or utilization with LMP and AE can exhibit phosphate-like binding properties.

Keywords: Phosphate; eggshell calcium powder; peçtin; acorn extract; restructured turkey steak

Elemental Selenium Limits the Deposition of Selenium in the Muscle of Broilers

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Selenium (Se) is an indispensable trace element crucial for the well-being of both animals and humans. However, diets often lack sufficient Se, leading to supplementation practices. For humans, ensuring an adequate intake of Se is vital, given its essential role in various physiological functions, including immune system support, thyroid function, and antioxidant defense. Meat from animals can be used as a dietary source of selenium for humans. The Se content in meat can be enhanced through supplementation, either in an inorganic form (sodium selenite, SS) or organic forms, such as SeYeast (SY) or as pure chemically synthetized Se forms, like hydroxy-selenomethionine (OH-SeMet). In some regions, Se is also supplemented as nano-Se (SeNP) or as Se proteinate (Se-Pro), which are claimed to be as efficient as organic Se forms. Se compounds can be differentiated based on their bio-efficacy, assessed through measuring Se deposition in muscle tissue. The present study was aimed to compare the bio-efficacy of different Se sources in chickens. A total of 120 d-old male broilers (Ross 308) were assigned to 10 treatments (4 replicates). The birds were fed a basal starter diet of maize-soybean meal for 14 days supplemented with different sources of Se at 0.3 ppm: a negative control diet (NC; no supplemental Se), SS, 3 different Se-Pro (Se-Pro 1, Se-Pro 2, Se-Pro 3), 2 different SeNP (SeNP 1, SeNP 2), 2 different SY (SY1; SY2), or OH-SeMet. On d 14, all birds were sampled for determination of total Se concentration in breast muscles by inductively coupled plasma mass spectrometry (ICP-MS). Differences were tested by means of one-way ANOVA ($P<0.05$). The Se sources significantly affected the Se deposition (mg Se/kg of DM) in the breast muscles ($P < 0.001$), with the higher bio-efficacy of OH-SeMet (1.12) than SY1 (0.57) and SY2 (0.84), and the organic forms superior than SS (0.379), SeNP (0.29 and 0.27) and Se-Pro forms (0.38, 0.31 and 0.33). Se-Pro and SeNP were equivalent or significantly low efficient than SS (SS = Se-Pro 1 > Se-Pro 2 = Se-Pro 3 > SeNP 1 > SeNP 2; $P<0.001$). To understand the variable Se deposition among these sources, the experiment was followed by the speciation of those products. A negative correlation ($R^2 = 0.7419$; $p< 0.001$) between the level of elemental Se and Se in tissues from SS, Se-Pro and SeNP sources was observed. Elemental Se is an inorganic and insoluble form of Se which explains the lower absorption and transfer of Se in tissues. Elemental Se has recently been identified as part of the composition of SY which, on top of their variable SeMet content, explains their lower bio-efficacy compared to pure chemically synthetized Se forms, like OH-SeMet. In conclusion, organic sources, especially OH-SeMet have a superior bio-efficacy compared to SS, Se-Pro and SeNP. Both Se-Pro and SeNP products showed to be equivalent of inferior to SS. Elemental Se seems to play an important role in the bio-efficacy of the Se, no matter the source.

Keywords: Selenium; nano-selenium; seleno-yeast; seleno-proteinate; hydroxy selenomethionine; elemental selenium

Effects of Dietary Fennel Volatile Oil on Performance, Egg Quality, and Egg Yolk Oxidative Stability of Laying Quails

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This study was conducted to determine the effects of adding different levels of fennel volatile oil (VO) to the laying quail diets on performance, internal-external egg quality parameters, and egg's oxidative stability. A total of 105 (6-week-old) laying quails (Coturnix coturnix Pharaoh) were used and quails were separated into 3 treatment groups including 5 replicated sub-groups. A basal diet not containing fennel VO was formulated for the control group, and fennel VO was added to the basal diet at the level of 200 and 400 mg/kg to Group 1 and Group 2, respectively. Diets and water were provided to quails ad libitum. Treatments continued for 56 days. As result, the addition of fennel VO to the quail diets did not effect feed efficiency, haugh unit, egg yolk color, egg weight, shape index, egg shell breaking strength. However, both levels of fennel VO increased feed intake ($P<0.05$), egg production ($P\leq0.001$), eggshell thickness ($P<0.001$), and decreased the damaged eggs rate ($P<0.05$). Although there is no difference in malondialdehyde (MDA) levels of egg yolks stored in the +4 ºC on day 1, both levels of fennel VO significantly reduced MDA levels of egg yolks on days 7 and 28 ($P<0.01$). The fact that fennel VO could be added to poultry rations as a natural feed additive to increase performance, improve eggshell quality, and minimize storage losses by extending the egg shelf life was concluded based on the data obtained.

Keywords: Egg quality, fennel volatile oil, laying quail, malondialdehyde, performance.

Introduction

As is well known, maintaining a healthy diet is possible by consuming adequate amount of animal protein on a daily basis. In this context, poultry products have significant value in meeting the animal protein demand of the increasing world population, due to their health benefits and cost-effectiveness. For many years, antibiotic growth promoters were used in the poultry nutrition to increase yield and product quality. However, the haphazard use of these agents has reached a level that poses a threat to public health, leading residues in poultry meat and eggs. Thus, in the early 2000s, the use of growth promoters antibiotics in poultry diets was banned in many developed countries. After the growth-promoting antibiotics were banned, natural feed additives (prebiotic, probiotic, aromatic plants and the volatile oils extracted from those aromatic plants) became one of the core conceptsin the poultry industry. Scientific attention has been drawn to the demonstrated effects of herbal extracts, including antimicrobial (4, 17, 31, 39), antiviral (4, 7), antiparasitic (38), anti-inflammatory (4), antifungal (4, 28), antioxidant (4, 8, 27, 40), immunostimulatory (4), hypolipidemic (44), palatability increaser (48) and digestion improver (10, 18, 26) as indicated by numerous studies on poultry.

Fennel (Foeniculum vulgare Mill), an aromatic herb belonging to the Apiaceae family, has been used in medicine or to add flavor to the foods since ancient times. (33, 42). The active components those provide flavor and aroma to the VO of fennel seeds are anethole, fenchone, estragol, 1,8-cineole, para-cymene, β-myrcene, linalool, alpha-pinene, beta-pinene, γ-terpinene, camphene, camphor and 3-methylbutanol (15). The main active component of fennel VO is trans-anethole, a phenolic ester (34). The amount of anethole consists of 60-70 % of the VO extracted from fennel seeds averagely depending on which part of the plant it is obtained from (19, 24).

Recently, the issue of maintaining healthy nutrition has occupied the agenda, which has led to a remarkable increase in the demand of foods containing natural preservatives by people all around the world. In this regard, studies are conducted by nutritionist in order to detect the protective effects of natural feed additives, especially aromatic plants and their VOs, and increase the quality and shelf life of poultry products. These studies have mostly focused on rosemary, thyme, turmeric, cloves and the VOs obtained from these aromatic plants, which have strong antibacterial and/or antioxidant capacity. There are limited number of studies investigating the effects of fennel in poultry compared to the aforementioned aromatic herbs. In addition, these studies focusing on fennel use mainly focused on broiler chickens (1, 18, 32, 47) and limited number of studies have been conducted on

layer quails. Moreover, there are very few studies that determine the chemical composition of fennel essential oil and also correlate the results by taking into account the existing active components contained in VO. It has been proven that the VO obtained from different parts of the fennel herb, especially its seeds, has antimicrobial (24), antioxidant and hepatoprotective (40, 43) effects.

Our hypothesis was that fennel VO added to laying quail diets may extend the egg shelf life via its antioxidant characteristic, and increase performance due to antimicrobial effect by improving intestinal health. It was also thought that herbal VO may improve the performance of quails due to their general effects including increasing feed palatability, promoting feed intake, increasing the digestive juices and enzymes activity of by enhancing liver functions. The aim of this study is to detect the effects of different levels of fennel VO added to the diet of laying quails on performance, internal-external egg quality parameters, and egg's oxidative stability.

Material and Methods

Animal material and management: This study was conducted under the confirmation of Bursa Uludağ University Ethics Committee (decision number: 2018-15/05). A total of 105 (6-week-old) laying quails (Coturnix coturnix Pharaoh) were used and quails were seperated into 3 treatment groups based on their live body weight. In addition, the main groups were seperatedinto 5 replicated sub-groups, each of them consists of 7 quails. Quails were placed in cages with an area of 112 cm2 for each of them. Diets and water were provided ad libitum. The research was continued for 56 days. Quails were subjected of 18 hours of light and 6 hours of darkness per day. During the research; it was taken care to keep the henhouse temperature at 23°C and the humidity at 55-60 %.

Experimental diets and analyses: Quails in the treatment groups were fed with an isocaloric and isonitrogenic basal diet based on corn-soybean. In the formulation of the basal diet, reference values reported by NRC (36) were taken into account to meet the requirements of laying quails. No antioxidants were added to the diet other than the basic level of vitamin E included in the premix (Table 3). In the research, a basal diet that did not contain fennel VO was prepared for the control group, and fennel VO was added to the basal diet at 200 and 400 mg/kg levels for Group 1 and Group 2, respectively. To prevent losses in the effectiveness of fennel VO, feeds were prepared weekly and then immediately placed in ziplock bags. Additionally, feed bags for each replicate were placed in buckets with lids and feeding was done twice a day. After fennel VO was obtained from a commercial company, its chemical composition was analyzed by gas chromatography-mass spectrometry (GC-MS). Fennel VO levels to be added to the laying quail diets were determined based on the literature (11, 14, 49) and the recommendations of the supplier company. The specific gravity value of fennel VO required to calculate the amount of fennel VO to be added to the trial diets was obtained from the supplier company. AOAC procedures were followed to determine the crude nutrients composition of the basal diet (5). Calcium (20) and total phosphorus (22) levels to determine spectrophotometric methods were used. The basal diet's metabolizable energy level was calculated by substituting the crude nutrient values obtained from the analyzes into the equation developed by Carpenter and Clegg (13).

Performance parameters: Eggs were collected and recorded daily, and the number of damaged eggs of groups in the replicate basis, was also noted. Egg production percentages were calculated on a replicate group basis. The amount of feed given to the groups was recorded, and the remaining feed from the replicate groups was weighed every 2 weeks to determine the daily feed intake of the quails. Additionally, to determine the egg weights of the groups, all eggs taken from the replicate groups were weighed one by one and the average egg weight was calculated. The feed efficiency of quails in groups was expressed as kg of feed consumed for the production of one kg and one dozen eggs.

Internal and external egg quality parameters: In order to determine the internal and external egg quality parameters of the groups, a total of 45 eggs were collected randomly every 2 weeks, 15 eggs from each treatment group (3 eggs from each repetition) for each measurement (4 x 45 = 180 eggs during the research period). Egg shell thickness was determined with an egg shell thickness gauge (Orka Technology Ltd, USA). After the shell membranes were removed, measurements were made on the shell samples taken from the upper, middle and lower parts of the eggs and their averages were taken. Eggshell breaking strength was determined in Newton units

using a console system (6). The egg yolk color was determined with Roche yolk color scale from 15 (dark orange) to 1 (light pale). In addition, the thick albumen height in the egg samples was measured and, the haugh unit of the eggs was calculated by taking into account the weight value of the same egg (12).

Determination of the chemical composition of fennel VO: Pure fennel VO, obtained by hydro distillation method and originating from Mersin/Turkey, was used the chemical composition of fennel VO was analyzed on an MS-Thermo Polaris Q GC-Thermo Trace GC (Thermo Ficher inc, MA, USA) ultra-fitted with a fused HP5 MS capillary column. The column temperature was programmed to increase the temperature 4 °C per minute from 95 °C to 240 °C. Samples were injected in split mode at 250 oC. Helium gas was used as the carrier at the pressure of 1.3610 atm. Determination was performed by FID (250 °C) and the injection volume was 8.1 µl for all samples. MS or MS/MS was used to determine chromatograms, and data were calculated using internal standards (37).

TBA Analysis: At the end of the treatments the level of MDA, a secondary oxidation product, was measured in 15 egg yolk samples from each treatment group (3 eggs from each replicated sub-groups)in order to detect the oxidative stability of the eggs. Egg yolk samples were stored in the refrigerator at +4 °C and the yolk lipid oxidation value was determined spectrophotometrically by the TBA analysis method (30) on the 1st, 7th and 28th days.

Statistical Analysis: Statistical Package for Social Sciences version 22.0 (SPSS, Chicago, IL, USA) was used to statistically evaluate the data of research. Performance parameters (feed intake, feed efficiency, egg production, egg weight), internal-external egg quality parameters, and yolk MDA level were evaluated with One Way ANOVA test. Values are expressed as arithmetic mean ± standard error of the mean (SEM). Tukey test was used as a post hoc test, and the significance level was considered as $P<0.05$ in all tests applied to the research data (45).

Results

The chemical composition, specific gravity value (0.961 g/mL) and amounts of fennel VO added to the diets of laying quails are given in Table 1 and Table 2, respectively. The specific gravity value of fennel VO was used to calculate the amount of VO to be added to quail diets. The main active components of fennel VO were trans-anethole (70.58 %), fenchone (10.50 %), estragole (5.01), 1,8-cineole (3.20 %), γ-terpinene (2.03 %), p-cymene (1.32 %), β-myrcene (1.30 %) and linalool (1.30 %). The ingredients and chemical composition of the basal diet are shown in Table 3. The nutrients (dry matter, ash, crude protein, ether extract, calcium, total phosphorus) and calculated metabolizable energy value of the basal diet detected by analysis were found within the normal range reported by the NRC for laying quails (36).

The addition of different levels of fennel VO to laying quail diets did not affect feed efficiency and egg weight. However, both levels of fennel VO increased feed intake ($P<0.05$) and egg production ($P\leq0.001$). The internal (haugh unit, egg yolk) and some external (shape index, eggshell breaking strength) quality parameters of eggs were not affected by the addition of fennel VO to the diets. At both levels of fennel VO, eggshell thickness increased significantly ($P<0.001$), and a decrease in the rate of damaged eggs was observed ($P<0.05$). While no difference was detected in the MDA levels of egg yolks stored in the refrigerator (+4 ºC) among the control and experimental groups on day 1, both levels of fennel VO reduced egg yolk MDA levels on days 7 and 28 ($P<0.01$).

Discussion and Conclusion

In this study; the main phenolic compounds in fennel VO added to laying quail diets were trans-anethole, fenchone, estragole, 1,8-cineole, γ-terpinene, linalool, β-myrcene and p-cymene (Table 1). The composition of VO in aromatic herbs can be affected by many factors like the type and variety of the herb, soil structure, climate, harvest time, extraction method and storage conditions of the extract.

The addition of fennel VO to the laying quail diets in the experimental group significantly increased feed intake compared to the control group (Group 1; 37.47 and Group 2; 36.93 vs Control; 34.37) (Table 4). While both dietary levels of fennel VO significantly increased egg production of quails, it did not affect feed efficiency (kilograms of feed: kilograms of eggs, kilograms of feed: dozen eggs). Buğdaycı et al. (11) added fennel seeds to the diets of laying quails at levels of 0.3 %, 0.6 % and 0.9 %, and they reported that fennel had no effect on

feed intake and feed efficiency (kilogram feed: dozen eggs) parameters. Nasiroleslami and Torki (35) investigated the effects of adding 300 mg/kg ginger or 300 mg/kg fennel VO to the diets on laying hen's performance. In the study, neither ginger nor fennel VO effected feed intake, feed efficiency and egg production. Contrary to the studies mentioned above, there are studies that support the performance data obtained from the current study, as well. In a study conducted by Yeşilbağ (49), the 300 mg/kg level of fennel VO in the diet caused a significant increase in feed efficiency and egg production of laying quails. In another study (2); the effects of phytogenic herbs on performance and egg quality in laying hens were examined, and fennel seeds, black cumin seeds and hot red pepper were added to the diets at the same level (5 g/kg). As result, it was stated that the best results were obtained from quails fed with fennel seed supplemented diet. Kazami-Fard et al. (29) reported that fennel VO at the level of 50 mg/kg in diet significantly increased the egg production of broiler chicken breeders. Sachdev et al. (41) suggested that the increase in egg production of poultry may be due to the presence of unsaturated fatty acids necessary for egg production, such as linolenic acid in fennel extract. It is stated that a significant percentage of the fatty acids contained in fennel seeds are linoleic (71.31%) and linolenic (11.66 %) fatty acids (3). In this study, it is considered that the higher feed intake of quails in the groups fed with diets containing fennel VO contributed to anincrease in egg production.

The addition of fennel VO to the laying quail diets did not have any effect on the shape index, breaking strength, haugh unit and yolk color of the eggs in the current study. However, both levels of fennel VO resulted in an increase in eggshell thickness, and a decrease in the rate of damaged eggs (Table 5). Bugdaycı et al. (11) added fennel seeds at different levels (0.3 %, 0.6 % and 0.9 %) to the diets of laying quails, and the researchers stated that fennel did not cause any effect on the internal and external quality parameters of the eggs. In another study (35), the addition of 300 mg/kg ginger or 300 mg/kg fennel VO to laying hen diets had no effect on egg quality parameters except haugh unit and eggshell thickness. It was observed that hens fed with a diet containing 300 mg/kg fennel VO had lower haugh unit, but higher eggshell thickness compared to the other groups. Yeşilbag (49) reported that rosemary (300 mg/kg) or fennel (300 mg/kg) VO added to the diets of laying quails improved eggshell thickness, yolk color and haugh unit. In the study, it was expressed that there was no significant difference in egg weight, egg mass, egg shape index and egg breaking strength between the control and experimental groups. Moreover, Gharaghani et al. (23) reported that the increase in damaged egg rate, which occurs as a result of low feed intake and poor egg calcification in laying hens raised under heat stress, can be greatly alleviated by adding fennel to the diets. It is stated that this may be related to the decrease in the amount of oxidative products formed in the reproductive organs due to the presence of antioxidant components in fennel and its positive effect on eggshell calcification.

Briefly, in this study, adding fennel VO to quail diets had no effect on egg internal and external quality parameters, except shell thickness and damaged egg rate. In this study, the improvement in eggshell quality of quails in the experimental groups may be due to the effect of anethole, which is the main active component of fennel VO. In our study, the analyzed anethol level of fennel VO added to the quail diets was 70.58 % (Table 1). It has been propounded that anethole has an estrogenic effect similar to phytoestrols and that steroidal estrogens increase the intestinal absorption of calcium by activating 1-α-hydroxylase enzyme in the kidneys (46). Additionally, in the current study, the decreased rate of damaged eggs in groups fed diets containing fennel VO may be related to higher calcium intake as a result of fennel VO increasing feed intake.

MDA levels in the yolks of eggs kept in the refrigerator (+4 oC) on the 1st, 7th and 28th days of storage were determined according to the TBA analysis procedure. The purpose of this analysis was to determine the effect of fennel VO on lipid oxidation. In parallel with the increase in the oxidation degree of lipids in the egg yolk during storage, there is an increase in the level of MDA, which is the secondary oxidation product. Although there is no significant difference in egg yolk MDA values on the first day of storage, egg yolk MDA levels) were decreased on the 7th (0.136 and 0.105 vs 0.438) and 28th (5.489 and 5.102 vs 6.794) days of storage in both levels of fennel VO (200 or 400 mg/kg diet).

The data obtained are consistent with the results of previous studies reporting that Fennel VO reduces the level of MDA by preventing the oxidation of lipids in the egg yolk. In a study by Cengiz (14), 50:50 % rosemary or

fennel (100 mg/kg rosemary + 100 mg/kg fennel or 200 mg/kg rosemary + 200 mg/kg fennel) VO was added to quail diets and diets enriched with rosemary and fennel VO contributed a significant decrease in meat MDA level on the 15th day of storage at +4 °C compared to the control group. Deniz et al. (16) stated that 200 or 400 mg/kg rosemary VO levels in laying quail diets remarkably reduced egg yolk MDA values on the 7th and 28th days of storage at +4°C. The 1,8-cineole and α pinene, which are among the most active antioxidant components in rosemary VO (27), are among the active components of fennel VO used in this research. Gharaghani et al. (23) reported that an increase in egg MDA levels was detected in laying hens exposed to heat stress, whereas MDA levels decreased significantly in eggs obtained from groups fed diets containing different levels of fennel fruits (0, 10 and 20 g/kg). In the current study, it is thought that the decrease in MDA levels in the egg yolks of the experimental groups is due to other antioxidant active components (1,8-cineole, α pinene etc.), especially anethole in fennel VO.

Based on theliterature mentionedabove, it is noteworthy that the studies investigating the effects of herbal extracts on poultry have different results (performance parameters, product quality etc.), althoughthe same poultry species and herb extract are used. It is suggested that this may be due to many factors including the composition of the basal diet and extract level used , extraction methods, feed intake, and the variability in environmental conditions (9, 25).

Consequently, the addition of 200 or 400 mg/kg fennel VO to laying quail diets increased feed intake, egg production, eggshell thickness. Meantime, both levels of fennel VO reduced the egg yolk MDA values during storage of eggs at +4 °C and damaged egg rate, without adversely affecting other parameters of studies. Based on the data obtained from laying quails it was concluded that fennel VO could be used as a natural feed additive in poultry diets to increase performance, improve eggshell quality, and minimize storage losses by extending the egg shelf life. Additionally, the results of this study proved that fennel VO is a beneficial source as a natural antioxidant.

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Table 1. Analysed Chemical Composition of Fennel VO.

Fennel VO	
Components	**(%)**
Trans-Anethole	70.58
Estragole	5.01
Fenchone	10.50
1,8-cineole	3.20
γ-Terpinene	2.30
p-cymene	1.32
Linalool	1.30
β-myrcene	1.30
α-Pinene	0.59
Camphor	0.40
β-pinene	0.30
3-methylbutanol	0.20

Table 2. Specific Gravity Value and Amounts of Fennel VO Supplemented to Quail Diets.

Specific Gravity*	**Control**	**Group1**	**Group2**
0.961 *g/mL*	-	*200 mg/kg diet*	*400 mg/kg diet*
	-	0.208 *ml*	0.416 *ml*

*This value was used to calculate the amount of fennel VO to be added to treatment diets.

Table 3. Basal Diet's Ingredients and Chemical Composition (as fed basis).

Ingredients, %	
Corn Grain	45.19
Soybean Meal (CP, 44%)	22.95
Full Fat Soybean (CP, 36%)	13.00
Wheat	4.00
Sunflower Meal (CP, 28%)	3.00
Vegetable Oil	3.70
$CaCO_3$	6.41
DCP	1.00
NaCl	0.30
DL-Methionine	0.10
Vitamin-Mineral Premix[a]	0.25
Analyzed values, %	
Dry matter	89.85
Crude Protein	20.40

Ether Extract	7.88
Ash	10.72
Calcium	2.57
Total Phosphorus	0.60
Available Phosphorus[b]	0.35
Metabolisable Energy, Kcal/kg[b]	2902.69

[a]Provides per kg diet: riboflavin 3 mg, niacin 20 mg, thiamin 3 mg, biotin 0.03 mg, pyridoxal 3.5 mg, pantothenic acid 4 mg, folic acid 1mg, choline 600 mg, cyanocobalamin 0.01 mg, retinol 2.4 mg, α-tocopherol acetate 20 mg, cholecalciferol 0.075 mg, Mn 80 mg, Fe 60 mg, Zn 60 mg, Se 0.15 mg, Co 0.2 mg, Cu 5 mg, I 1 mg.
[b]Calculated value.

Table 4. Performance Parameters of Laying Quails.

	Control			**Group 1**			**Group 2**			
Fennel VO (mg/kg)	**0**			**200**			**400**			**P**
Feed intake, g/d	34.37	±	0.67[b]	37.47	±	0.47[a]	36.93	±	1.17[a]	<0.05
Egg production, %	73.32	±	2.58[b]	83.32	±	1.12[a]	82.24	±	1.77[a]	≤0.001
Egg weight, g	11.00	±	0.10	11.07	±	0.11	11.15	±	0.12	>0.05
Feed efficiency, kg /kg	4.35	±	0.21	4.08	±	0.08	4.01	±	0.11	>0.05
Feed efficiency, kg /dozen	0.58	±	0.03	0.54	±	0.01	0.54	±	0.02	>0.05

The difference between the means with different letters in the same row is significant (P<0.05).

Table 5. Egg Quality Parameters of Laying Quails.

	Control			**Group 1**			**Group 2**			
Fennel VO (mg/Kg)	**0**			**200**			**400**			**P**
Shape index	77.28	±	0.29	77.90	±	0.38	77.22	±	0.55	>0.05
Eggshell thickness, µm	0.13	±	0.00[b]	0.15	±	0.00[a]	0.15	±	0.00[a]	<0.001
Eggshell breaking strength, N/cm^2	13.17	±	0.23	13.00	±	0.25	13.47	±	0.25	>0.05
Haugh unit	90.43	±	0.49	90.44	±	0.54	90.25	±	0.50	>0.05
Yolk color	11.72	±	0.06	11.67	±	0.07	11.73	±	0.06	>0.05
Damaged egg, %	1.05	±	0.26[a]	0.55	±	0.14[b]	0.39	±	0.14[b]	<0.05

The difference between the means with different letters in the same row is significant (P<0.05).

Table 6. MDA Levels in Egg Yolk Samples.

	Control			**Group 1**			**Group 2**			
Fennel VO (mg/kg)	**0**			**200**			**400**			**P**
Day 1	0.052	±	0.010	0.036	±	0.007	0.038	±	0.007	>0.05
Day 7	0.438	±	0.100[a]	0.136	±	0.022[b]	0.105	±	0.009[b]	<0.01
Day 28	6.794	±	0.408[a]	5.489	±	0.177[b]	5.102	±	0.216[b]	<0.01

The difference between the means with different letters in the same row is significant (P<0.05).

Current Salmonella Serovar Distribution in Broiler Carcasses of Slaughterhouse Origin

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This study was conducted to determine the serotypes in salmonellae isolated from broiler carcasses of slaughterhouse origin A total of 104 salmonellae isolated from broiler carcasses by the ISO 6579-1:2017 method, which were confirmed by Salmonella-specific real-time PCR in our laboratory between 2021 and 2023 were used as material. Gold Standard conventional serotyping method was performed to determine the serovar distribution of the isolates. Serogrouping and serotyping were performed using commercial antisera by slide and tube agglutination tests, respectively. Results were evaluated based on the White-Kauffmann-Le Minor Scheme. Serotyping results indicated that the most dominant serovar among broiler isolates was Salmonella Virchow (86/104, 82.70%) followed by S. Schwarzengrund (15/104, 14.42%) as the second most prevalent serovar. Out of the remaining 3 isolates, 1 isolate (1/104, 0.96%) was identified as Salmonella Bredeney, while 2 isolates (2/104, 1.92%) could not be serotyped. Study results are of significance in terms of demonstrating the absence of Salmonella Enteritidis and Salmonella Typhimurium, as mandated to be tested for their presence in broiler carcasses according to our regulations, whereas revealing the presence of various other pathogenic Salmonella serovars. Additionally, these findings provide original and unbiased data to national and international literature regarding currently circulating Salmonella serovars in broilers in Türkiye.

Keywords: Salmonella; serovar; broiler; carcass

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2024 International Poultry Congress

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SESSION 10

WPSA Student Event

Secrets of Success in Science

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Scientific excellence is fundamentally nourished by an endless curiosity and a desire to uncover the undiscovered. Scientists advance the scientific process by carefully observing the world around them and constantly questioning existing relationships. This approach determines the direction of scientific research and forms its basic structure. Scientists ensure the continuous evolution and expansion of knowledge by asking new questions and offering criticisms based on existing information. This constant questioning and critical thinking are key to scientific progress and lead researchers to the threshold of new discoveries. Interdisciplinary collaboration in the research process necessitates the synthesis of data from different fields of knowledge, leading to the production of innovative solutions beyond isolated disciplines. This requires scientists to quickly adapt to new technologies, methods, and theories, and integrate these innovations into their work. This adaptation process reflects the dynamic nature of scientific progress, demonstrating the continuous evolution of research and development activities.

Scientific work also requires collective effort. Sharing research findings, receiving critical feedback, and interdisciplinary collaboration are vital for the advancement of the scientific community. This process enables the evaluation of research from a broader perspective and helps preserve scientific accuracy. Failure is an inevitable part of the scientific process and offers valuable learning opportunities. It allows for the refinement of knowledge through the testing of hypotheses, examination of theories, and improvement of methodologies. Scientists expand the boundaries of scientific inquiry by learning from their mistakes and using these experiences to shape future work. Finally, the foundation of success in science rests on high ethical standards and a responsibility to serve society. Research should be designed and conducted in a way that contributes to the benefit of humanity. This requires researchers to conduct their work in accordance with principles of transparency and responsibility, taking into account the social and environmental impacts. Ethics in science covers not only research methods but also how knowledge is used and shared, thereby contributing to the preservation of scientific integrity.

Keywords: Scientific excellence; scientific research; ethics in science

education organization research

2024 International Poultry Congress

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POSTER PRESENTATIONS

The Place and Importance of Bursa Province in Türkiye Poultry Production

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Bursa province is a city of history, tourism, art, trade and industry located in the south of the Marmara Region. It has important advantages depends by its location on Türkiye's geography and ecological structure. The geographical and historical location of the province and its distance to the important and developed centres of the country have improved land, sea and even air transportation alternatives. This creates a great advantage for the poultry industry. The breeder material needed by our country is supplied from abroad at a rate of 98.5-99.0% in layer breeder and 100% in broiler breeder. It is extremely important for the sector to have integrations with large-scale breeder enterprises in Bursa. In the poultry sector, Bursa has advantages in terms of knowledge, production technology, proximity to markets, production in line with EU norms, product processing capacity, export potential, added value and intense employment provided by the sector. In this study, information is given about the development of poultry farming in Bursa from the past to the present and its place and importance in Türkiye's poultry sector.

Keywords: Poultry sector; Bursa; breeder; integration

Introduction

Poultry species have undergone the most striking change in their production characteristics compared to all farm animal species raised. Originally raised as a food source in rural and urban life, poultry is now used in industrial-scale production in many countries. Multinationals and a small number of large breeding companies have dominated this change. Of course, small-scale poultry farming remains important in many countries, but the size of the industrial poultry sector dwarfs this. As a result, poultry production is carried out by a wide range of producers, ranging from substantial industrialised units in developed countries to small family-based farming units in parts of India, much of Africa and Southeast Asia.

Poultry farming has become a giant sector with its breeder enterprises, production enterprises, the industry where the products are processed, and the industrial branches from which it receives input. There has been rapid progress in the poultry sector, especially since 1980. Along with the rapid development in the technology used in production, the same progress has been achieved in marketing organisation, organisation and market potential.

According to UN data, the world population reached 6 billion in 1999, 7 billion in 2011, and 8 billion in 2022; according to UNFPA's "2023 State of the World Population Report", the current figure has exceeded 8 billion and will be 9.55 in 2050; in 2100 it will be 10.85 billion. The population in Türkiye is constantly increasing. While the population of Türkiye was 21 million in 1950, it reached 85 million in 2022, and it is estimated to be 93.5 million in 2050.

Bursa province is located south of the Marmara Region and is a city of history, tourism, art, trade and industry. Its location in Türkiye's geography and ecological structure has important advantages. The geographical and historical location of the province and its proximity to important and developed centres of the country have enabled the development of land, sea and even air transportation alternatives. The agriculture-industry relationship is extremely developed in Bursa. Food industries such as canned food, fruit juice, frozen food, oil and tomato paste are based on agricultural production in the province. At the same time, animal products are also an important source of income. According to TUIK 2020 data, 10.2% of the employed population is in agriculture, 40.4% is in industry, and 49.3% is in the services sector (Anonymous, 2023).

This study aims to give information about the place and importance of poultry farming in Bursa Province in Türkiye.

World Poultry Production

Chickens dominate the global poultry production sector, but other species, including Türkiyes, ducks, geese,

guinea fowl, pheasants, partridges, quail and pigeons, are also important in many countries. FAO (2019) data shows that the annual poultry meat sector in 2017 was dominated by chicken meat, with an estimated production of 109 million tons, followed by Türkiye meat (6 million tons), duck meat (4 million tons), goose meat and guinea fowl (3 million tons), respectively. OECD/FAO (2016) estimates that world meat production and consumption will increase by 48 million tons by 2025. Approximately 44% of the total production increase will be made up of poultry meat, and this increase will correspond to other types of meat. More than 70% of the increase in poultry production is expected to come from low- and middle-income countries, and the increase in consumption is expected to occur more equally across regions and income levels globally.

According to FAO (2021) data, the world's poultry population is 28 billion, of which 93.6% is chicken, 4.0% is duck, 1.3% is Türkiye, and 1% is goose and guinea fowl. Poultry meat production is 138 million tons, of which 88.1% is chicken meat, 4.2% is Türkiye meat, 4.5% is duck meat, and 3.2% is goose and guinea fowl. World egg production is 92.6 million tons, 93.3% of which are chicken eggs (Gülaç, 2023). Egg production varies significantly between countries, but the egg industry in different countries also varies greatly in many respects. These differences include legislation, consumer preferences, and various growing systems.

Poultry Production in Türkiye and Bursa

In Türkiye, an integration model is generally used in poultry production, that is, a production model that includes breeder flocks, hatcheries, broiler flocks, feed silos, slaughterhouses and processing facilities and marketing (Gülaç, 2023). In our country, Bursa is one of the cities where fully integrated organisations are located.

According to 2022 data, the number of poultry in Bursa province constitutes 5.04% of the number of laying hens, 2.15% of broiler chickens, 0.38% of Türkiyes, 0.74% of ducks and 2.10% of geese in Türkiye (Table 1). According to 2022 data, Bursa province accounts for 5.32% of Türkiye's table (fresh) egg production, 13.84% of incubated broiler egg production, 30.35% of layer breeder egg production and 2.24% of chicken meat production. It produces fame (Table 2).

Table 1. Poultry presence in Türkiye and Bursa province

2022	Layer	Broiler	Türkiye	Duck	Goose
Bursa, piece	5 534 802	5 398 019	13 841	10 236	9 088
Türkiye, piece	109 806 000	251 290 000	3 670 000	1 386 000	432 000

Reference: Anonymous (2023), TUİK (2023)

Table 2. Türkiye and Bursa province poultry data

2022	Table Egg, piece	Broiler Breeder Egg, piece	Layer Breeder Egg, piece	Poultry Meat, tonne
Bursa	1.053.462.367	243.168.365	58.720.539	54.118
Türkiye	19.808.539.000	1.756.970.000	193.464.000	2.417.995

Reference: Anonymous (2023), TUİK (2023)

Broiler chicken production in Türkiye is concentrated in the Southern Marmara, Adapazarı and Bolu provinces. Bursa is an important place in terms of both the number of producing enterprises and the total chicken meat production in its region and throughout Türkiye. According to 2022 data, there are 47 meat-type breeder enterprises in Bursa Province, constituting 8.97% of meat-type breeder enterprises throughout Türkiye. These enterprises raise 12% of the total number of meat-type breeders in Türkiye in total capacity. According to 2022 data, 27,315,877 broiler chicks were produced in Bursa.

According to the data from the same year, there are 147 commercial broiler chicken farming enterprises in Bursa Province, constituting 1.60% of the broiler chicken enterprises in Türkiye. These enterprises produce 2.29% of Türkiye's total broiler chicken production in total capacity.

According to 2022 data, there are ten layer-type breeder enterprises in Bursa Province, constituting 2.31% of layer-breeder enterprises in Türkiye overall. These enterprises raise 19.23% of the total number of layer breeders

in Türkiye in total capacity. According to 2022 data, 16,604,251 layer chicks were produced in Bursa.

According to the data of the same year, there are 34 commercial layer enterprises in Bursa Province, constituting 0.60% of the layer enterprises in Türkiye in general. These enterprises raise 4.40% of Türkiye's total layer hen production in total capacity (Anonymous, 2023).

When we looked at the export products of Bursa province in 2022, it was determined that the highest product value was exported to frozen chicken and Türkiye meat products, table eggs, breeder eggs and chicks, respectively, while breeder chicks with a value of 45,508,000 dollars were imported (Table 3).

Table 3. Export and Import data of the poultry sector in Bursa

2022	Product quantity	Product value ($)
Export		
Frozen Chicken-Türkiye Meat Products	30.804.732 kg	45.508.000
Table Egg	12.449.486 piece	17.095.576
Broiler/hatchery/breeder eggs	3.876.696 piece	14.637.723
Chick	115.510 piece	993.178
Imports		
Breeder chick	366.863 head	45.508.000

Reference: Anonymous (2023), TUİK (2023)

Bursa's Strengths, Weaknesses, Opportunities and Threats in the Poultry Industry

Strong Points

Ecological conditions and climate suitable for poultry production,
Türkiye's population exceeds 80 million, and the increasing importance of Bursa in the Marmara region,
Proximity to major consumption centres,
Increase in poultry meat and egg consumption,
EU, pre-accession financial assistance tool IPARD supports,
The location of the Marmara region in poultry production offers important export opportunities,
Increase in productivity due to coop construction and poultry automation,
Strong technology and innovation,
The existence of legal regulations regarding poultry.

Weak Points

The predominance of small-capacity businesses in a highly fragmented structure.
Türkiye's poultry meat and egg export problems to EU countries have not been resolved.
High macroeconomic risks.
Automation poultry systems that will increase efficiency create high costs.
The increase in feed raw material prices increases the input costs of the poultry industry.

Opportunities

Bursa's geographical location offers very important trade opportunities.
Türkiye's possible EU membership may offer important export opportunities for poultry products in the future.
The presence of strong local companies in the poultry industry,
Existence of legal legislation on environmental protection, quality and food safety for poultry production.
Increasing trend in poultry production and consumption from year to year.

Threats

Variable feed raw material prices.
Despite public awareness efforts, prejudice against poultry products in a segment of the society.

After the Avian Influenza that can be seen in our country and region, our exports will be interrupted. High temperatures and adverse weather conditions pose a threat to poultry production.

Conclusion

Bursa is one of the provinces where poultry products are produced intensively throughout Türkiye. It is important in total chicken production, breeder and layer poultry farming, especially with enterprises producing fully and partially integrated broiler chickens. This study tried to reveal the place and importance of poultry and poultry production in Bursa.

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A Combination of Competitive Exclusion Product and Probiotic to Favor Muscle, Skeleton and Immune Organ Development in Chicks

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In broiler production, the kinetics of organ (muscle, bone, immune organs) development is very fast after hatching and can be efficiently sustained by adequate early life nutrition. The objective of the study was to evaluate in a field trial the effect of a combination of 2 probiotics (competitive exclusion product and a strain of Pediococcus acidilactici) on organ development in chicks. In the same commercial farm (France, 2023), 2 field trials were performed in May (batch 1) and October (batch 2) comparing 2 barns: one control (C) and one supplemented with a combination of competitive exclusion product (AviGuard, Lallemand, 1 dose/bird at start by spraying) and probiotic (P. acidilactici CNCM I-4622, Bactocell Drink, Lallemand, 5×1011 cfu/m3 in drinking water) during 30d (supplement, S) (n = 20 000 birds/barn, Ross 308 mixed sex). 8 chicks/group were randomly selected and humanely sacrificed at 13d (batch 1, bodyweight (BW): 402±32g) and 21d (batch 2, BW: 1404±107g) and the relative weights of organs (pectoralis muscle - PM, keel bone, Bursa of Fabricius – BF, spleen) calculated from live BW (including the esophagus and digestive tract) were recorded. PM thickness was individually measured by non-invasive ultrasonography, the resorption of yolk sac was individually noted, and the level of PM fat and proteins was analyzed on 2 pools of 4 chicks per group. Litter dry matter (DM, %) and total N (N×6.25) were analyzed on 2 litter (straw) samples per group (8 random sampling spots per barn: 4 samples pooled in 2 bags per barn) and muscle scoring for petechia was individually performed (score 1: few; score 2: numerous). The relative weights of organs were statistically analyzed by T-test and yolk sac resorption by Chi2 test. A predictive equation of PM weight was also established by linear regression with the live weight (LW) and the PM thickness as predictors. In batch 1, keel bone (C: 2.9%, S: 4.5%, $P<0.01$) and pectoralis muscle (C: 14.2%, S: 16%, $P<0.05$) were heavier in S group, while PM quality was improved by S in batch 2 with less petechia (C: 100% score 2, S: 100% score 1, $P<0.001$), higher protein level (C: 88.9, S: 92.1 g/100g DM) and lower fat level (C: 6.6, S: 4.8 g/100g DM). In batch 2, the yolk sac was completely resorbed in S group (C: 63%, S: 100% of resorption, $P<0.1$) and BF was heavier in S group (C: 0.148%, S: 0.2%, $P<0.1$), leading to increased BF/spleen ratio (C: 1.77, S: 2.60, $P=0.01$). The measurement of PM thickness allowed to establish the following predictive equation: PM weight = 0.20×LW + 1.76×PM thickness - 41.83 ($R2=0.98$, $P<0.001$). Litter DM increased and total N decreased in S litter (DM: C: 57.5%, S: 59.8%; total N: C: 247.5, S; 228.4 g/kg DM). These results highlight the efficiency of this supplement to favor muscle, skeleton and immune organ development in chicks, while promoting healthy litter.

Keywords: Probiotic; organ development; chick

Effect of Yeast Cell Wall Supplementation on Broiler Performance: Analysis of 3 Trials

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In the context of antibiotic growth promoters' replacement, mannan oligosaccharides (MOS) originated from yeast cell wall (YCW) and used as feed supplements in poultry diets appear interesting to promote performance and to induce positive physiological effects. The objective of this study was to investigate the effects of dietary supplementation of a new commercial YCW product (Optiwall, Lallemand) on zootechnical performance of broilers raised in standard commercial conditions. Three consecutive trials were performed in a small experimental farm in France during 35 days on Ross 308 broiler chicks males (trials 1 and 3) and females (trial 2) randomly allotted at day 0 into 2 groups (13-15 birds/pen): control (C: n = 6 pens/trial, 248 birds in total: 80, 78, 90 birds for trials 1, 2, 3, respectively) and Optiwall (O: n = 7 pens/trial, 289 birds in total: 93, 91, 105 for trials 1, 2, 3, respectively) supplemented at 2 kg/ton feed. The same starter crumble diet (corn, wheat, soybean meal) produced by Qualisol (France) was used for the 3 trials during the whole trial duration (35 days). Feed and water were provided ad libitum. Body weight (BW) and feed refusals were recorded at days 0, 11, 18, 25 and 35. Average daily gain (ADG), feed intake (FI) and feed conversion ratio (FCR) were calculated for each period. The combined analysis on the 3 trials for FI and FCR was performed until D25 as FI was not recorded for the last period (25_35) in trial 1, and until D35 for BW and ADG. Broiler performance was analyzed by 2-way ANOVA with the group, the trial and their interaction as fixed effects, while mortality was analyzed by Kaplan-Meier test. O decreased mortality by 3.4 pts (C: 6.5%, O: 3.1%, $P<0.1$), increased BW at D35 by 5.6% (C: 1934 g, O: 2043 g, $P<0.001$) and improved ADG 0_35 by 5.7% (C: 54.1, O: 57.2 g/bird/day, $P<0.001$). While FI was not significantly different between the 2 groups at any time point, FCR appeared improved numerically at D25 (0_25): -1.9% (C: 1.565, O: 1.536) and significantly at D11: -6.5% (C: 1.447, O: 1.353, $P<0.05$). In conclusion, this new YCW product appears as an interesting solution to improve zootechnical performance of broilers.

Keywords: Yeast cell wall; broiler; performance

Investigation of the Usage Possibilities of Puncture Vine (Tribulus terrestris L.) Powder in Layer Hens

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Feed expenses take the largest share in the costs of livestock enterprises. In reducing the high cost of feed, it is very important to use mostly imported feed additives. The use of antibiotics and hormones used as growth factors has been banned by the European Union, and their use is also prohibited in our country. For this reason, consumers' demands for food products that use natural resources are increasing day by day. For this purpose, studies are being carried out on the use of herbal products (plant extracts, roots, bark, leaves, seeds, etc.) as an alternative to antibiotics and synthetic hormones in feed mixtures. The use of herbal products in the livestock and food industry is in demand primarily because they protect consumer health, are safe and are also economical. Recently, feed additive herbal extracts have been widely used in poultry rations in many countries. Puncture Vine (Tribulus terrestris) contains with saponins, flavonoids, glycosides, alkaloids and other components. In this study, the effects of the use of Puncture Vine (Tribulus terrestris) on layer hens were investigated. For this purpose, 15 literatures were examined. Studies conducted with Tribulus terrestris showed a decrease in serum and egg total cholesterol and serum glucose levels; It was determined that egg production, egg shell breaking strength and egg shell thickness, linoleic acid, total protein and calcium levels increased. More studies are needed on the use of Puncture Vine (Tribulus terrestris) as an alternative feed additive.

Keywords: Puncture vine (Tribulus terrestris); layer hens; herbal products

POSTBIOTICS as a New and Powerful Feed Additive in the Poultry Industry

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The poultry industry is one of the important sectors in the world and in our country, with its advantages such as meeting the animal protein needs of the society, providing high employment, modern integrated facility and technology investments, expert production, marketing network and high export capacity, and healthy and sustainable animal production. One of the most important factors contributing to progress in the sector is scientific developments in the field of animal nutrition. Because factors such as ration formulation, technological processes applied to feed, feeding practices and use of feed additives directly affect performance, intestinal health and the quality of the produced product. Many scientific studies are conducted on feed additives that specifically target intestinal health and thus significantly affect the bird's performance, immune system, carcass quality and production efficiency parameters, as well as business economy. Feed additives have recently included postbiotics, which can have a significant impact on intestinal health and the immune system. The International Scientific Association for Probiotics and Prebiotics (ISAPP) defines postbiotics as "non-living microorganisms and/or their components that provide health benefits to the host." Postbiotics are a product of controlled fermentation that can contain various biologically active substances such as proteins, small peptides, oligosaccharides, vitamins, minerals, enzymes and metabolites. Postbiotics are inactivated microbial cells or cell components and when taken into the organism, they have similar effects and benefits as probiotics. However, they are known to be more advantageous than probiotics because they are resistant to industrial feed processing technologies and maintain their stability during long-term storage processes. Postbiotics are very interesting to use in poultry farming due to their anti-inflammatory, hypocholestrolemic, antibacterial, immunomodulatory and antioxidant properties. One of the most researched postbiotics is the Saccharomyces cerevisiae fermentation product. Scientific studies have reported that the inclusion of this product in the diet increases live weight, feed conversion ratio and carcass yield in broilers and Türkiyes, and egg weight, yolk weight and hatchability in commercial layers and breeder chickens. In addition, it is known that it causes an increase in humoral and cellular immune responses by modulating the immune system. Studies have shown that postbiotics improve the intestinal microbiota towards beneficial microorganisms and reduce the number of pathogenic microorganisms such as Salmonella and Campylobacter. As a result, postbiotics are seen as a promising feed additive that can support the increase of animal health and performance parameters, increase production efficiency, and maintain the sustainability of economic and quality animal production and global food security.

Keywords: Intestinal health; performance; postbiotic; poultry

Using Herbal Products Rich in Phenolic Compounds to Combat Heat Stress in Poultry

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Today, global warming and climate change are serious problems that deeply affect crop and animal production. The environmental stress factor that affects poultry the most is high temperature. The sensitivity of laying hens to stress factors, especially high environmental temperatures, causes lipid peroxidation to occur with disruption of body homeostasis. Synthetic or natural antioxidant substances should be added to chicken rations to protect them from the negative effects of oxidative stress. Recently, the toxic and carcinogenic harmful effects of synthetic antioxidants, which are relatively cheap and easy to obtain, have been revealed and a tendency towards natural alternatives has begun. There has been an increase in studies on plant-derived antioxidants that do not have the harmful effects caused by synthetic antioxidants, are reliable, have potential nutritional properties and have therapeutic effects. Fruits and vegetables, which are the most important sources of antioxidants, are rich in polyphenols and phenolic compounds. In addition to antioxidant properties, phenolic compounds also have antiallergic, antiviral, anti-inflammatory and antimutagenic properties. To date, natural antioxidants have been produced from many plants and spices such as grape seeds, sage, cumin, thyme and ginger. Failure to meet the increasing supply demand in agriculture and animal husbandry leads to the search for alternative methods. In recent years, there has been an increase in the number of studies conducted to make more active use of plant resources rich in phenolic compounds. This review aims to provide information about herbal products used against heat stress in poultry in recent years.

Keywords: Poultry; phenolic compound; herbal product; antioxidant

The Impact of Reduced Dietary Protein and Threonine, Arginine, and Tryptophan Supplements on Broiler Chicken Growth, Carcass Characteristics, and Intestinal Morphology

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The study investigated how decreasing dietary protein and using threonine, arginine, and tryptophan supplements impact broiler chickens. The experiment used 360 Ross 308 broiler chicks divided into six treatments, five replicates. The experimental treatments include: 1) Standard diet, 2) Standard diet + synthetic amino acids, 3) 10% reduced protein diet, 4) 20% reduced protein diet, 5) 10% reduced protein diet + synthetic amino acids, and 6) 20% reduced protein diet + synthetic amino acids. Reducing dietary protein by 10% and 20% led to decreased weight gain. The 20% reduction significantly impacted weight gain throughout the experiment, especially in the starter and finisher periods. It also decreased feed intake, while a 10% reduction didn't make a significant difference. Lower protein levels affected the feed conversion ratio, with synthetic amino acid supplements improving weight gain and feed conversion ratio, except in the finisher period. A 20% decrease in dietary protein led to reduced carcass yield and intestine length relative to body weight. The use of synthetic amino acid supplements resulted in a reduction in relative pancreas weight and the ratio of intestine length to body weight. In the duodenum, villi length was not affected by protein levels, but villi thickness increased with reduced protein consumption. In the jejunum, villi height and thickness decreased with lower protein intake, and crypt depth also decreased significantly with a 10% protein reduction. The thickness of the muscular layer increased in the jejunum and ileum with reduced protein consumption. Intestinal morphology was significantly impacted by synthetic amino acid supplements, including reductions in villi height and increased crypt thickness in the jejunum, and increased muscular layer thickness in the ileum. A diet with 20% less crude protein led to a significant increase in serum HDL concentration compared to the standard diet. Consumption of synthetic amino acids resulted in a significant increase in serum HDL level. Overall, there were significant interactions between dietary protein levels and synthetic amino acid supplements for total protein, albumin, and HDL. In conclusion, the study showed that reducing dietary protein decreased weight gain in broiler chickens, with a significant impact on feed intake and overall feed conversion ratio. The use of synthetic amino acid supplements improved weight gain and feed conversion ratio, with some effects on intestinal morphology and liver traits. These findings suggest that dietary protein levels and amino acid supplementation play important roles in broiler performance and physiological characteristics.

Keywords: Amino acids; broiler chickens; dietary protein; intestinal morphology; synthetic amino acids; weight gain

Introduction

Reducing the protein content in the diet of broiler chickens using diets containing commercial amino acids, including methionine, lysine, and threonine, offers improvements in chicken meat production and cost savings in the consumption of nutrients for chicks. This method allows important amino acids to be added to the diet and results in a reduction in crude protein in the diet. This approach leads to the preparation of diets rich in nutrients and better meets the amino acid requirements of broiler chickens (Kidd *et al*., 2013).

In a study, reducing the amount of crude protein in the diet from 210 to 165 grams per kilogram resulted in a decrease in the amount of soybean meal from 335 to 184 grams per kilogram. This 45% reduction in soybean meal was accompanied by an increase in synthetic amino acids. This study indicates that reducing the crude protein in the diet not only helps maintain desirable performance but also emphasizes reducing dependence on soybean meal. Decreasing the protein content can lead to risks such as increased fat deposition and digestive imbalance (Chrystal *et al.,* 2020a, 2020b). Additionally, this reduction can lead to nitrogen excretion and the release of ammonia into the environment, which is a critical issue and can raise concerns in countries like Europe (Nahm, 2007).

Low-quality bedding and the associated problems have become a welfare concern, but reducing raw protein in the diet can improve bedding quality and reduce foot pad lesions and other wastes (Dunlop *et al.,* 2016). The use of antibiotics in broiler diets has decreased, and diets with reduced raw protein can reduce the amount of undigested protein, which helps prevent the proliferation of potential disease agents. The current research was designed to investigate the effect of reducing 2 to 4% raw protein in the diet and using synthetic amino acids threonine, arginine, valine, isoleucine, and tryptophan on broiler chickens.

Material and methods

In this study, 180 broiler chicks of Ross 308 breed were examined. The experiment included 6 treatments and 6 replications, with each replication consisting of 5 chicks. Diets were formulated based on the specific nutrition regimen for Ross breed chicks. The total duration of the experiment was 42 days, including initial phases (days 1-10), growth phase (days 11-24), final phase and final 2 (days 25-42). Weight gain and feed intake were measured at different times and diets were adjusted accordingly. Weight and feed consumption were measured on specified days.

Experimental treatments included:
Ration containing the recommended level of crude protein and without synthetic amino acids,
Ration containing 2% less crude protein than the recommended level and without synthetic amino acids,
Ration containing 4% less crude protein than the recommended level and without synthetic amino acids,
Ration containing the recommended level of crude protein and with synthetic amino acids,
Ration containing 2% less crude protein than the recommended level and with synthetic amino acids,
Ration containing 4% more crude protein than the recommended level and with synthetic amino acids.

Synthetic amino acid supplements of threonine, arginine, valine, isoleucine, and tryptophan were used in this experiment. To calculate the amount of feed consumed per experimental unit, the remaining feed at the end of each rearing stage is subtracted from the total feed given. The average feed consumption per rearing stage has been calculated using the daily chicken method to determine the growth and feed consumption of the chicks lost during the experiment. To calculate the weight gain per unit in each time period, the difference between the final and initial weights of the growth period has been calculated. Before weighing, bird feed is withheld for 4 hours to ensure uniformity in digestive system conditions. Also, the feed conversion ratio has been calculated for different time periods by dividing the average feed consumed by the average weight gain of chicks for each period to calculate the conversion ratio.

On the 42nd day of the experiment, eight pieces of chicken from each treatment were selected. Blood was taken from these chickens through the wing vein. Then, the blood samples were collected in coagulation tubes and the serum was separated. This serum was kept at a temperature of 20 degrees Celsius. Then, the blood samples were sent to the laboratory for measuring triglycerides, cholesterol, HDL cholesterol, LDL, total protein, and albumin in the blood serum. The measurement of metabolites was done using enzymatic kits (Pars Azmoon Co, Iran) and a spectrophotometer. In the research, 2 chickens from each group were slaughtered and three sections of each chicken's intestine were examined for morphology. The intestines were processed, paraffin-embedded, sections were prepared, stained, and then subjected to microscopic and histomorphometric analysis. Morphological features evaluated included the height, depth, and width of the crypts, and the ratio of height to depth of the crypt. In this factorial experiment, the effects of the level of crude protein in the diet and the use or non-use of amino acid supplements on the performance of the animals under study were examined. The data was recorded and analyzed in Excel, and then analyzed using the SAS statistical software using the GLM method and 2*3 factorial analysis. Ultimately, to investigate significant differences between the means of the data, a Duncan's comparative test with a significance level of 5% was used.

Results and discussion

In this experiment, reducing the protein level in the diet by 2 and 4 percent from the recommended amount resulted in a decrease in daily weight gain of broiler chickens. This effect was significant in both the early and late stages of the experiment ($P<0.05$). Significant differences in weight gain were also observed in other periods among different groups of broiler chickens with varying levels of raw protein ($P<0.05$) (Table 2). In various rearing periods, reducing the protein level in the diet by less than 4% from the recommended level led to reduced feed intake in periods such as growth, early, and late stages ($P<0.05$). However, a 2% reduction in raw protein did not lead to a significant difference in feed consumption. Overall, reducing dietary protein led to a dose-dependent

decrease in feed intake ($P<0.05$) (Table 3).

Table 1. Experimental diets containing different crude protein levels and supplemented with synthetic amino acids

	STRTER							
	1	2	3	4	5	6	1	2
Corn	51.71	58.70	65.72	52.05	60.55	69.5	57.10	64.08
Soy Meal	39.71	33.54	27.35	39.23	31.32	22.95	34.25	28.08
Soy oil	3.98	2.88	1.76	3.87	2.4	0.84	4.50	3.40
DCP	2.04	2.09	2.15	2.04	2.12	2.19	1.76	1.82
CaCo3	1.05	1.06	1.07	1.05	1/06	1.07	0.93	0.94
Min Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.24	0.22	0.22	0.24	0.22	0.21	0.25	0.22
Ca(HCO3)3	0.16	0.19	0.19	0.17	0.19	0.19	0.15	0.19
DL- Met	0.37	0.41	0.45	0.37	0.43	0.49	0.33	0.37
L-Lys	0.24	0.41	0.59	0.25	0.48	0.72	0.23	0.40
Threonine	0	0	0	0.16	0.25	0.35	0	0
Valine	0	0	0	0.05	0.17	0.29	0	0
Isoleucine	0	0	0	0.02	0.14	0.27	0	0
Arginine	0	0	0	0	0.17	0.39	0	0
Tryptophan	0	0	0	0	0	0.04	0	0
	100	100	100	100	100	100	100	100
ME (Kcal/Kg)	3000	3000	3000	3000	3000	3000	3100	3100
CP %	22	22	20	20	18	18	20	20
Lys%	1.25	1.25	1.25	1.25	1.25	1.25	1.12	1.12
Met + Cys%	0.93	0.93	0.93	0.93	0.93	0.93	0.85	0.85
Met%	0.65	0.65	0.68	0.67	0.71	0.69	0.59	0.59
Threonine%	0.69	0.84	0.84	0.62	0.84	0.55	0.63	0.75
Valine%	0.90	0.94	0.94	0.81	0.94	0.72	0.82	0.85
Isoleucine%	0.82	0.84	0.84	0.73	0.84	0.64	0.74	0.76
Arginine%	1.35	1.34	1.29	1.19	1.19	1.03	1.20	1.19
Tryptophan%	1.60	1.58	1.42	1.47	1.25	1.35	0.21	0.21

Experimental treatments included: 1.Ration containing the recommended level of crude protein and without synthetic amino acids, 2. Ration than the recommended level and without synthetic amino acids, 4.Ration containing the recommended level of crude protein and with synthe 4% more crude protein than the recommended level and with synthetic amino acids.

GROWER				FINISHER					
3	4	5	6	1	2	3	4	5	6
71.08	57.37	65.98	74.95	62.44	69.42	76.43	62.66	71.38	80.35
21.90	23.85	25.82	17.41	28.85	22.68	16.50	28.53	20.38	11.97
2.29	4.41	2.92	1.36	5.04	3.94	2.83	4.97	3.46	1.89
1.87	1.77	1.83	1.91	1.47	1.53	1.59	1.48	1.56	1.63
0.95	0.93	0.95	0.96	0.82	0.83	0.84	0.82	0.83	0.84
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
0.22	0.25	0.22	0.21	0.26	0.22	0.21	0.25	0.21	0.21
0.19	0.16	0.19	0.19	0.14	0.19	0.19	0.14	0.19	0.19
0.42	0.33	0.39	0.45	0.28	0.32	0.36	0.28	0.34	0.40
0.58	0.24	0.47	0.71	0.20	0.37	0.55	0.21	0.44	0.68
0	0.13	0.23	0.33	0	0	0	0.10	0.20	0.30
0	0.04	0.16	0.29	0	0	0	0.03	0.15	0.28
0	0.02	0.15	0.27	0	0	0	0.03	0.15	0.28
0	0	0.18	0.41	0	0	0	0	0.20	0.42
0	0	0.01	0.04	0	0	0	0	0.01	0.06
100	100	100	100	100	100	100	100	100	100
3100	3100	3100	3100	3200	3200	3200	3200	3200	3200
18	18	16	16	17.5	17.5	15.5	15.5	13.5	13.5
1.12	1.12	1.12	1.12	0.94	0.94	0.94	0.94	0.94	0.94
0.85	0.85	0.85	0.85	0.73	0.73	0.73	0.73	0.73	0.73
0.62	0.61	0.65	0.64	0.49	0.50	0.53	0.52	0.55	0.53
0.75	0.56	0.75	0.48	0.55	0.63	0.63	0.47	0.63	0.40
0.85	0.73	0.85	0.64	0.71	0.73	0.73	0.63	0.73	0.54
0.76	0.65	0.76	0.56	0.64	0.65	0.65	0.55	0.65	0.46
1.16	1.04	1.16	0.88	0.02	1.02	0.99	0.86	0.99	0.70
0.18	0.18	0.18	0.15	0.18	0.18	0.15	0.15	0.15	0.12

containing 2% less crude protein than the recommended level and without synthetic amino acids, 3. Ration containing 4% less crude protein
tic amino acids, 5. Ration containing 2% less crude protein than the recommended level and with synthetic amino acids, 6. Ration containing

Table 2. Effect of dietary crude protein and synthetic amino acids supplementation on growth rate of broiler chickens

Treatment	Starter	Grower	Finisher	Total Period
Effect of Amino Acids				
Supplement -	14.12[b]	28.37	78.63	42.55[b]
Supplement +	15.32[a]	29.33	84.45	46.41[a]
SEM	0.34	1.03	2.10	0.90
P-value	0.01	0.51	0.06	0.005
Effect of Crude Protein				
Recommended	15.47[a]	33.48	90.00[a]	50.61[a]
2% less	15.03[a]	28.90	89.50[a]	46.18[b]
4% less	13.66[b]	24.18	65.12[b]	36.64[c]
SEM	0.41	1.26	2.57	1.10
P-value	0.01	0.001>	0.001>	0.001>
Amino Acid supplement × Crude Protein				
SEM	0.58	1.79	3.64	1.56
P-value	0.85	0.84	0.14	0.23

Different superscripts within a column indicate a significant difference (P<0.05).

Table 3. Effect of dietary crude protein and synthetic amino acids supplementation on feed intake of broiler chickens

Treatment	Starter	Grower	Finisher	Total Period
Effect of Amino Acids				
Supplement -	21.00	42.17	94.74	76.10
Supplement +	20.95	38.61	94.92	76.96
SEM	3.12	1.74	1.03	0.67
P-value	0.31	0.15	0.90	0.37
Effect of Crude Protein				
Recommended	21.20	48.72a	100.02[a]	83.43[a]
2% less	21.05	38.85b	97.88[a]	77.28[b]
4% less	20.68	33.59b	86.59[b]	68.88[c]
SEM	0.38	2.13	1.26	0.82
P-value	0.61	0.001>	0.001>	0.001>
Amino Acid supplement × Crude Protein				
SEM	0.54	3.02	1.79	1.17
P-value	0.02	0.70	0.43	0.90

Different superscripts within a column indicate a significant difference (P<0.05).

Table 4. Effect of dietary crude protein and synthetic amino acids supplementation on feed conversion ratio of broiler chickens

Treatment	Starter	Grower	Finisher	Total Period (1-42 d)
Effect of Amino Acids				
Supplement -	1.50_{a}	1.48_{a}	1.95_{a}	1.82^{a}
Supplement +	1.37_{b}	1.32_{b}	1.67_{b}	1.67^{b}
SEM	0.03	0.04	0.04	0.03
P-value	0.01	0.02	0.003	0.006
Effect of Crude Protein				
Recommended	1.37_{b}	1.45	1.58_{b}	1.65^{b}
2% less	1.40_{b}	1.36	1.84^{a}	1.69^{b}
4% less	1.55_{a}	1.39	2.00^{a}	1.89^{a}
SEM	0.04	0.06	0.06	0.04
P-value	0.01	0.53	0.001	0.001
Amino Acid supplement × Crude Protein				
SEM	0.06	0.08	0.08	0.06
P-value	0.22	0.39	0.09	0.07

Different superscripts within a column indicate a significant difference (P<0.05).

In the early, late, and overall rearing periods, a 4% reduction in diet protein significantly reduced the recommended level of raw protein (P<0.05) and a 2% reduction went slightly above the recommended level (P<0.05). However, no differences in feed conversion ratio were observed in the growth period with different levels of raw protein (Table 4).

The use of synthetic amino acid supplements affects the productive traits of broiler chickens. Supplementation with multiple amino acids leads to improved daily weight gain in starter and total growth periods (P<0.05). In the growing and second final periods, daily weight gain increased somewhat, but this effect was not statistically significant. The consumption of amino acid supplements did not have an effect on feed intake. These supplements have reduced the feed conversion ratio, and the observed differences in this regard have often been statistically significant (P<0.05). The interplay between dietary protein levels and amino acid supplements was only significant in terms of feed intake in the early period (P<0.05).

Table 5 shows that a reduction in protein levels in the diet can have various effects on carcass traits. A 4% reduction in crude protein intake resulted in a decrease in carcass percentage (P<0.05). An increase in the length of the intestines relative to body weight was also observed due to this protein reduction (P<0.05). The use of diets with lower protein content led to an increase in liver weight (P<0.05). On the other hand, the consumption of synthetic amino acid supplements led to a decrease in relative weight of the pancreas and the ratio of intestinal length to body weight (P<0.05). The result showed that there was no observable interaction between the diet protein level and synthetic amino acid consumption.

Table 5. Effect of dietary crude protein and synthetic amino acids supplementation on carcass traits of broiler chickens

Treatment	Carcass	Heart	Liver	Abdominal Fat	Bursa of Fabricius	Spleen	Pancreas	Small intestine length ratio
Effect of Amino Acids								
Supplement -	60.72	0.59	2.55	1.72	0.17	0.10	0.22a	9.14[a]
Supplement +	59.72	0.58	2.44	1.61	0.19	0.09	0.19b	8.34[b]
SEM	0.54	0.02	0.06	0.10	0.009	0.008	0.008	0.21
P-value	0.23	0.71	0.27	0.47	0.36	0.27	0.01	0.01
Effect of Crude Protein								
Recommended	60.31[ab]	0.56	2.22c	1.59	0.19	0.10	0.20	8.10[b]
2% less	61.59[a]	0.57	2.48b	1.61	0.17	0.09	0.21	8.22[b]
4% less	58.87[b]	0.63	2.79a	1.80	0.18	0.10	0.22	9.90[a]
SEM	0.67	0.02	0.08	0.12	0.01	0.009	0.009	0.25
P-value	0.02	0.18	0.002	0.43	0.45	0.67	0.51	0.001>
Amino Acid supplement × Crude Protein								
SEM	0.94	0.03	0.12	0.17	0.01	0.01	0.01	0.23
P-value	0.09	0.16	0.94	0.56	0.21	0.91	0.25	0.56

Different superscripts within a column indicate a significant difference (P<0.05).

By reducing the diet protein level, the length of villi had a significant increase (P<0.05), but the villi height in the jejunum decreased with the reduction of protein level (P<0.05). Additionally, the thickness of crypts in the duodenum and jejunum increased (P<0.05), but was not affected in the ileum. The significant effects of amino acid supplement consumption included a decrease in villi height and an increase in crypt thickness in the jejunum, and an increase in muscular layer thickness in the ileum (P<0.05). The interactive effects between diet protein level and amino acid supplement consumption on some intestinal morphology traits were evident (P<0.05) (Table 6).

Table 6. Effect of dietary crude protein and synthetic amino acids supplementation on small intestine morphology of broiler chickens

Treatment	Villus Height	Villus Thickness	Crypt Depth	Crypt Thickness	Muscular layer Thickness
Effect of Amino Acids					
Supplement -	1145.8	163.2	156.5	12.4	231.7
Supplement +	1135.3	141.8	182.6	17.7	198.2
SEM	65.19	12.4	10.49	1.86	13.4
P-value	0.91	0.23	0.09	0.05	0.09
Effect of Crude Protein					
Recommended	1087.3	116.4[b]	182.7	11.3	235.5
2% less	1103.2	198.1[a]	153.3	16.1	187.4
4% less	1231.1	143.8[b]	172.8	17.8	221.9
SEM	79.84	15.22	12.85	2.28	16.41
P-value	0.39	0.003	0.28	0.13	0.12
Amino Acid supplement × Crude Protein					
SEM	54.85	19.45	13.91	3.38	7.64
P-value	0.001	0.06	0.003	0.89	0.001

Different superscripts within a column indicate a significant difference (P<0.05).

In this study, it was observed that birds whose diet contained 10% less protein, had higher levels of total protein, albumin, total cholesterol, and serum triglycerides compared to the other two groups (P<0.05). Additionally, consuming a diet with 4% less raw protein led to an increase in serum HDL concentration, and this difference

was statistically significant compared to the standard diet (P<0.05). The increase in serum HDL levels due to the consumption of synthetic amino acid supplements was significant (P<0.05); however, other blood parameters were not affected. The interactive effects between the protein level in the diet and the consumption of synthetic amino acid supplements on total protein, albumin, and HDL were significant (Table 7).

Table 7. Effect of dietary crude protein and synthetic amino acids supplementation on serum parameters of broiler chickens

Treatment	Total Protein (mg/dl)	Albumen (mg/dl)	Cholesterol (mg/dl)	Triglyceride (mg/dl)	HDL (mg/dl)
Effect of Amino Acids					
Supplement -	3.05	1.45	168.28	159.83	50.22b
Supplement +	3.45	1.67	179.72	161.83	60.11a
SEM	0.17	0.11	11.45	14.22	2.69
P-value	0.11	0.20	0.48	0.92	0.01
Effect of Crude Protein					
Recommended	2.67^{b}	1.23^{b}	124.17^{b}	93.16^{b}	48.42^{b}
2% less	3.94^{a}	2.09^{a}	209.50^{a}	205.42^{a}	56.92^{ab}
4% less	3.15^{b}	1.37^{b}	188.33^{a}	183.92^{a}	60.16^{a}
SEM	0.21	0.14	14.02	17.41	3.30
P-value	0.001	0.004	0.005	0.002	0.04
Amino Acid supplement × Crude Protein					
SEM	0.31	0.20	19.83	24.63	4.67
P-value	0.003	0.006	0.12	0.31	0.002

^{b,a}: Different superscripts within a column indicate a significant difference (P<0.05).

Reducing the dietary protein level from 22 to 18 percent resulted in decreased performance. However, the use of synthetic amino acids in low-protein diets improved performance. Research has shown that reducing crude protein in the diet of broiler chickens may lead to a decrease in the import and use of soybean meal, but supplementation with essential amino acids can address this issue. If the amino acid requirements are met, the amount of crude protein in the diet can be reduced.

Macelline *et al,* (2020) observed that feeding broiler chickens with a low-protein and essential amino acid diet, under hygienic conditions, had no adverse effects after 14 days and led to a reduction in nitrogen excretion in all environmental conditions. This nutrition resulted in the expression of tight junction genes ZO1 and claudin 1, which are essential for maintaining gut health. Additionally, a significant increase in liver weight was observed in broiler chickens fed with a low-protein diet compared to those fed with higher protein diets (Swennen *et al*., 2006). This increase may be related to the increase in the energy-to-protein ratio in the low-protein diet, which facilitates body lipogenesis (Rosebrough, 1985). Furthermore, the increase in blood plasma cholesterol concentration in broiler chickens fed with a low-protein diet confirms this hypothesis. In a recent study, Saleh and colleagues (2021) concluded that abdominal fat in birds fed a low-protein diet compared to a standard diet does not make a significant difference. Si *et al.* (2004) found that the level of essential amino acids in a diet affects the carcass components of broiler chickens. Badawi *et al*, (2019) showed that feeding a diet with reduced crude protein compared to a standard diet does not have a significant effect on body weight, but it can increase abdominal fat.

Van Harn *et al*. (2019) also reported that an increase in abdominal fat deposition in broiler chickens occurs with a diet containing 17% crude protein compared to 24%. Abd El-Moneim *et al*. (2019) emphasized that increasing the energy-to-protein ratio can lead to increased abdominal fat deposition with a low-protein diet. Kobayashi *et al,* (2012) also stated that in low-protein diets, carcass yield was lower, even when supplemented with essential amino acids. The percentage of deposited fat can also lead to changes in carcass yield. The current research trend indicates that a high-protein diet can improve carcass performance and enhance the genetic potential to increase breast meat yield. This is crucial in the trend towards increasing demand for processed products and convenience food globally.

Studies support the role of intestinal morphology in the efficiency of nutrient absorption. The impact of different

levels of dietary protein on villi height and crypt depth of the intestine has been mentioned. Various studies including abbasi *et al,* (2014) and Sritiawthai *et al*, (2013) emphasize this issue and have investigated various effects such as reducing villi height, influencing the ratio of villi height to crypt depth, increasing the number of goblet cells, using nutrients for protein synthesis, the effect of threonine on fecal output, and so on. Tryptophan is one of the essential amino acids that plays an important role in maintaining the health of the intestine and the functioning of the digestive system. Tryptophan is involved in protein synthesis and produces important metabolic substances such as glycine and serine. A deficiency of tryptophan in the diet can lead to weight loss and improper intestinal structure in broiler chickens. Adding an amino acid supplement to the diet can increase the height of the villi in the ileum of the intestine, even in a diet containing 18% crude protein.

Macelline *et al,* (2020) reported that broiler chickens fed a diet containing standard protein had higher villus height in the small intestine than broiler chickens fed a low-protein diet on day 35. Law *et al,* (2018), observed that a low-protein diet supplemented with artificial amino acids resulted in a weak intestinal structure in broiler chickens compared to a standard diet. Previous research has shown that the undesirable effect of a low-protein diet may be associated with a reduction in the levels of non-essential amino acids related to the growth of intestinal epithelium and the production of digestive secretions and mucins, especially glycine, glutamine, and proline.

In the current study, the use of synthetic amino acid supplements led to a reduction in villi height. However, a study by Nikoofard *et al,* (2015) reported different results; they observed an increase in the level of synthetic amino acids associated with both an increase in villi height and a slight decrease in crypt depth. Methionine is known as an important amino acid for protein synthesis and may promote villi growth. It has also been reported that methionine may reduce the gut microbial population, which could help reduce genomic damage and villous atrophy in the ileum. A decrease in crypt depth may indicate slower tissue turnover and less need for compensating the natural decrease or atrophy of villi with nutrients. Therefore, to support slower tissue turnover, providing fewer nutrients may be appropriate. Reducing protein levels in the diet may lead to an increase in cholesterol, triglycerides, and LDL in the blood. The amino acid methionine can act as a fat burner, contribute to protein balance, and also play a role in the synthesis of choline, betaine, and carnitine. Research has shown that sulfur-containing amino acids can modulate fat metabolism and increase HDL cholesterol. Cysteine decreases VLDL levels, taurine reduces VLDL cholesterol and increases HDL cholesterol. Sulfur-containing amino acids can increase HDL cholesterol and decrease VLDL cholesterol. These findings suggest that use of synthetic amino acid supplements improved weight gain and feed conversion ratio, with some effects on intestinal morphology and liver traits. These findings suggest that dietary protein levels and amino acid supplementation play important roles in broiler performance and physiological characteristics.

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Nutrition Strategies for Sustainable Production in the Poultry Industry

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In meeting the need for animal protein in our country; The poultry sector is one of the sectors that has come to the fore in a short time with its reliable, economical and sustainable production method and has continued its rapid development in the last 50 years. With this progress, in addition to the increase in performance and economic returns, the environmental footprint of the sector has decreased by approximately 50% compared to 50 years ago. A 36% reduction was achieved in greenhouse gas emissions, which are one of the most effective factors in global warming and climate change, which are the biggest problems of our age. The fact that the poultry sector has a more environmentally friendly production method compared to other sectors causes poultry production to gain importance. Poultry has the best feed-to-product conversion ratio and lowest environmental footprint in terms of energy and water use per kg of meat or eggs produced. In the report prepared by FAO using the Global Livestock Environmental Assessment Model (GLEAM), CO2 emissions in cows are stated as 5,024 million tons and in chickens as 790 million tons. When the broiler sector is compared to other animal production sectors; It has advantages such as approximately 75% less resource use in production, 72% less production area requirement, 58% less water consumption and 39% less fossil fuel requirement. However, environmental effects such as greenhouse gases, otification and acidification in poultry production should not be ignored. There are also some differences between ruminants and poultry in terms of emission sources. According to FAO, enteric methane release from ruminants accounts for more than half of greenhouse gas emissions. The main source of greenhouse gas emissions in poultry production is feed production processes and transportation, which is approximately 57%. Eutrophication potential, defined as the degradation of the aquatic ecosystem as a result of nutrients reaching water resources as a result of leakage, runoff or atmospheric deposition, and acidification potential, which is an indicator of the decrease in soil pH, are basically related to fertilizer management. and digestive health. The main sources that cause autrification potential in poultry are nitrite, phosphate and ammonia emitted into the atmosphere. In environmentally friendly animal production, animal nutrition and feed production processes, which constitute 60-80% of operating costs and directly affect performance, product quality, animal health and environmental footprint, are considered the most important criteria. Basic nutrition strategies for sustainability in poultry production include: The effects of feed production and the concept of Life Cycle Assessment in mixed feed production, determination of alternative feed sources (especially protein), feed additives effective on intestinal health, digestive system health and nutrient excretion through feces are included.

Keywords: Animal nutrition; intestinal health; poultry; sustainability

Feeding Whole Wheat Grains to Broiler Chickens

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This study focuses on monitoring the feeding of whole wheat grains to broiler chickens and evaluating the effects of this feeding on the performance parameters of chickens and the quality of the carcass. The development of the digestive tract, the weights of the proventriculus and gizzard, the weight of the gizzard cuticle, the weight of the pancreas, and the length of the small intestine were also included in the study. The experiment was conducted on 570 Cobb 500 hybrid chicks from day 10 to day 35. From day 10, six pens were fed with a pelleted mixture containing whole wheat grains, and next six pens were fed with a pelleted mixture as a control. The chicks consumed different feed mixtures: grower 1 from day 10 to 21, grower2 from day 22 to 28, and finisher from day 28 to 35. All chicks consumed the same feed mixture starter until day 10. There was no significant difference in live weight and feed conversion between the control and experimental groups on days 10 and 18. At day 25, the feed conversion in the experimental group was significantly better ($P < 0.05$), averaging 1520.3 g/kg, compared to the control group with a feed conversion value of 1573.2 g/kg. There was no significant difference between the experimental and control groups at the age of 31 days and at the end of the rearing period on day 35. There was also no significant difference in the weights of the carcass, abdominal fat, gizzard, cuticle of the gizzard, proventriculus, and pancreas, nor in the proportions of these parts from the carcass. However, there were significant differences ($P < 0.05$) in the length of the small intestine between the control and experimental groups. The experimental group had a shorter length of the small intestine, averaging 165.5 cm for roosters and 166.3 cm for hens, compared to the control group, where roosters had an average length of the small intestine of 173.8 cm and hens 169.2 cm. When assessing the influence of gender on the development of the digestive tract, higher significant differences were found in all parts for roosters. Based on the results, feeding whole wheat grains as part of the feed mixture is recommended without significant effects on chicken performance parameters, carcass quality, and the development of the digestive tract.

Keywords: Whole wheat grains; broilers; digestive tract

Behavioral and Welfare Indicators of Aviary Laying Hens Using a Focal Sampling Approach

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Focal sampling is one of the most important sampling approaches used in behavioral research of poultry. We used focal sampling to assess the behavior and welfare of aviary laying hens during peak lay. The method consisted of focusing on an animal, watching its behavior for 5 minutes and recording length of each behavior of hen performed. Data were collected from hens housed in 2 styles of multi-tier aviaries (Natura-60 and Natura-step Big Dutchman®) at the MSU Poultry Farm. Each aviary had three-tiers running the length of the pen, but the location of feeder, drinker, perches, and nests varied between styles. There were 4 pens along the length of each room, with 576 hens/room in Natura 60 and 656 hens/room in Natura-step aviaries. Observations were made of hens located in the bottom tier of the aviaries. Initially a hen from left side of bottom tier was selected for a starter location and then 5th hen to the right from this hen was selected as a focal hen and its behavior was monitored for five minutes after waiting quietly for one-minute. Data collection was done at 32, and 36 weeks of age between 09.00 am to 12.30 pm. The length of each behavior was recorded. If a focal bird moved out of the bottom tier before 240-s, the observer selected as a new focal bird and then restarted observations. Birds were visually inspected for feather loss, wounds, and keel bone damage at the end of the observation. In total, data was collected from 64 hens from both aviary styles. Durations of every displayed behaviour were calculated as a percentage of the total time each bird was observed and were analyzed using SPSS 28.0. For all behaviors, the model included week, aviary style, and their interactions as fixed effects. The most commonly observed behaviors were standing, perching and walking. Aviary style significantly affected hens' perching ($P<0.002$) and walking behavior ($P<0.012$). Almost no adverse behaviors or poor welfare indicators were observed, except a few instances of gentle feather pecking and slight feather loss in breast, back and tail in a few hens. These preliminary results indicate that the style of the aviary in which hens are raised can affect some behaviors. Data collection will continue as the hens age to further evaluate influence of aviary style on behavior and welfare outcomes.

Keywords: Laying hens; aviary; focal sampling; behavior; welfare

Welfare of Broilers from Anadolu-T Dam Line as Affected by Diets with a Sustainable Production Approach

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This study investigated if welfare-related traits of broilers from a local line affected by dietary modifications attempting a more sustainable production with local ingredients and dried black soldier fly (BSF) larvae inclusion. A total of 252 day-old chicks from a local line (Anadolu-T dam line) were randomly distributed into 3 groups. 1) corn-soybean-based diet (Control), 2) soybean was partly replaced with local ingredients (SPR), 3) BSF (5%) was added to SPR (SPR+BSF). Dietary soybean (as an average of starter, grower, and finisher) reduced by 6.6% in SPR and 11.4% in SPR+BSF compared to the Control. There were 6 replicate pens per diet (14 chicks/pen, 25 kg/m2). The slaughter age of broilers was 55 d with an average live weight of 2247±31 g. At slaughter age, blood samples from 18 birds/diet with equal numbers of each sex were collected for corticosterone and heterophil to lymphocytes ratio (H/L) measures. All birds were scored for plumage cleanliness (PC) and footpad dermatitis (FPD). A four-scale scoring (0: clean, 1: slight, 2: moderate, 3: severe dirtiness), for PC (Welfare Quality©) and a three-scale for FPD (0: intact, 1: mild lesions, 2: severe lesions) were used. Total FPD score was calculated for each diet multiplying counts for mild and severe scores by 0.5 and 2, respectively. The dry matter content of individually collected excreta (n=5 per diet) was analysed. One-way Anova analysis indicated that diet effect was not significant on serum corticosterone concentration (ranged from 7.44 to 8.18 ng/ml), H/L ratio (ranged from 0.28 to 0.31), and excreta dry matter (ranged from 25.44 to 26.90%). For PC, there were no birds scored 0 or 3; therefore, all birds were scored either slightly (75.6%) or moderately (24.4%) dirty. Chi-square test indicated that PC and FPD frequencies were not dependent on diets (P>0.05). The incidence of FPD was 31.05%. However, the percentage of broilers with severe FPD tended to be lower (13.8%) than expected in SPR+BSF diet while severe FPD was observed more often (48.3%) in SPR fed broilers ($\chi 2$ =8.452, P=0.076). Total FPD score for control, SPR, and SPR+BSF diets were 35, 44.6, and 18.67, respectively. It can be concluded that the stress parameters of broilers from Anadolu-T dam line was not significantly affected by the diet modifications under the experimental conditions. While the incidence of severe FPD tended to increase with SPR diet, BSF inclusion could positively alter this effect. *This project was supported by PRIMA Foundation (Grant agreement number 2015).

Keywords: Black soldier fly larvae; corticosterone; footpad dermatitis; H/L ratio; plumage cleanliness

Effects of Lysine Supplementation to the Diets of Laying Hens under Heat Stress

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Climate change is one of the most important problems to be solved today because it affects the living conditions of our ecosystem. As in many parts of the world, with global warming in Türkiye, temperature values reach 40-45°C in some regions (Alkan et al., 2003; Al-Sagan et al., 2020). One of the most important factors affecting animal welfare, health and performance in poultry farming is environmental temperature. If the temperature exceeds 18–22 °C, it causes the poultry to go into heat stress (Şahin et al., 2009). Heat stress causes physiological and behavioral changes in poultry. Heat stress negatively affects poultry farming, causing large economic losses every year (Hajializadeh, 2017: Radwan, 2020). Modern livestocks have to reduce these negative effects as much as possible; However, keeping the environmental temperature under control requires high costs. Since cooling systems with environmental control of poultry houses are very expensive, nutritional measures come to the fore in reducing the negative effects of heat stress in terms of productivity and health (Attia et all., 2015) On the other hand, while feed consumption decreases due to heat stress, the protein needs of laying hens also increase. However, optimum temperature (20°C) conditions are taken as basis in determining the amount of amino acids used in the ration. Therefore, the requirement for lysine under high temperature conditions should be re-evaluated. In other words, implementing a balanced and adequate diet has become very important. Lysine is one of the essential amino acids whose deficiency is most common in poultry diets. Nowadays, the amino acid needs of animals are met in a more balanced way by adding synthetic forms of this amino acid to the rations. Thus, the utilization efficiency of ration proteins (Leeson et al., 2001) and egg productivity increased (Novak et al., 2004). It is stated that lysine limitation in the diet causes inflammation in organs such as kidney, liver and spleen (Han et al., 2016), inhibits intestinal lysine transport. In this case, it will be possible to benefit from the nutrition of laying hens and reduce productivity losses by increasing the amino acid intake in the feed consumption of laying hens, which decreases by adding lysine to the diets of laying hens against heat stress. As a matter of fact, it has been reported that amino acid digestibility decreased by 40% in broiler hens raised at high temperatures compared to those raised under normal temperature conditions (Habashy et al., 2017).

Keywords: Laying hens; heat stress; lysine

Greenhouse Gas Emissions from the Poultry Industry: Türkiye's Contribution to the Global Footprint

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The global population is increasing rapidly, leading to a significant rise in the demand for food and protein. Consequently, the livestock sector is expanding, including the poultry industry, which responds quickly to demand due to the short reproductive cycle and rapid growth characteristics of chickens. However, this growth is causing environmental problems, such as the emission of greenhouse gases. This study aims to demonstrate Türkiye's contribution to environmental problems, including global warming and climate change, through the emission of greenhouse gases such as methane (CH4) and nitrogen oxide (N2O) from the livestock and poultry industry. The goal is to understand the current situation and take precautions against future situations, given Türkiye's significant position in the world's chicken population. FAOSTAT data for 2021 were analyzed and organized in order to learn about the greenhouse gas emissions related to livestock and poultry worldwide and Türkiye's share in this phenomenon. Chicken numbers, CH4 and N2O emission amounts and percentages were evaluated. Türkiye is ranked 11th in the world in terms of chicken population. In the broiler and layer poultry industry, Türkiye ranks 31st for CH4 gas emissions and 11th for N2O emissions. Globally, poultry accounts for only 1% of CH4 gas emissions and 9% of N2O emissions from animal husbandry. These figures are much higher for cattle, at 69% and 56% respectively. As a result, it was found that Türkiye has lower CH4 gas emissions compared to other countries due to poultry farming, especially when considering the chicken population. However, there is still room for improvement in reducing N2O emissions from poultry farming. In addition, it should be noted that the share of poultry in greenhouse gas emissions related to livestock worldwide is significantly lower than that of cattle. Overall, poultry farming is considered to be a more environmentally friendly option compared to other livestock sectors.

Keywords: Greenhouse gas emissions; poultry industry; Türkiye, global

Antiviral Effectiveness of Ionizer Air Purification Device (Indor 200t) on Respiratory Viruses (Coronavirus, Influenzavirus)

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The role of respiratory air is extremely important, especially in the transmission of respiratory system diseases. Although there are many disinfection methods recommended to prevent such contamination; It depends on determining factors such as effectiveness, performance, spectrum of action, difficulty of application, environmental effects, undesirable effects on equipment, restrictions on the practitioner and cost. The disinfection approach with ozone applications has come to the fore even more since the COVID-19 pandemic period. Ozone (O3) is a very unstable gas and decomposes into harmless structure (O2) in a very short time under normal atmospheric conditions. It has important advantages such as not leaving any residue and not having any undesirable effects on the environment and living things when used under controlled conditions. In this study, the effectiveness of ozone applied to ambient air on respiratory system viruses was tested under experimental laboratory conditions. For ozone production, the inDOR200t ionizer air purification device was used and was mounted in a specially designed trial cabin. A coronavirus strain (*Betacoronavirus*, Bovine coronavirus, BCoV-Mebus), which is in the same genus as the COVID-19 agent, and an influenzavirus strain (*Influenzavirus* H1N1), one of the most commonly known agents of respiratory infections, were used as virus material in the experiment. MDBK and MDCK cell lines were used in the production and testing of the viruses, respectively. The process of treating viruses with ozone was carried out in a specifically designed trial chamber where the 12-hour average concentration of the applied ozone was about 130 ppb and not momentary exceeded 300ppm. Ozone production amounts and ozone concentrations in the environment were controlled with the special software of the device (inDOR200t). In the study, the decreases in the infectivity (titer, TCID50) of the test viruses were evaluated by applying ozone for 30 minutes, 1, 2, 4, 8, 12 and 24 hours. It was observed that the amount of ozone produced by the inDOR200t device could be successfully controlled by keeping it close to the recommended levels of the critical threshold for human health. The infectivity (titer) of the coronavirus was decreased 74.8% in 30 minutes; 90.45% in 1 hour and 99.43% in 24 hours. Similarly, it was determined that the infectivity of the influenza (flu) virus started to decrease from the 30th minute onwards and that there was no infective virus left in the environment at the 12th hour (100% inactivation). The data obtained in this study showed that the inDOR200t device can be used in closed environments to eliminate virus contamination and reduce the infectious load that causes contagion. For this reason, it has been evaluated that it would be appropriate to use it in areas open to human use and in animal shelters such as poultry. (This study was carried out within the scope of R&D projects numbered BUÜ-TTO-20-039 and 23-013.)

Keywords: Air purification device; Coronavirus; Influenza virus; ozone

Seroprevalence of H5, H7 and H9 Subtypes of Avian Influenza Viruses in Domestic Pigeons of Ardabil Province, Iran

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Avian influenza virus (AIV) is an acute respiratory, highly contagious and zoonotic disease and it is very important in terms of economic and public health viewpoint. Pigeons are in communication with other birds such as wild species in urban areas. Domestic pigeons can cause spread this virus to industrial poultry and humans. Therefore, the aim of this study was to survey seroprevalence of H5, H7 and H9 subtypes of AIV in domestic pigeons of Ardabil, northwest of Iran. This cross-sectional study was conducted from January to June of 2022. In this study, One hundred and twenty blood samples were collected randomly from unvaccinated and adult birds in household pigeons at different parts of Ardabil and sent to laboratory. The hemagglutination inhibition (HI) test was performed on the serum samples according to OIE protocol to detect H5, H7 and H9 subtypes of AIV. Sera with titers ≥4 (log2) were considered positive. Out of 120 birds sampled, 18 birds (15%) were sero-positive for H9N2 subtype of influenza virus. All the examined sera were negative for H5N1, H5N2, H7N1 and H7N7 subtypes of influenza virus. The Results of this study show seroprevalence of H9N2 influenza virus and its circulation in domestic pigeons of Ardabil and also this is the first report of no positive sero- prevalence of H5 and H7 subtypes of AIV in these birds. Therefore, it seems necessary to implement detailed health measures and control programs such as vaccination and continuous monitoring of circulating viruses in pigeons.

Keywords: Avian Influenza viruses, domestic pigeon, HI, ardabil

Peritoneal Washings in Poultry

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Nowadays, peritoneal washings in poultry are widely used in research laboratories, mainly in immune response control and testing, through collecting heterophils, macrophages and peritoneal exudates for analysis. Usually used after intraperitoneal injection of immunogenic substances followed by peritoneal washing with PBS or normal saline. However, realizing this technique is not simple and needs more time due to anatomic particularities of avian species. In our recent studies, peritoneal washings are complicated and fastidious techniques due to obstructions of syringe tips and tubes, used for peritoneal washings, by intestine, air sacs and even adipose tissue. In order to overcome and minimize occurrence of these obstructions and to collect more liquids in reduced time we used a tube with rounded bottom with many holes. Inserting this tube in abdominal cavity leads to siphonage of peritoneal liquids into the tube through the many small rounded holes made in its two thirds bottom parts. The peritoneal washes, aspirated in the tube, are readily collected by inserting adapted syringe or cannula. Peritoneal washings in poultry are complicated and fastidious techniques and need more improvements. This new proposed solution represents a potential alternative technique to reduce time and contamination as well as decomposition and deterioration of exudates components for getting best results.

Keywords: Poultry; peritoneal washing; injection; technique

Introduction

Investigating the avian immune system is critical for managing poultry diseases and for developing effective vaccines. Peritoneal lavage has emerged as a valuable tool for researchers in this domain. This minimally invasive technique allows for the collection of immune cells, such as heterophils and macrophages, directly from the peritoneal cavity.

The intraperitoneal injection of irritant is the best method to get high proportion of heterophils and it is the most used. The irritant solutions used to get avian polymorphonuclear-rich peritoneal exudates are glycogen solution (Brune and Spitznagel, 1973; Brune et al., 1972; Macrae and Spitznagel, 1975), and granulated starch (Sephadex G.50) solutions 3% (Evans et al., 1994; Evans et al., 1995; Harmon et al., 1992), and starch solution 0.5% (Harwig et al., 1994).

Materials and Methods

Intraperitoneal injection

There is great variety between papers about the solution to be injected, sterile starch solution 3% was used, and about 60cc of this solution was injected to each animal by intraperitoneal route according to the method described by Sabet et al. 1976.

Intraperitoneal lavage

According to the work of Harmon et al. 1992, the best time to have great number of heterophils in the peritoneal exudate was situated between 20 and 22 hours post injection, the peritoneal washing was done between 18 and 22 hours post injection using phosphate buffer saline (pH = 7.2). Briefly,

The broilers were euthanized by cervical dislocation, and layered on the dorso-sacral position, the abdominal cavity was carefully opened by using the hand scalpel and scissors, about 10 ml of heparinase phosphate buffered saline was injected in the abdominal cavity and the abdominal cavity was massaged then the perforated tube was introduced down in the abdominal cavity, care must be taken to avoid the abdominal air sacs, then a mounted tube to the syringe was introduced in the perforated tube, and the accumulated fluid in the perforated tube was aspirated. This operation was repeated several times until 100 ml of the phosphate buffered saline was used.

Results and Discussion

Intraperitoneal injection

As known poultry respiratory system has many air sacs, and the abdominal air sacs fill spaces among the viscera thus intraperitoneal injection in poultry is very complicated and failure to inject solution correctly with be followed by nasal discharge of the injected materiel. The intraperitoneal injection in poultry species needs high skills to avoid respiratory air sacs and the intraperitoneal route according to the method described by Sabet et al. (1976) must be followed. The volume of the injected solution is sufficient to induce peritoneal inflammation and exudates. In literature the injected volume varies from 20 cc of sterile aqueous, 3% granulated starch solution (Harwig et al., 1993) to 200 ml of saline with 0.5% starch in adult broiler chickens (Harwig et al., 1994).

Intraperitoneal lavage

The result of our work showed that conventional peritoneal lavage in poultry can be cumbersome due to obstructions encountered by used syringe tips and cannulas and it is very hard to get the peritoneal liquid. These obstructions arise from contact with soft abdominal tissues like intestines, air sacs, and adipose tissues. To address this limitation and facilitate faster collection of larger fluid volumes, we implemented a novel tube design. This tube features a rounded bottom with numerous small holes along its lower two-thirds. During insertion into the abdominal cavity, the holes enable efficient siphoning of peritoneal fluid. The collected fluid within the tube can then be easily retrieved by attaching a modified syringe or cannula.

Conclusion

Peritoneal lavage, while a valuable tool in avian research, faces limitations due to challenges associated with traditional techniques. These limitations can include time consumption, contamination risks, and potential degradation of collected samples. This novel approach using a specially designed tube with siphoning capability offers a promising alternative. It has the potential to reduce collection time, minimize contamination, and improve the viability of crucial components within the peritoneal exudates, ultimately leading to more reliable results.

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Multidrug Resistance Profile and PCR Identification of Salmonella Strains of Poultry Isolated at the Level of Poultry Sector in Batna District

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In recent years we have noticed an emergence of atypical diseases in the poultry sector of the wilaya of Batna, many professionals are thinking about the emergence of atypical viral pathologies such as NewCastle Disease, Infectious Bronchitis and even Avian Flu; only these diseases are almost permanently associated with colibacillosis and salmonellosis which have also become atypical and multi-resistant to antibiotics. As part of the identification of the main bacterial causes of mortality in the poultry sector in the wilaya of Batna, 26 strains of salmonella were isolated from poultry from laying hens, broiler breeders and layers having a age ranging from a few weeks to the end of flock age from poultry buildings with a herd ranging from 5,000 to 100,000 birds. The samples of viscera from autopsied animals are essentially in order of frequency Liver, Spleen, Heart, Bone marrow, ovarian cluster; gallbladder, intestines. The samples from viscera were inoculated on Hektoen Agar, SS, XLD, the identification was made using the classic gallery then with the antiserum O specific for Salmonella and finally an RTPCR was launched to identify the species isolated species; an antibiogram was carried out to determine the sensitivity of the strains to the most commonly used antibiotics. the 26 isolated strains turned out to be O9 serotypes of group D. The OMPC Primers with base pair lengths of 204 pB were able to detect all the strains, which means that all these strains belong to the same circulating clone. The antibiogram revealed 9 strains with a resistance profile: NA.CIP.S, a multi-resistant strain with A.C.NA.CIP.SXT.S.TE.MEM profile; a multi-resistant profile strain: CRO.NA.CIP.SXT.S.TE.; 3 strains resistant to 5 A.NA.CIP.S.GMN Antibiotics, 5 strains resistant to 5 Antibiotics with A.NA.CIP.S.CAZ profiles and 6 triple antibiotic resistance profiles different from each other. We believe that avian salmonellosis is due to a single clone, namely Salmonella Gallinarum, which is beginning to become multi-resistant to antibiotics, including gentamycin

Keywords: Salmonella PCR; MDR; Algeria

Introduction

In recent years we have noticed the emergence of atypical diseases in the poultry sector of the wilaya of Batna, Many professionals have noticed the appearance of new atypical viral diseases BI;NDC and avian flu, Only these pathologies are almost permanently associated with colibacillosis and salmonellosis which have also become atypical and multi-resistant to antibiotics. The breeding model adopted by our country is an intensive breeding model based on modern technology and rigorous production organization and planning, owever, the dependence of our poultry farming on the foreign market for food, medicines and equipment remains the main handicap to the development of Algerian poultry farming. Added to this the increase in costs, the disengagement of the state and the fluctuations in marketing. This has pushed many breeders to change their profile, which leaves the poultry sector currently in crisis.

The most common pathologies are coocidiosis; mycoplasmosis; Colibacillosis; Salmonellosis; Infectious bronchitis, New Castle Disease, Gumboro; avitaminoses. All broiler farms follow modern industrial farming.

Materials and methods

As part of the identification of the main strains of salmonella causing mortality in the poultry sector in the wilaya of Batna 26 strains of salmonella were isolated from laying, breeding and laying hens with an age ranging from a few weeks to the end of the flock from buildings containing a poultry flock ranging from 5,000 to 100,000 subjects, Samples of viscera from autopsied animals (liver, spleen, heart, bone marrow, ovarian cluster, gallbladder) These samples were isolated on Hektoen XLD or SS agar. The identification was made using the classic gallery then with the specific salmonella antiserum and finally an RTPCR.

Results and Discussion

The 26 isolated strains by Ayachi et al. (2017) turned out to be O9 serotypes of group D. The OMPC primers with a length of bp 204 were able to detect all the strains; these strains belong to the same circulating clone. The results of the antibiogram revealed 9 strains with a NA.CIP.S resistance profile 01 multiresistant strain with A.C.NA.CIP.SXT.S.TE profile 01 multiresistant strain with profile CRO.NA.CIP.SXT.STE. 03 strains resistant to 05 antibiotics having the profile A.NA.CIP.S.GNM 05 strains resistant to 05 antibiotics with A.NA.CIP.S profile 06 Triple antibio-resistance profiles different from each other. While El groud & al (2009) with A total of 2490 samples, collected between 2005 and 2007, showed a *Salmonella* contamination wich affected 37% of farms and 73% of slaughterhouses. Among the 55 isolates found, 10 different serotypes were identified. The most frequently isolated serotypes, both on farms and in slaughterhouses, were S. Hadar (36.4%, n=20), S. Virchow (16.4%, n=9), S. Infantis and S. Albany (10.9 %, n=6). S. Carnac (7.3%, n=4). The serotypes S. Heidelberg (1.8%, n=1), and S. Rissen (1.8%, n=1) were only found on farms, while the serotypes S. Typhimurium (9.1%, n=5), S. Enteritidis (3.6%, n=2), and S. Montevideo (1.8%, n=1) were isolated only in slaughterhouses.

Thirty-nine isolates (79.9%) were resistant to at least one antibiotic and 50.9% were multi-resistant, to two or more antibiotic molecules. Among the 55 isolates, 56.4% (n=31) were resistant to streptomycin, 34.5% (n=19) to tetracyclines, 27.2% (n=15) to nalidixic acid, 12.7% (n=7) to ofloxacin and 1.8% (n=1) enrofloxacin.

Finally, 7 distinct antibiotic resistance profiles were identified. On the other hand, the genotypic characterization of the strains gave us 16 profiles by ericPCR, 20 profiles by is-PCR and 34 profiles by PFGE (Pulsotyping). The 3 methods and particularly PFGE demonstrated the clonality of certain serotypes, confirming the diffusion and persistence of the same clone throughout the sector and in our region, but also the polymorphism of other serotypes indicating the diversity of potential reservoirs of non-salmonella. typhoid.

In another hand Bouzidi et al. (2012); Out of 2754 environmental samples collected, only 19 isolates were recovered and 9 different serovars identified. Thirteen isolates were resistant to at least one antimicrobial agent. Of these, six were resistant to at least three different classes of antimicrobials. Salmonella Kentucky isolates were resistant to fluoroquinolones

A genotypic characterization of the strains isolated from farms, and those collected from human cases during the 2 years was carried out.The strains thus generated 21 PFGE pulsotypes, 13 IS-PCR profiles, and 12 ERIC-PCR profiles.These 3 methods demonstrated on the one hand, the clonal nature of certain serovars, particularly human serovars, thus reinforcing the hypothesis of clonal diffusion in these regions, and on the other hand, the heterogeneity of the profiles of other serotypes thus leaving assume a possible diversity of sources of contamination in these two regions.

As for Bounar-Kechich et al (2012): Out of 100 strains isolated, thirteen serotypes were identified; the most prevalent were S. Heidelberg (24%), S. Enteritidis (20%), S. Albany (16%), and S. Typhimurium (9%). The strains showed resistance to 8 out of 34 antibiotics tested; 53% of the isolates were resistant to at least one antibiotic, including 15.09% multiresistant. Resistance to quinolones dominated with 58.49%. Plasmid transfer carried out on 53 strains showed that 11 transferred one or more resistance markers; the most common being ampicillin, followed by tetracyclines, sulfonamides and kanamycin.

Medjbar et al (2008) reported for a A total of 360 samples were taken from 5 killings spread across three municipalities in the wilaya of Blida. 12 salmonella isolates were identified, bringing the overall contamination rate to 3.33%. The serovars that were most frequently isolated during our study are, in decreasing order of frequency: S. Hadar (33.33%), S. Infantis (25%), S. Typhimurium, S. Virchow and S. Enteritidis (8.33%). The classic method allowed us to identify 4 serotypes of salmonella: S. Hadar (n=2), S. Infantis (n=1), S. Typhimurium (n=1). The alternative method allowed us to identify 10 salmonella serotypes: S. Hadar (n=4), S. Infantis (n=3), S. Virchow (n=1), S. Typhimurium (n=1) and S. Enteritidis (n=1)

Finaly Mezali et al (2019) noticed in 128 samples analyzed (16.14%) were positive. Serotyping of 23 (17.97%) isolated strains made it possible to identify 12 different serovars with predominance of S. Enteritidis (21.74%, n=5) and S. Heidelberg (13.04%, n=3) . The study of antibiotic sensitivity revealed that 95.24% (n=20) of the isolates were resistant to at least one antibiotic, among which 38.10% (n=8) were multi-resistant.

All isolates were susceptible to ciprofoxacin and cephalosporins, but some showed resistance to pefoxacin (9.52%, n=2). Resistance to sulfonamides (85.71%, n=18), nalidixic acid (33.33%, n=7), tetracycline (19.05%, n=4) and streptomycin (9.52%, n=2) were the most frequent., 7 distinct antibiotic resistance profiles were identified; the phenotype of S. Typhimurium resistant to 9 antibiotics, includes type penta-resistance, 7 distinct antibiotic resistance profiles have been identified

Conclusion

The antibiotic resistance profile discovered in our country by the various studies is overall: 9 strains with a NA.CIP.S resistance profile (**Ayachi et al**) 7 distinct antibiotic resistance profiles have been identified (**El groud et al)** 7 distinct antibiotic resistance profiles have been identified **(Mezali et al**) An Salmonella Typhimurium DT 104 profile was discovered in humans.

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Carcass Composition and Economics of Production of Male Layer-Type Chickens Reared at Different Stocking Densitie

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Two experiments with male layer-type chickens of the Lohmann Brown Classic breed was carried out at the Institute of Animal Science-Kostinbrod, Bulgaria, to investigate the differences in carcass composition and economics of production of the birds when reared at different stocking densities, thus to explore the possibilities of utilisation of this type of birds for meat products, to avoid their culling right after hatching. The experiments were carried out in 2022 and 2023. In both trials the birds were reared in a controlled microclimate, with an initial stocking density of 22 birds/m2 for the first trial and 9 birds/m2 for the second one. At five weeks of age, fragmentation of the stocking density was applied, decreasing the number to seven birds/m2 and 3 birds/m2, respectively for the first and second experiment. The fragmentation of the stocking density aims to select the chickens with higher live weight that will be further reared for producing meat and is applied after 5 weeks which is the earliest age for genuine results of selection. Chickens were slaughtered at five and nine weeks of age. Carcass composition was assessed in the 9-week-old male layer type chickens (10 birds from each trial). The initial live weight at slaughter was significantly lower in the chickens reared at lower stocking density. Similarly these birds displayed lower weight of the ready to cook carcass ($P<0.0001$) but had higher percentage of the thighs ($P=0.0065$) and wings ($P<0.0001$) in comparison with the chickens reared at higher density. The economic analysis showed that in both trials regardless of the stocking density the cost price per kg was higher for the male chickens slaughtered at 5 weeks of age than for the 9 weeks old birds which shows the advantage of slaughtering male layer-type chickens at the later age.

Keywords: Male layer-type chickens; stocking density; economics of production

Acknowledgement: The study was supported by the Bulgarian National Science Fund, Ministry of Education and Science in Bulgaria (Project INOVAMESPRO, Contract No KP 06-N56/10, 12 November 2021).

Welfare Quality Assessment in Poultry: Feather Condition

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Poultry welfare is the primary state of good physical, psychological, social, and environmental well-being in hens. Feather conditions have been associated with animal welfare in poultry. Feathers provide insulation to extremely environmental temperature and protect to skin injuries in animals. All birds may have feathers in different shapes, sizes, colors. Feather formation is regulated by hormones in response to environmental factors and nutritional components. Feather quality contributes to assessing chickens' health, performance, and welfare status. Feather pecking is a substantial behavior in laying hens, leading to feather damage, feather loss, and cannibalism. Poultry feather damage may be caused by feather pecking and cannibalism behaviors, leading to injuries and deaths. Feather damage in hens occurs due to genotype, age, management conditions, cage system, stocking density, light intensity, damaging pecking behavior and nutritional deficiencies. This review provides information feather formation mechanism, feather damage and welfare relations in poultry.

Keywords: Poultry welfare, feather quality, feather pecking, feather formation

Introduction

Animal welfare has significantly impact on the assessment of poultry production (laying hens, broilers, breeders, etc.) (Broom, 2001). Welfare status should be considered an acceptable balance between positive and negative conditions. So that, the five freedom principles for the rearing all farm animals approved by the United Kingdom's Farm Animal Welfare Council (FAWC, 1979). Among principles are freedom from hunger and thirst, discomfort, pain, injury, and disease, freedom to express normal behaviour, and freedom from fear and distress (Webster, 2005). The welfare of poultry entails physical and psychological needs and behaviors, and requires constant attention to ensure their well-being. Comfort behaviors, including dustbathing, stretching, and playing, include positive activities and high-quality welfare. In the contrary, damaging activities in feather pecking and cannibalism have been recognized as indicators of inadequate welfare in poultry (Nicol et al, 2013). Additionally, several factors have been related to poultry welfare, such as feeding, housing, health status, lameness, appropriate behaviors, and feather condition, according to the European Welfare Commission (Fraser and Broom, 1990; EFSA, 2023).

In biological aspect, a feather is an epidermal part with hierarchical branching structures. Feather growth begins on day 5 of incubation and keratinization is complete 2-3 days before hatching in hens. Differences in color formation develop during embryonic development despite most poultry having white or brown poultry feathers. Besides its functions consist of moving, flying, endothermic processes, communication, thermoregulation, and preventing the rearing system from its scratching effect (Terrill and Shultz, 2023). Because all of these, feather pecking in hens remains to be a significant welfare concern. This behavior may result in painful skin injuries, and birds may become cannibalistic (Rodenburg et al., 2008). Furthermore, feather loss has been associated with heat loss, which causes feed consumption to increase by (10% to 30%) and reduces egg production with a higher mortality rate in laying hens (Rodenburg and Koene, 2003).

It is crucial to consider the feathers quality directly affects on hen performance and consumer perception of behaviors. Additionally, genotype, age, physiological aspects, hormones, nutritional deficiencies, rearing systems, stocking density, lighting management, and environmental enrichment practices have importance for the occurrence of feather pecking and cannibalism (Nicol et al, 2017). Consequently, this paper reviews the formation of feather, the cause of feather pecking and feather damage, the relationship between feather damage and welfare status in poultry.

Feather Structure and Functions

The avian body is covered (approximately 4%-9% of live weight) with a layer of feathers made up of keratin. Its formation consists of the body parts in the shoulder, thigh, tail, chest, neck, abdomen, leg, vent-back, wing,

and head. Additionally, the hen's feathers' physical and morphological compositions have been revealed that crude lipid (0.83%), crude fiber (2.15%), crude protein (82.36%), ash (1.49%), NFE (1.02%), and moisture content (12.33%) (Tesfaye et al, 2017). The process of feather formation begins with a conjunctive papilla, which involves the two layers of the dermis and the epidermis. It separates from the epidermal layer to form the cover that contains the skin's radii. The final stage of formation is also characterized by the disruption of the cover that surrounds the initial state. The feather comprises three distinct parts once its development is complete. The axis consists of the calamus and rachis, providing the essential stiffness that binds them together (Yu et al, 2004).

The secondary structure (spines) is attached to the central axis, called the rachis. The rachis is covered with foam (medulla) and is semi-rectangular in shape, narrowing in cross-section towards the tip of the feather. The rachis is composed of fiber layers in opposite directions. The medulla nucleus, structured from keratin, comprises a large part of the rachis (Lin et al, 2022). Furthermore, the rachis contain residual materials, pigments, and proteins formed during the feather's formation (Pahua-Ramos et al, 2017). At the bottom of the calamus is a pore in which the feather is nurtured during its growth, called the inferior umbilicus. The rachis begins to become flattened in the upper part of the calamus, and where the calamus ends, there is another hole called the superior umbilicus, where the laminar body of the feather emerges as it begins to grow (Schelestow et al, 2017). Besides, old feathers are pulled out of the follicle as the follicles grow in place of new feathers, which occurs in the next cycle. Papillary growth is stimulated by exposure to thyroid substances and progesterone (Shaffner, 1954; Yu et al., 2004). Birds may be extremely ornamental by using a variety of pigmentation colors to protect themselves from potential environmental threats. The pigment pattern formation is accomplished by controlling the presence, distribution, and differentiation of melanocytes. Therefore, melanocytes originate from the feather follicle and are responsible for producing pigmentation (Inaba and Chuong, 2020).

Feather Pecking Behavior

Feather pecking is a detrimental behavior in poultry that consists of pecking at each other's feathers, leading to feather loss and ingestion. Birds occasionally peck at the bellies and necks and rump each other on the ground without skin injuries. This behavior endangers birds' health and welfare, resulting in concern for poultry production (Bilcik and Keeling, 2000). Feather quality assessment may serve as an indicator of welfare in laying hens among housing systems. The feathers are responsible for protection against pecking, scratches, cannibalism, and abrasive materials in cages (FAWC, 2009). Extensive plumage in chickens leads to severe feathering in their beaks, possibly resulting in feather emergence and cannibalism. On the other side, the process of feather pecking in birds may cause pain, injury, trigger cannibalism, and result in increased heat loss, leading to a 10-30% increase in food consumption (Glatz, 1998). According to Keeling (1995) feather pecking has been categoried into two types as gentle feather pecking and severe feather pecking. Gentle feather pecking involves pecking the feathers of another bird without causing any damage. Otherside, severe feather pecking (FP) has been characterized by aggressive behavior, including pulling, damaging, plucking, and consuming the feathers of the pecked bird. Additionally, aggressive pecking, gentle feather pecking without removal of feathers, severe feather pecking leading to feather loss, tissue pecking in bare areas, and vent pecking have been identified as feather pecking categorized as a welfare issue (Savory, 1995). All these classifications has been widely acceptable for understanding this behavior mechanism (Rodenburg, 2003).

Causes of feather pecking behavior

Genotype, Age and Physiological Aspects

Feather pecking behavior in poultry has been associated with psychological aspects and management conditions. Preventing feather pecking and ensuring healthy hen flock management depends on various factors, such as genetic, age, environmental conditions, lighting, housing, group size, stocking density and nutrition. These issues are related to reducing the occurrence of feather pecking and enhance bird welfare (Rodenburg and Koene, 2003). Feather pecking and cannibalism on hens are the most significant welfare issue for maintaining profitable rearing practices and egg production. These behavior may occur among different strains of hens. It has been proposed that genetics and selective breeding programs promote a potential treatment for this behavior (Chen et al, 2015).

Chicken genotypes have different tendencies against pecking behavior. So that, genetic selection may reduce pecking problems, which is related to fearfulness in birds (Muir and Cheng, 2014). Genetic heritability estimates range from 0.04-0.56 depending on age (Bessei, 1984; Rodenburg et al, 2003).

The feather pecking behavior may be related in age, especially for younger and older laying hens and breeders (Rodenburg and Koene, 2003). The some findings show that young birds are mainly affected by gentle feather pecking, whereas older birds are more susceptible to severe feather pecking and cannibalism (Nikolov and Kanakov, 2020). Addition to age factor, feather pecking during the laying period has been affected hormonal regulation and stimulation by estrogen and progesterone or blocked testosterone. Hormonal secretion is essential for maximizing profitability, reducing feather pecking, and promoting hen welfare (Hughes, 1973).

Management and Nutritional Aspects

Poultry welfare has been affected by housing systems and management conditions. Differences in welfare status has been approved for hens between conventional production systems (cage system, enriched cage system) and alternative production systems (free-range, organic system). Caged hens may have limited freedom behaviors with lower risk of health issues, resulting in lower morbidity and mortality rates. Alternative production systems (free-range and organic systems) in pasture-based allow poultry freedom to express a more expansive behavioral repertoire (positive) compared to intensive indoor housing systems, although significant risk factors of predation, climatic extremes, endoparasites infestation, and infections carried by wild birds (harmful) (Elson, 2015).

During all rearing period management conditions strongly impacts on feather pecking behaviour. The feather pecking incidence may depends on the production system. Besides, litter condition, light intensity, stocking density, temperature, and humidity strongly influence pecking behavior (De Haas et al, 2014; Shi et al, 2019). Severe feather pecking during the rearing of hens significantly increase the likelihood of pecking issues in adult hens (Hartcher et al, 2015). Management practices may minimize the risk of severe feather pecking include using litter, providing environmental conditions, minimizing stress and fear in the birds, providing environmental enrichment, appropriate rearing conditions, adequate nutritional factors and flock density (Gilani et al, 2013). In addition, feather pecking behavior may be observed in all production systems despite the stocking density differences (Fijn et al, 2020). This behavior is enhanced with the absence of forage material (straw, wood shavings, sand, and peat in conventional production systems). On the contrary, foraging may cause feather pecking behavior, which leads to the assumption that it is related to dustbathing activity in alternative production systems (Nicol et al, 2013).

Feather pecking has been shown in all production systems (cage system, aviary system, litter-based system, free-range and organic system) (Hartcher and Jones, 2017). Otherside litter material in breeding contributes to the preventation of feather pecking behavior. It is important that litter material in shelter to early age of chicken reduces the pecking problems and fearfulness in later age period (Brantsæter et al, 2017). In a flock, the use of perch in breeders and laying hen egg production provides decreased feather pecking behaviors during the laying period (Sandilands et al., 2009). Otherside, excessive light is crucial in the occurrence and severity of feather pecking and cannibalism in breeders and laying hens. Higher light intensity (>11 lux) may be the reason for pecking damage and feather-pecking behavior in hens especially colony cages (Inaba and Chuong, 2020).

It is known that damaged behaviors in a hen are related to directly nutritional composition. Especially, protein deficiency in nutrition causes engaging in harmful behavior such as feather pecking and cannibalism. It has been proved that raw materials, crude protein, and particular nutrients such as amino acids and minerals influence the feather pecking (Kjaer and Bessei, 2013). So that, optimizing nutrition programs is crucial to minimize the risk and ensure bird welfare and adequate methionine may prevent any potential health concerns arising from a deficiency (Elwinger et al, 2002). Tryptophan is a precursor of serotonin, which acts as a neurotransmitter. The dietary level of tryptophan influences the level of serotonin in the brain, which in turn modulates aggressive behavior and fear in hens (Van Hierden et al, 2004). In poultry, inadequate sodium supply in the diet may cause cannibalism. High sodium level in nutrition may lead to decreased egg production and plumage conditions, indicating an increase in feather pecking (Hughes and Whitehead, 1979). The feed structure with coarse particles, especially pellet and

crumble feed, comprises more feather pecking and cannibalism than ground feed. This effect was explained by the influence of feed structure on the time spent feeding. Moreover, feeding poultry in pellet form poses a higher risk of feather pecking, whereas using mash feed reduces this risk (Aerni et al, 2000; Kjaer and Bessei, 2013).

Conclusion

This review focused on the feather formation mechanism, feather damage, and welfare relations in poultry. To promote health and productivity in poultry production, breeders, farmers, and researchers must take proactive measures to minimize the adverse effects of welfare issues, especially feather pecking and cannibalism. There is a consistent interrelationship between management, nutritional conditions, and feather pecking behavior because protein deficiencies and feed structure increase the risk of feather pecking in poultry. It is recommended that light intensity be reduced and the supply of nutrient requirements (high fiber diets, protein supplementation) for production to reduce feather pecking and cannibalism. In an appropriate management and nutrition program, the risk of feather pecking may be decreased in poultry production.

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Cultural Relevance and Genetic Differentiation in Pradu Hang Dum Chickens

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The PraDu Hang Dum chicken, a domestic breed native to Thailand and widely distributed across the country, holds significant cultural and practical importance. It is actively promoted among villagers for both subsistence and cockfighting purposes. Moreover, competitions showcasing the beauty of PraDu Hang Dum chickens underscore their cultural and practical relevance in local communities under the Siam Chicken Bioresource Project, which further contributes to their conservation and sustainable use. Microsatellite genotyping was employed to investigate genetic differentiation within populations. This analysis revealed a distinct separation, delineating chickens raised for subsistence from those designated for cockfighting. Furthermore, microsatellite genotyping facilitated the identification of genetic variations among chickens participating in beauty competitions, showcasing unique aesthetic qualities resulting from differential breeding strategies. The study highlighted that the selection for champion looks, cockfighting, or restricted pedigrees significantly contributes to population fragmentation. Beyond this, understanding the impact on food security is crucial, as the genetic dynamics of PraDu Hang Dum chickens, influenced by these factors, can have implications for local food production and sustainability. It emphasizes the need to recognize artificial barriers impeding gene flow between these populations. The necessity of such barriers should be critically evaluated, and there is a suggestion to potentially abolish them to ensure the preservation of genetic diversity within the PraDu Hang Dum breed. This approach aims to maintain the breed's integrity and adaptability in response to evolving cultural practices and breeding preferences, ultimately contributing to enhanced food security in the region.

Keywords: PraDu hang dum; food security; microsatellite; siam chicken bioresource Project

Effects of On-Farm Hatching on Chick Length and First Day Chick Behavior of Different Broiler Genotypes

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Conventional hatchery-hatched chicks are exposed to dust and sometimes pathogens during the hatching and post-hatch procedures and remain without feed and water until they have arrived on the farm. Long-term feed and water deprivation during this period has a negative impact on the development of the gastrointestinal and immune systems and the subsequent performance of chicks. This study was made to investigate the effects of conventional and on-farm hatching on chick length and first-day behavior of three broiler genotypes: Anadolu-T, Cobb500, and Ross308. Eggs in conventional and on-farm hatching groups were subjected to standard hatching procedures until 18 d of hatching. Subsequently, eggs of on-farm hatching groups were transported and placed in an experimental poultry house, while eggs in a hatchery hatching group were transferred to the hatcher. Day-old chick length in conventional and on-farm hatch groups was measured 24 hours after all the chicks hatched in all groups. The birds pecking feed on the feeder, pecking litter or any object on the ground, and close to the feeder were counted at two-hour intervals with direct observation at day-old age. Data were statistically analyzed using the SPSS 28.0 statistical package (IBM Corp 2021) by a generalized linear model with a hatching system (conventional hatchery hatching and on-farm hatching) and broiler genotype (Anadolu-T, Cobb500, and Ross308) as taken into effects of main factors and all interactions. In general, on-farm hatching resulted in a higher body length, a best-known indicator of subsequent body development and performance, at day 0 ($P<0.001$). Day-old Cobb 500 chicks were significantly longer than those of Anadolu-T and Ross ($P<0.001$). The hatching system or genotype significantly affected first-day chicks feeding behavior ($P<0.009$, $P<0.03$). Based on these findings, it can be said that on-farm hatching and Anadolu-T broiler genotype seem to be competitive with the conventional hatching and commercial broiler genotypes.

Keywords: Broiler; on-farm hatching; Anadolu-T

Latest Approaches on Monitoring Poultry Welfare and Assessment

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In parallel with the increase in the world population, animal production is increasing. This situation occurs in the form of an increase in the number of animals used in production, as well as an increase in the amount of productivity per animal, thanks to developments in the field of breeding, feed industry, breeding techniques and health. This increase in productivity also increases the physiological and metabolic pressure on animals. This situation has a special importance, especially in the poultry sector, where a large number of animals are kept in a unit area and are mostly reared in closed environments and cage systems. Ensuring and monitoring poultry welfare is a very difficult situation due to the large capacity of the poultry houses. Technological developments are used to monitor welfare in the poultry industry. Applications such as imaging systems, cameras, sensors, mathematical models and artificial intelligence are used for this purpose. Using these technologies, diseases, stress status, feather and gait scores, and body temperature changes due to metabolic disorders can be detected in laying and broiler chickens. It is anticipated that advances in technology will be used to ensure and monitor bird welfare in the future.

Keywords: Poultry welfare; welfare assessment; broiler; laying hen

Introduction

Parallel to the increase in the world population, there is a tendency for animal production to increase as well. Particularly, consumers with good economic status are showing an increasing interest in animal welfare. Animal rights advocates, consumers, and civil society organizations continuously keep the issue of animal welfare on the agenda by pressuring retail chains and governments. In connection with this, retail chains set criteria for animal welfare to their suppliers during production, and governments establish rules to be followed during animal production. In our country, minimum standards have been determined by the Ministry of Agriculture and Forestry regarding the protection of laying hens and broiler chickens. The poultry industry, which holds a significant place in animal production and is the most produced sector worldwide, is one of the most debated sectors in terms of animal welfare due to its structure. Moreover, consumers who are sensitive to animal welfare are willing to pay more for animal products produced in systems that comply with animal welfare standards. However, it is not possible to say that the welfare of animals is ensured solely by determining welfare standards. Especially due to the increase in poultry capacities, ensuring and monitoring welfare criteria has become difficult and complex. Many studies are being conducted on this issue, and as an example, in the European Union, the condition that foot pad dermatitis must be below a certain threshold for slaughter of broilers brought to the abattoir can be cited (Council of the European Union Document DS 564/05). Studies are being conducted using technological capabilities to evaluate the welfare status of chickens, identify potential welfare risks in flocks, control their effects, and minimize risks. Technologies such as sensors and cameras that monitor behaviors such as movement, body temperature, feather pecking, optical flow imaging technologies, infrared rays, mathematical modeling, and artificial intelligence applications are examples of this. Additionally, a holistic approach to the concept of welfare has been developed through methods such as qualitative evaluation of behavior. It can be predicted that the expected increase in poultry production in the coming years will bring along the issue of welfare, and consumer sensitivity and studies in this regard will increase.

Monitoring and evaluation technologies for poultry welfare

Imaging methods

Imaging methods provide the opportunity to monitor factors such as movement, health, live weight estimation and control, stocking density, stress, and welfare status of poultry without disturbing them and disrupting their natural behavior. Cameras, some of which also have the ability to record infrared, are used to capture images, while imaging methods such as thermography enable monitoring of temperature changes in the animal's body, allowing for the detection of conditions such as disease and stress (Redaelli et al., 2014). Image analysis methods called optical flow are used in monitoring movements in many fields. This method, when combined with other applications and algorithms, can be used to assess feather damage, walking score, daily mortality rate, certain

diseases, growth rate, water and feed consumption, foot pad and hock dermatitis, and welfare status in poultry (Sassi et al., 2016). X-ray imaging systems can also be used to evaluate poultry welfare. Libera et al. (2024) reported in their study that they visualized the wings and feet of broiler chickens taken from the abattoir using an X-ray tomography device, thus determining the deformations in the wing and leg bones of chickens and consequently their welfare status.

Infrared thermal imaging systems can also be used to determine heat stress, immune system, and physiological condition of poultry. These systems are particularly used to observe behaviors such as drinking water, fluffing feathers, and resting in cool areas of the poultry house, which are aimed at reducing body temperature due to heat stress. Through these systems, body surface temperature, thermal changes in metabolism, body heat loss can be monitored, and foot pad dermatitis and feather scores can be determined (Sassi et al., 2016; Wilcox et al., 2009; Zhao et al., 2013). Kinematic analysis methods are systems that explain the geometry of movement (Beggs, 1983; Sassi et al., 2016). Studies have been conducted on broiler chickens' gait scores using this method (Caplen et al., 2012; Mench and Blatchford, 2014; Sassi et al., 2016). Images obtained from cameras and imaging systems are digitized using specially developed software, artificial intelligence applications, machine learning, and deep learning systems to monitor poultry welfare and poultry house management (Neetherajan, 2022; Nilsson et al., 2015). Some of the software used in imaging studies are Eyenamic Software, LabelImg software, YOLOv5s, Convolutional neural network (CNN), U-net model (Li et al., 2021; Campbell et al., 2024).

Sensor technologies

Sensor technology has advanced significantly in recent years and is finding applications in various fields, including the poultry sector, especially wireless sensors. Environmental sensors are integrated with software programs to detect and optimize environmental factors in poultry houses and are widely used successfully. These sensors can be used to determine temperature, humidity, and gas levels in poultry environments and optimize the environment for the chickens (Sassi et al., 2016).

Movement is a crucial factor in determining the welfare status of poultry. Healthy and well-being chickens will be able to move as needed and exhibit their natural behaviors. The movements exhibited by chickens during behaviors such as walking, feeding, and drinking can be detected and evaluated using sensors placed on their bodies that measure movement and body temperature, allowing for the detection of their welfare, health, and stress conditions (Daigle et al., 2014; Okada et al., 2014). Additionally, the use of equipment such as perches in poultry houses, determining factors such as the duration of outdoor use in free-range systems, and the number of entries and exits can be determined using motion sensors to assess welfare and behavioral status (Nasr et al., 2012; Banerjee et al., 2014; Richard et al., 2012).

Chickens produce different vocalizations in situations such as socialization, discomfort, fear, hunger, thirst, egg laying, hot and cold stress (Bright, 2008). By recording and analyzing these sounds, the welfare, stress, and disease conditions of chickens can be determined (Sassi et al., 2016). Monitoring the sounds of chicks during the hatching process can determine characteristics such as hatching interval, hatching strength, and chick quality, which can be correlated with chicken welfare (Van de Ven et al., 2011; Sassi et al., 2016).

Other application

Mobile phone applications are also used for the assessment of poultry welfare. Some developed applications can be installed on mobile phones and used for welfare assessment. Additionally, there are mathematical models, machine learning algorithms, software programs available for this purpose (Sassi et al., 2016).

Conclusion

In poultry production systems largely conducted in closed environments with high stocking densities, animal welfare has always been and will continue to be a significant issue. The importance consumers place on poultry welfare motivates producers and regulators to make more efforts in this regard. Since monitoring and determining the welfare status of poultry raised in high numbers per unit area is quite challenging, the use of technology is inevitable to achieve this. It can be anticipated that new developments in technology will be utilized for monitoring animal welfare.

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Comparison of the Efficiency of Different Selection Strategies for Feed Conversion Ratio in Anadolu-T Broiler Male Line

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In this paper, some of the first findings of the doctoral thesis study titled "Comparison of the Efficiency of Different Selection Strategies for Feed Conversion Ratio in Anadolu-T Broiler Male Line" will be presented. The aforementioned study is carried out within the scope of TAGEM project titled "Breeding of Broiler Parent Pure Lines Grown in Eskisehir Geçit Kuşağı Agricultural Research Institute and Parent Production Studies" and includes some of the data of 2 generations. According to the study, it was planned to make pedigree selection according to live weight, feed conversion ratio and breast area data taken at different periods in B2 pure line. The effects of these traits in different periods were compared with each other for 2 generations. As it is known, feed conversion ratio (FCR) is the main of commercial broiler breeding programs, and the feed conversion ratio (FCR) of Anadolu-T, Türkiye's first domestic and national broiler chicken, is stated as 1.67 in the registration information. In the field trials conducted between 2020-2023, it was determined that this value increased up to 1.7-1.9 levels. This situation causes integrated companies to look at Anadolu-T negatively from a commercial point of view, although they support the studies from a strategic point of view. In addition, as shown in the studies conducted on the pure lines from which Anadolu-T was obtained, the feed conversion ratio feature should be further improved. Based on all these, this doctoral thesis aims to determine the most appropriate method by comparing different selection strategies and to increase the FCR performance of Anadolu-T in commercial conditions. Within the scope of the study, the control group (4963) in B2 pure line males consisted of the selection treatment made according to the data of FCR between the 49th-63rd days and Breast Area (BA) measured on the 42nd day. The treatment groups consisted of the selection treatments according to the same data calculated between 21-35th days (2135) and 35-49th days (3549) and BA values obtained on the 28th day for 2135 and 35th day for 3549. According to the preliminary results, the heritability (Standard Error; 0.08-0.12) for the trait of FCR was determined as 0.38, 0.47 and 0.26 for 2135, 3549 and 4963 groups, respectively. The heritability of body weight gain trait (Standard Error; 0.06-0.09) was 0.39, 0.46 and 0.14 for 2135, 3549 and 4963 groups, respectively. The heritability (Standard Error; 0.06-0.08) for Breast Area trait was 0.56, 0.60 and 0.54 for 2135, 3549 and 4963 groups, respectively. These initial results suggest that pedigree selection in the B2 pure line should be carried out according to the data obtained between the 28th and 42nd days.

Keywords: Broiler breeding; feed conversion ratio; pure line; selection practice

Response of Different Broiler Genotypes to Fear Tests at Different Ages

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The aim of this study was to evaluate the fear levels of broilers from a local (L) and commercial (C) line with different growth rates (n=24/genotype) through the novel environment (NE) test performed on day 1 and the tonic immobility (TI) test performed on day 34. For the NE test; latency to vocalize, number of vocalizations, latency to the first flight attempt and number of flight attempts were measured. For the TI test; number of inductions and duration of TI were measured. Since the values were not normally distributed, the nonparametric Wilcoxon test was used. Spearman's correlation analysis was used to show the relationship between the fear measures. There is no significant difference between genotypes in the latency to vocalize (L: 14.36±2.75; C: 10.51±2.15) (P=0.353) and number of vocalizations (L: 196.54±10.38; C: 206.72±10.66) (P=0.823). However; there is significant difference between genotypes in the latency to the first flight attempt (L: 109.95±5.59; C: 80.33±9.33) (P=0.007), number of flight attempts (L: 0.58±0.28; C: 3.08±0.84) (P=0.005), number of induction attempts (L: 2.12±0.25; C: 1.29±0.14) (P=0.005) and duration of TI (L: 45.75±8.09; C: 84.00±6.85) (P=0.001). Spearman correlations revealed a trend for negative correlation between number of flight and number of induction attempts in local (r=-0.36, P=0.085) genotype; but a positive correlation trend for the commercial one (r=0.38, P=0.068). Results suggest that commercial genotype can be considered to be less fearful (more active behavior) in NE test but more fearful (longer TI duration) in TI test. On the contrary, local genotype showed less activity in NE test but shorter TI duration on d 34 that may indicate higher and lower fear responses, respectively. Since the genotypes showed opposite responses to tests applied at different ages and overall lack of correlations between the parameters of the two tests, results confirm that the emotion of fear is multidimensional or can change over time. Therefore, it would be useful to choose behavioral tests that simulate conditions in which animals might face in their lives and to interpret the results in the context of the tests. Although high activity behavior in the NE test is considered an indicator of low fearfulness, the commercial genotype may show more energy consuming behavior and may be injured due to escape attempts that may cause reduced welfare in such environmental conditions similar to the NE test. However; the commercial genotype may also have a more adaptive response to predator contact. The opposite correlation tendencies obtained in the escape and induction attempts may also indicate that the two genotypes perceive the test conditions differently. As fearfulness is associated with welfare, the relationship between fear tests and welfare is ongoing. This study was supported by PRIMA Foundation (Grand agreement number 2015).

Keywords: Novel environment; tonic immobility; slow-growing broiler; fast-growing broiler; welfare

Effects of Selection, Strain and Parental Age on Egg Weight and Hatch Characteristics of Five Broiler Pure Line Chicken Strains for Six Consecutive Years

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This study was designed to determine the effects of the ongoing selection applications, broiler pure line strain and parental age on egg weight and hatch characteristics of five broiler pure line chicken strains for six consecutive years from 2018 to 2023. The main objectives of this study were (1) to present the six years of hatch data of five pure lines whose are the genetic origins of Türkiye's national broiler chicken, Anadolu-T®, (2) to demonstrate the changes in selected hatch characteristics over 6 consecutive years and (3) to investigate relationships among those characteristics. In this study; egg weight, egg weight loss at day 18, one-day old chick weight of males and females, fertility and hatchability of six consecutive years (from 2018 to 2023) of five broiler pure line strains (three dam lines A1, A2 and A3 and two sire lines B1 and B2) whose are under ongoing selection applications in Broiler Breeding and Genetics Research Campus in Eskişehir Transitional Zone Research Institute, were collected and analysed. Each year, eggs of pure line strains were collected, stored and incubated for the purpose of reproduction of pure lines. Data subjected to mixed model analysis, using the PROC MIXED procedure in SAS Studio. Results showed that fertility and hatchability are the most prominent parameters that have been changed significantly. Both fertility and hatchability of all pure lines have increased more than 10% from 2018 to 2023 ($P<0.001$). The other promising results are the relationship between parental age – fertility and parental age – hatchability. The eggs of older chickens showed lower fertility and hatchability in each year ($P<0.001$). Parental age over 40 weeks resulted in higher egg and chick weights than parental age below 40 weeks, as expected ($P<0.001$). Results of this study suggest that; (1) the experience of the technical team has increased year by year and hatchability has increased with more efficient and accurate incubation techniques. (2) ongoing selection practices in sire lines has led to increased fertility. (3) hatchability of all pure lines has increased due to the decrease in dirty ground eggs and the increase in clean eggs in the nest box due to the change in cage design year by year. (4) egg and chick weights are directly proportionate to parental age. (5) six years of hatch data of five pure lines whose are the genetic origins of Türkiye's national broiler chicken, Anadolu-T®, will be a scientific paper guide for upcoming studies and projects.

Keywords: Broiler; sire line; incubation; hatch data; Anadolu-T

The Evaluation of Morphologic Traits in Zebra Finch (Taeniopygia guttata)

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Zebra Finch (Taeniopygia guttata) is an important model organism used for understand of the biological, physiological and behavioral characteristics of poultry and avian species. The morphological traits may have a significant role in examining some relationships, especially at the level of sexual dimorphism, sexual selection, and breeding studies. This study aimed to determine the morphological traits, and the multivariate discriminant analysis of these traits in genders and different varieties. The body weight, head length, head width, head index, beak length, head+beak length, beak width, beak index, chest width, back length, tail length, shank length, shank width, and middle finger length were measured in a total of 231 birds of both genders from 3 different varieties (Fawn, Gray and White). All birds measured were 10-12 months old. The head width 10.82a, 10.18b and 10.48ab mm; head index 1.50b, 1.58a and 1.54ab; beak length 10.38ab, 10.55a and 10.27b mm; beak width 6.40b, 6.54a and 6.46ab mm; breast width 14.83a, 14.29b and 14.48ab mm; shank width 1.26b, 1.34a and 1.33a mm, these traits were statistically significant in the Fawn, Gray, and White varieties, respectively ($p<0.05$). The body weight 13.76, 13.90 ve 14.29 g; head length 16.04, 15.89 and 15.93 mm; head+beak length 26.41, 26.43, and 26.20 mm; beak index 1.62, 1.62 and 1.59; back length 37.86, 38.07 and 38.98 mm; tail length 34.58, 34.72 and 34.63 mm; shank length 12.04, 12.09 and 12.22 mm; middle finger length 10.57, 10.96 and 10.83 mm, these traits were statistically insignificant ($p>0.05$). The females were 0.49 g heavier than males ($p<0.05$). The males were significantly larger than the females in terms of head length, head width, head + beak length, beak width, tail length, and middle finger length, as 0.40 mm, 0.37 mm, 0.46 mm, 0.13 mm, 1.03 mm, and 0.52 mm, respectively ($p< 0.05$). Discriminant analysis showed that samples correctly classified 71.5% of the 3 varieties and 73.3% of the genders into their groups.

Keywords: Zebra finch; morphology; discriminant analysis; body weigth; gender

Effects of Calorie Restriction, Bee Products, Starch Based Sugar and Ad-libitum Feeding on Egg Production, and Ovarium Performance in Older Broiler Breeder Hens

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This study aimed to investigate effects of calorie restriction, dietary addition of bee products or starch based sugar, and ad-libitum feeding on number of eggs and relative ovarian weights of broiler breeder hens and these effects were comparised with commercial restricted feeding program used routinely. In the study, fifty-six weeks old 200 commercial broiler breeder hens (Ross 308) were used and the experiment was proceeded 18 weeks. Hens were randomly allocated 5 groups, each with 4 replicates. The feeding treatments consisted of: (1) fed on a basal diet at 160g/day/hen (commercial feed restriction) during experimental period (Control); (2) applied ad-libitum feeding only in the first 4 weeks of the experiment (ALF); (3) fed on diet containing royal jelly (200 mg/hen/day) and apilarnil (5 g /hen/ day) only in the first 4 week of the experiment (BP); (4) fed on diet containing starch based sugar only in the first 4 week of the experiment (SBS); (5) applied about calorie restriction (45% of commercial feed restriction) only in the first 4 week of the experiment (CR). Throughout the experiment, egg production of the groups was recorded daily, and the ovarian weights and number of large yellow follicles were determined in 10 hen slaughtered each group at the 4th, 8th and 18th weeks. In the 4th week of the experiment, relative ovarian weights and number of large yellow follicles tend to be lower in the CR group, these reductions were not statistically significant and compensated in the 8th and 18th weeks. The egg production of in treatment groups were at similar from 1 to 4, 5 to 8, and 1 to 18 weeks. Total egg production of the BP group increased by approximately 28% compared to the control group. This improvement was not statistically significant but was a remarkable increment in commercially. These results indicated that bee products application resulted in an increasing trend in egg production and thus the age-related decrease in egg production might partially be prevented. Therefore, further research is needed to clarify if bee products application for longer durations than 4-week would be benefical on production performance of aged broiler breeders.

Keywords: Bee products; broiler breeder hen; calorie restriction; egg production; ovarian performance

Effects of Post-Hatch Feeding Time on Growth and Organ Development of Male Turkey Chicks at Early Ages

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This study was conducted to examine the effects of post-hatching feeding time feed on live weight and organ development of commercial white turkey chicks at early ages. A total of 120 Big6 male turkey chicks were used in the study. During the 21-day trial, chicks were fed with a commercial turkey starter diet (28% crude protein, 2800 kcal/kg ME) obtained from a commercial feed mill in Izmir. In the study, chicks were distributed into 2 treatment groups (60 per treatment) as Early and Late feeding. The first group had access to feed in the transportation box at the hatchery (Early-fed) while the second group was held for 48 hours without feed and water (Late-fed). The chicks randomly distributed into 5 replicate pens bedded with wood shavings under standard rearing conditions. Feed and water were provided ad libitum. One chick from each replicate (a total of 5 chicks from each group) was killed by cervical dislocation on days 3, 7, and 21 after recording their live body weights. Breast muscle, legs, residual yolk, spleen, liver, bursa fabricius, heart, and digestive system weights were recorded and relative weights of carcass parts and organs to live weight (%) were calculated. The results showed that the live weights of Early-fed chicks were significantly higher than Late-fed chicks at 3 and 7 days of age ($P<0.05$). However, the live weight difference between the groups disappeared at the age of 21 d. Liver, heart, breast muscle and leg weights of early-fed chicks at 3 and 7 days of age were significantly higher than the Late feeding group ($P<0.05$), but these differences were not observed on d 21. Not only actual weight of breast muscle but also relative weight of breast muscle was reduced by Late feeding at 3 and 7 days ($P<0.05$). However, there was no difference between the groups at d 21. As a result, turkey chicks that accessed feed with a 48-hour delay after hatching had a reduced live weight and lower organ weights at early ages. However, these differences were compensated for on the 21st day.

Keywords: Breast muscle; late feding; live weight; organ development; turkey chicks

IN OVO FEEDING for Early Intestinal Development in Poultry

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Early nutrition, one of the topics that has been emphasized recently, is very important for intestinal development and health. Nutrient intake in the early period is the main element that stimulates histomorphological development and microbiota in the intestines. The last few days of the incubation period in poultry and the first few days after hatching are considered the critical period for the intestinal development of the chick and the formation of the intestinal microbiota. In addition, the 16th day of incubation is very important for the functionality of the small intestine, oral intake of amniotic fluid and villus development. For this reason, it is very important to introduce the poultry digestive system to nutrients at an early stage. However, in the current production system, transportation of chicks between hatcheries and production farms can delay the chicks' access to feed by 48-72 hours, and this delay period prevents early feed intake, microbiota formation and stimulation of the intestinal histomorphological structure. These hours are especially critical for the development of the digestive and immune systems. In ovo feeding technique is one of the new feeding methods in order to prevent the negativities that may occur in the process from incubation to feeding and to maximize intestinal development in the embryonic period. The in ovo injection method, known as the in-egg feeding technique, is applied by injecting various nutrients and various feed additives as liquid solutions into the embryonic sacs at any time during the incubation period. There are many factors that affect the success of the method, such as reproductive age, egg storage time and conditions, egg size, injection site, needle thickness, application location and time, and the compound to be injected. It is very important to know the embryonic development stages of poultry when choosing the application time and place of in ovo injection. There are generally five preferred sites for in ovo injection (allantoic sac, amniotic sac, yolk sac, embryo body, air sac). When intestinal health is targeted, the most appropriate injection site has been determined as the amniotic sac. In practice, the most appropriate injection time is considered to be the 17th and 18th days, which is the physiological development period between the start of the yolk sac being pulled into the abdomen and the breaking of the outer shell with the head curling under the wing. These days are also advantageous in that they parallel the development of the small intestine during the embryonic period. Therefore, 17-18. Small intestinal development and the formation of the intestinal microbiota can be supported by supplementing nutrients and feed additives on days. Thus, the chick, which starts life with its digestive system at the maximum level, can have advantages such as better utilization of feed, strong immune system, high production efficiency and economical production. Studies on the current presentation are within the scope of the project supported by TUBITAK (Project No: 122O808).

Keywords: Gut health; in ovo feding; intestine; poultry

Effects of a Non-Fast Moulting Program on Post-Moult Egg Quality Characteristics of Different Genotypes of Laying Hens

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This study investigated the pre and post-moult egg quality characteristics of different genotypes of laying hens as commercial Nick Brown, Susex, Atak-S, and a local cross-line called Turquoise hen housed in a commercial farm. The hens in all flocks were 72 weeks old and were the optimum age for molting. The birds in each genotype group were allowed ad libitum access to water and their whole corn-based molting diet during the molting period for 16 d., and then a complete layer ration after the molting program. In total, 240 eggs, 60 eggs from each genotype group, were collected randomly from all eggs laid on a particular day four weeks before the beginning and four weeks after the end of the molting period. The egg quality assessment included egg weight, egg length, egg width, shell color (L*, a*,b*) traits, shell thickness, shell weight, yolk height, thick albumen height, and yolk color. Differences in the traits among the groups were analyzed statistically by two-way analysis of variance. When the analysis of variance revealed a significant effect ($P < 0.05$), means were separated using the Tukey test. Post molt egg weight of all genotypes was significantly greater than those of premolt egg weight ($P<0.001$). Eggs of commercial Nick Brown had significantly greater weight ($P<0.025$) and shell thickness ($P>0.001$) than those of the other eggs. The post-molt shell thickness of eggs was significantly greater than those of pre-molt shell thickness of eggs in all genotypes except Sussex. The cross-line hen's eggs have significantly the lowest shell thickness. The albumen and yolk height of eggs was not significantly influenced by genotype and molting practices. In conclusion, it can be said that moulting treatment had a significant effect, especially on external egg quality traits, as expected. Commercial Nick Brown had slightly better pre and post molt egg weight and shell thickness than the other genotypes, while Sussex and Atak-S had similar external quality characteristics.

Keywords: Laying hens; non-fast molting; egg quality; genotype

Effect of Allicin and Apple Cider Vinegar on the Shelf Life of Chicken Meat Products

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Poultry meat has recently become one of the preferred foods due to its unique taste, low-fat content, high nutritional value, and ideal fatty acid profile. The need for microbially safe, healthy, minimally processed fresh meat has been increasing recently. Therefore, bioactive substances with natural antimicrobial properties have begun to be used in food processing plants. Apple cider vinegar has antioxidant polyphenols, organic acids such as acetic acid (3-9%), vitamins, and minerals. Plant extracts, oils, powders, and by-products are an excellent source of natural preservatives with antibacterial activity. It is known that garlic tissues produce allicin as a defense against pathogens, yeast&molds, and have strong antioxidant properties and inhibitory activities against various microorganisms such as bacteria, fungi, protozoa, and viruses. In this study, two different chicken meat samples were studied and studies were conducted in the pilot plant. Firstly, breast cubes (0.8% fiber and carrageenan, 10% water, 9% spice sauce) currently available for sale, allicin marinated with spice mixture, were compared with the existing product, considering microbiological and sensory analysis. As a result of the 18-day shelf life study, while there was no significant difference ($P<0.05$) in the total viable count until the 11th day, an approximately 1 log decrease was observed in the allicin-added group on the 16th and 17th days. A 1.4 log decrease was observed on the 18th day compared to the control group. Analysis results show that allicin has a significant positive effect on yeast & mold counts after the 9th day. In the sensory analysis results, both sample groups gave positive and very close values. Secondly, the effects of natural antimicrobial powder (70-80 % apple cider vinegar, 20-30 % salt) and allicin on schnitzel, which is a chicken meat product, were mixed into schnitzel dough at different concentrations (0.045 % and 0.37 %) and total viable counts and yeast&mold counts were examined. In addition to this information, antioxidants and antimicrobials were not used in all sample groups in the product spect. It was observed that the effect of the natural antimicrobial powder mixture on the schnitzel product had a more growth inhibiting effect on both the total viable and yeast&mold compared to the control and allicin groups.

Keywords: Natural antimicrobial powder; apple cider vinegar; sensory; antioxidants; marination

Factors Affecting Meat Color in Broiler Chickens

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Poultry meat has become an essential animal protein source due to its health benefits and production efficiency. Broiler meat quality properties comprise appearance, texture, juiciness, wateriness, hardness, tenderness, odor, and flavor. Its effectiveness on meat quality depends on water holding capacity, cook loss, pH, shelf life, collagen content, protein solubility and fat binding capacity. Biochemical processes contribute muscle conversion into meat after slaughtering in poultry. Post-mortem carcass temperature directly affects rigor mortis and PSE development. The physicochemical changes on carcass are influenced by postmortem glycolysis, temperature, and pH. Besides these, meat color is essentially a sensory characteristic on meat production. Color is a significant component for assessing consumer acceptance on meat products. The presence of antioxidants, lipid oxidation, mitochondrial activity and pH are endogenous components that contribute to meat color. Otherside, broiler chicken age, sex, strain, management conditions, rearing systems, handling, slaughtering, meat processing and nutrition impact on broiler meat color. Broilers skin and carcass pigmentation depends on the lipid-soluble pigments like carotenoids in the feed sources, xanthophylls concentrate and feed additives. Myoglobin concentration and muscle pH both contribute to meat color and meat color abnormalities. Meanwhile, poultry meat has considerably lower myoglobin than other farm animal's meat. This review provides to assess of the broiler meat color mechanism and the factors affecting broiler meat color in poultry production.

Keywords: Broiler; meat quality; carcass; meat color; nutrition

The Effects of Different Egg Weights on Egg Quality Traits in Turkish Native Geese

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This study is aimed to investigate the effects of egg weight on the egg quality traits of Turkish native geese. A total of 30 eggs were obtained from geese flock in the second production year, and categorized into two subgroups as "light eggs (<150 g)" and "heavy eggs (>150 g)", and subsequently interior and exterior egg quality parameters, pH and dry matter of yolk and albumen were measured (n: 15 eggs per weight group). The mean value of light and heavy eggs' weight were found to be as 148.2 g and 162.6 g, respectively (P<0.001). Significant differences were observed for albumen and shell weight (P<0.001), whereas any significant changes were found for percentage of yolk, albumen and shell. The egg weight affected the yolk index (28.0 vs. 34.4%), albumen index (5.7 vs. 4.6%) and Haugh unit (90.9 vs. 69.3) in light and heavy eggs (P<0.05). As a conclusion, it could be highlighted that egg weight affect some of quality criteria's in Turkish native geese, that could be meaningful under practical conditions from the point of view for feeding of breeders, storing eggs, and managing of incubation process.

Keywords: Egg weights; interior egg quality; exterior egg quality; Turkish native geese

Introduction

Recently, geese production has increasingly gained importance as an animal protein source, and is performed for their meat, feathers, and also liver in both different parts of the world and in Türkiye. In our country, geese production is mainly performed especially in rural areas, particularly in Southeastern Anatolia, Western Black Sea, Inner Aegean, Eastern Anatolia and Central Anatolia (Kuru and Kırmızıbayrak, 2024).

Differently for other poultry species, geese have some advantages for their management requirements, for example low maintenance and feeding costs, minimal housing conditions (Kokoszyński, 2017; Akhtar *et al*., 2021). Generally, geese are kept under extensive conditions, with their higher ability to digest the high cellulose content feed, herbs and wild plants, and natural resistance against to various weather conditions and diseases (Kozák, 2021).

Geese start the egg-laying activity in early days of March and finish the laying in the middle of June. During this period, geese produce a substantial quantity of eggs, which could show variation according to the many factors including age, genotype, nutrition and environmental conditions. Respecting this limited egg laying period, goose eggs are mainly used for incubation process. Therefore, egg quality parameters have significant importance to provide maximum hatchability and optimum quality of one-day old gosling (Galić *et al*., 2019).

Previous studies showed that the Turkish native geese breeds produce the eggs with a weight of 155 g at 1st years of egg cycling, then shows an increment to 168 g at 3rd years, while the average of egg weight could be guessed around at 163 g (Önk and Kırmızıbayrak, 2019; Kırmızıbayrak and Boğa Kuru, 2016). This study is aimed to investigate the effects of egg weight on the egg quality traits of Turkish native geese.

Materials and methods

In this study, a total of 30 hatching eggs were collected a native Turkish geese flock at 2nd production year (n: 15 eggs/egg weight group). The geese flock was reared according to the industry practices within a specialized poultry production facility. These eggs were categorized into two groups as "light eggs" under 150 g, "heavy eggs" higher than 150 g.

The external and internal egg quality analysis were performed 24 h after the eggs were laid. After weighing of eggs with ±0.01 g precision, the length and width of the eggs were measured by using a digital caliper with 0.01 mm precision (Mitutoyo, 300 mm, Neuss, Germany). The measured values were used to calculate the egg shape index with a formula of (egg width/egg length) × 100 (Reddy and Reddy, 1979).

The eggs were broken to obtain the albumen and yolk, and then the yolk weight was measured with ±0.01 g precision. The eggshells were cleaned by washing process and then put in an oven at 105 °C (Nüve FN-500,

Ankara, Türkiye) for drying process for 24 h. Then, the eggshell weight was determined with ±0.01 g precision. Albumen weight was calculated by subtracting yolk and shell weight from total egg weight. The ratios of albumen, eggshell, and yolk were given as a percentage of EW. Eggshell thickness was measured at three different points of the eggshell, specifically air cell, sharp end, and equator region, by using a digital caliper with ±0.01 mm precision. The eggshell thickness was given as the average of three values measured for these points.

To calculate the yolk index, albumen index, and Haugh unit, yolk diameter, albumen length, and albumen width were determined by using a digital caliper with ±0.01 mm precision (Mitutoyo, 300 mm, Neuss, Germany). Albumen height and yolk height were measured by using a tripod micrometer. Egg yolk index, albumen index, and Haugh unit were calculated using the formulas given by Funk (1948), Heiman and Carver (1936), and Haugh (1937) respectively:

Yolk index = (Yolk height/Yolk diameter) × 100

Albumen index = (Albumen height /(Albumen length + Albumen width)/2)) × 100

Haugh unit = 100 × log (Albumen height + 7.57 − 1.7 × Egg weight$^{0.37}$)

A total of 5 samples from each egg weight group were prepared for dry matter (method number 934.01), content, according to AOAC (2006), and also pH measurement. The effects of egg weight on egg quality parameters were subjected to the t-test procedure in SAS (version 9.4, 2012, Cary, NC, USA). Analyses of percentage data were conducted after arcsine square root transformation of the data. Differences were considered statistically significant at $p \leq 0.05$.

Results and discussion

The egg weight and exterior egg quality of light and heavy egg are given in Table 1. As shown in the table, the mean value of egg weight was found to be as 148.2 and 162.6 g in light and heavy eggs, respectively (P<0.001). A higher of yolk index was observed in heavy eggs (34.4%, P<0.01), whereas the albumen index was higher in light eggs (5.7%, P<0.05).

Furthermore, Haugh unit was significantly higher in light eggs compared to the heavy ones (90.9 vs. 69.3, P<0.01). In a previous study performed by Boğa Kuru and Kırmızıbayrak (2024), a similar shape index was observed among the different egg weights as light (125.5 g), medium (152.1 g) and heavy (174.9 g) goose eggs. On the other hand, as the egg weight is increasing, some deterioration could be seen in egg quality in the manner of Haugh unit. The lowest of mean value for Haugh unit was observed in heavy eggs, compared to the light ones.

Table 1. The egg weight and exterior egg quality parameters

Experimental groups	Egg weight (g)	Shape index (%)	Yolk index (%)	Albumen index (%)	Haugh unit
Light eggs	148.2 ± 1.6	79.6 ± 0.26	28.0 ± 0.9	5.7 ± 0.3	90.9 ± 3.1
Heavy eggs	162.6 ± 1.1	79.5 ± 0.48	34.4 ± 2.0	4.6 ± 0.4	69.3 ± 5.5
P value	<0.001	0.846	0.008	0.027	0.003

n = 15 eggs/experimental group

This current study shows that any significant changes were observed among two egg weight groups in the view of yolk percentage, albumen percentage, eggshell percentage and eggshell thickness (P>0.05). However, Boğa Kuru and Kırmızıbayrak (2024) reported a decline in eggshell thickness as egg weight increased.

Table 2. The egg content and eggshell thickness

Experimental groups	Yolk (%)	Albumen (%)	Eggshell (%)	Egghell thickness (mm)
Light eggs	40.0 ± 3.0	48.6 ± 1.0	11.4 ± 1.4	0.581 ± 0.07
Heavy eggs	38.1 ± 2.2	50.5 ± 2.3	11.4 ± 1.0	0.609 ± 0.07
P value	0.061	0.126	0.946	0.265

n = 15 eggs/experimental group

As seen in Table 3, any significant differences were observed for dry matter content and pH value of yolk and albumen in light and heavy eggs (P>0.05).

Table 3. The interior egg quality parameters

Experimental groups	Yolk dry matter (%)	Albumen dry matter (%)	Yolk pH	Albumen pH
Light eggs	54.8 ± 1.4	13.0 ± 2.1	6.11 ± 0.34	8.81 ± 0.13
Heavy eggs	55.2 ± 1.0	12.2 ± 0.8	6.30 ± 0.28	8.77 ± 0.35
P value	0.972	0.191	0.144	0.435

n = 5 eggs/experimental group

Conclusions

Due to crucial importance of eggs for embryo development during incubation process, the egg content, quality and chemical composition should be taken into account for a successful breeding and hatching process. The current findings clearly showed that egg weight have potential to affect the egg quality in Turkish native geese. As a conclusion, it could be recommended to study in detailed about the effecting factors of egg quality in geese to determine the crucial factors.

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Recent Approaches in Broiler's Nutrition in the Aspects of Breast Meat Quality

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Today, broilers have been successfully bred all over the world to keep the global animal source protein demand, and also has importance in terms of health benefits, cost and production efficiency. In broilers, effective genetic selection with breeding programs and intensive nutrition techniques has significantly increased the productivity with a higher percentage of meat and breast yield. However, parallel to this growth in performance, it has resulted in unfavorable meat quality and body composition due to triggering factors, for example, fast growth, bacterial and parasitic infections, metabolic disorders, heat stress, and the nutritional facts. In recent years, myopathies have started to emerge, and cause negative effects on growth, histology and metabolism of muscle fibers in breast, deteriorating the meat quality, and finally results in serious yield and economical losses. Some of breast myopathies are white striping, wooden breast, spaghetti meat, green muscle disease and cranial dorsal myopathy. It should be possible to alleviate these syndromes by nutritional strategies by modulating nutritional composition of diets. Recent studies have highlighted that the modulating of nutrition by bioactive compounds, including probiotics, prebiotics, exogenous enzymes, polyphenol compounds, and organic acids, have positively affects for protecting breast meat quality and minimize the myopathy problems in broilers.

Keywords: Broilers; white striping; wooden breast; spaghetti meat; nutrition

Introduction

Due to intensive genetic selection, modern broiler hybrids with fast growth rate and high breast meat yield are predisposed to some physiological abnormalities (Aviagen, 2014). For example, some undesired facts have been largely experienced in breast muscle development, that causing defects in the appearance and expansion of myopathies affecting the pectoral muscle of broilers. Some of these abnormalities are identified as pale, soft and exudative conditions, deep pectoral muscles, spaghetti meat, white striping, wooden breast (Maiorano, 2017). These problems are caused by a fast growth rate and increased muscle size of broilers, which results in defects of structure, metabolism and repair mechanisms of muscles (Velleman, 2015). Besides physiological limitations, these abnormalities are also closely associated with intensive management standards and exhausting production systems (Petracci et al., 2015).

White Striping

White striping is defined as white striations parallel to muscle fibers by fiber degenerations with lipidosis and fibrosis as shown in Figure 1 (Huang and Ahn, 2018). The major histopathological changes of white striping are characterized with necrosis of fibers, degenerating and regenerating fibers of variable size, loss of cross striations, mineralization of nuclei, hyalinization, fibrosis, lipidosis, and lymphocytes and macrophages infiltration (Russo et al., 2015).

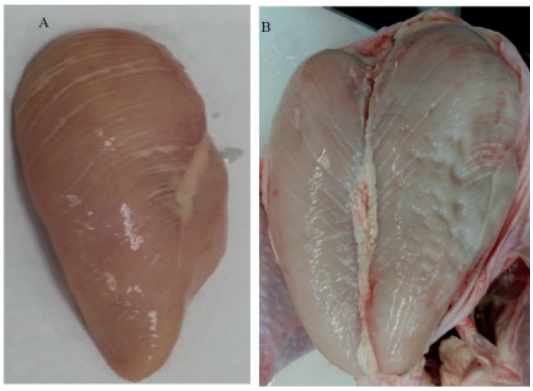

Figure 1. White striping on a breast muscle (A) and on a carcass (B) (Huang and Ahn, 2018)

The incidence and severity of white striping have been investigated by numerous studies (Kuttapan 2012, 2013; Petracci et al., 2013). Kuttapan et al. (2012) created a scoring system based on visual appearance including normal, moderate and severe of white striping. It was reported that more than 50% of broilers between 59-63 days of age had white striping (Kuttapan et al., 2013).

Interestingly, previous reports clearly indicated that the incidence and severity of white stripe showed a rapid increment by years, which was 5% in 2012 (Kuttappan et al., 2012a; Petracci et al., 2013), 29% in 2015 (Russo et al., 2015; Tijare et al., 2016), and to 75.5% in 2017 (Gratta et al., 2017) in broilers. Besides, it has been reported a discrepancy among broiler genotypes, which was shown susceptibility in Ross 308 broilers compared to the Cobb 500 (25.9% vs. 7.4%, Lorenzi et al., 2014).

In broiler nutrition, diets with high energy provided a higher body weight at the end of the production period, but also results in an increment of incidence and severity of white striping. Besides, diets with higher fat content and lower protein content was also triggering white striping (Kuttappan et al., 2009). To reduce the incidence of white striping, Meloche et al. (2018) suggested a feed reduction during rearing period. A feed restriction between 13 and 21 days of age could be effective to control the white striping by providing fiber degeneration (Kuttapan et al., 2012).

Wooden breast (Woody breast)

Wooden breast is identified as bulged, hard and rigid muscles with a surface hemorrhage and the presence of a light-yellow viscous exudate on the muscle surface (Mudalal et al., 2015), as shown in Figure 2. This abnormality could histopathologically characterized with increased degenerative and atrophic fibers, variability in fiber size, floccular and/or vacuolar degeneration and lysis of fibers, hyalinization, lipidosis, extensive fibrosis, and macrophage infiltration (Soglia et al., 2016).

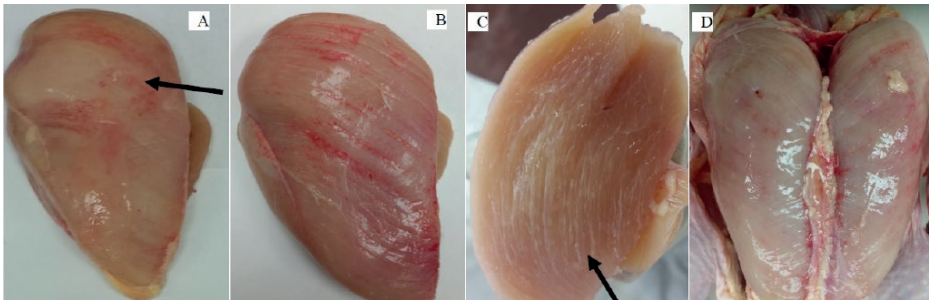

Figure 2. Wooden breast, bulged areas and hemorrhage (A); bulged area with white stripes and hemorrhages (B), cross section of muscle with wooden breast, white lines with fibrosis and lipidosis (C), wooden breast with bulged area, white stripes, hemorrhages and yellowish viscous fluids (D) (Huang and Ahn, 2018)

It has been reported that broilers with high growth rate, feed efficiency and breast yield had an tendency for wooden breast due to a rapid development of myopathies, and it could be explained by outgrowing of muscle tissue than the supporting system such as connective tissues and capillaries, by changing of the structure and metabolism of the muscle (Petracci and Cavani, 2012). It has been reported the incidence of wooden breast has been explained with an approximate percentage of 5-10% of commercially produced breast fillets (Huang and Ahn, 2018). There has been also some reports presenting the incidence of wooden breast with a percentage of 30% to 50% of broilers at 56 days of age with a higher body weight (4.2 kg; Owen et al., 2014), and 96.1% of wooden breast incidence in broilers reared fed with commercial diets (Tijare et al., 2016).

The nutritional solution, as dietary supplementation of some trace minerals including selenium, zinc, manganese, copper in a combination with some antioxidants, could be helpful to reduce the incidence of wooden breast, by enhancement of broilers' defense system in the tissues, and reducing the free radical production preventing muscle myopathies (Kidd, 2004).

Spaghetti meat

Spaghetti meat could be defined as poor muscle cohesiveness due to the immature intramuscular connective tissues

(Radaelli et al., 2017). In this abnormality, the density of connective tissues in endomysium and perimysium progressively decreases, and thus the muscle fiber bundles become easily disintegrated or mushy (look like spaghetti) (Puolanne and Voutila, 2009).

Spaghetti meat was recognized for the first time in 2015, called as "Mushy Breast", and described as a myopathy causing the loss of muscle integrity of the *Pectoralis major* muscle of fast growing broilers (Bilgili, 2015). Then due to its phenotypically appearance with the detachment of the fiber bundles composing the pectoral muscle, which appears soft, mushy, and sparsely thigh, resembling spaghetti pasta (Figure 3). Therefore, it has been started to called as "Spaghetti meat" or "Spaghetti breast".

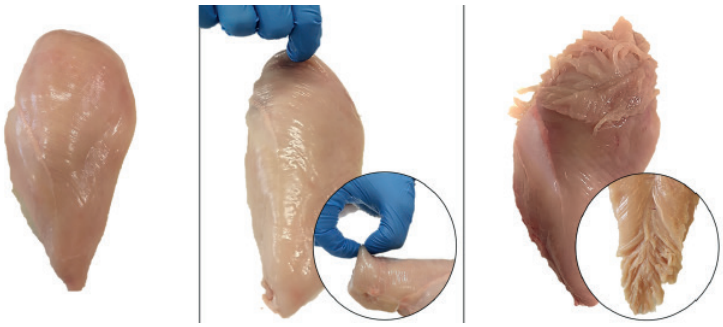

Figure 3. Spaghetti breast meat with different severity (Baldi et al., 2021)

Conclusions

Regarding to breast meat abnormalities, the future studies could focus on the triggering factors of white striping, wooden breast and spaghetti breast in broilers, and preventing procedure relation to management conditions and nutritional aspects, to minimize the economic losses due to these abnormalities.

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Using Chickpea Boiled Water as Egg Replacer in Heat-Treated Chicken Meat Products

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Eggs are considered a valuable source of nutrition. Additionally, eggs play a crucial role in various food applications due to their functional properties, such as gelling, foaming, texture enhancement, flavoring, emulsification, and coloration. Therefore, eggs are commonly used as fundamental ingredients in food formulations. Chickpea boiling water is consider waste, which has the potential to be an important food source.This study aims to evaluate a waste with important functional properties by using aquafaban as an egg replacer in heat-treated chicken meat products. This liquid has many functional properties such as foaming, emulsifying, and thickening. The proteins in aquafaba are amphiphilic molecules containing hydrophilic and hydrophobic groups. While hydrophilic groups interact with water, hydrophobic groups stabilize interactions with the gas/oil phase. Therefore, these molecules accumulate at the air-water/water-oil interface and the solution can lower the interfacial tension, causing the proteins to partially unfold. This low interfacial tension allows the encapsulation of air bubbles or oil droplets and the assembly of protein molecules, leading to an intermolecular adhesive film with sufficient flexibility to stabilize foams and emulsions. In this study, chickpea foam was used in certain proportions (0%, 80% and 100%) as egg substitute in meatball products. The trials were subjected to tests such as color, texture and heat treatment loss. Compared to the reference in the desired parameters; Differences were observed only in terms of hardness, gummunies and chewiness. No difference was seen in hardness tests compared to the reference. The reference value was the lowest in chewiness. In terms of chewability, the trial containing 80%, was perceived to be best. In color measurement tests, the 80% closest to the reference value was determined as the trial. No significant difference was observed in cooking waste.This could be transformed from a low-cost, organic waste product into a new value-added natural functional foodstuff, which could significantly increase pulse production. The use of aquafaban as an egg substitute allows the production of new products containing entirely plant-based protein, suitable for the needs of individuals who cannot consume eggs due to reasons such as egg allergy or vegan diet preferences. Literaturestudies, the functional properties of aquafaba are particularly limited to products such as meringues, sponge cakes, and similar items. Additionally, it serves as a functional component in the development of gluten-free food products. Future studies could expand on the products used and explore increasing the variety of products made with chickpea cooking water. Therefore, investigating the use of aquafaba in thermally processed chicken meat products would contribute new insights to the literature and represent an unprecedented study in this field.

Keywords: Aquafaba, waste, eggs, chickpea boiling water

Possibilities of Using Light Microscopy for the Detection of Processed Animal Proteins in Poultry Feeds

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Due to the first cases of bovine spongiform encephalopathy (BSE) in Europe, a "species-to-species" ban on processed protein sources began to be implemented. It can be detected by various methods, such as light microscopy, enzyme-linked immunosorbent assay, polymerase chain reaction, near infrared microscopy and near infrared spectroscopy, to detect prohibited processed protein sources. According to the EU Commission Regulation of 2009, light microscopy and polymerase chain reaction (PCR) are only official method for the detection and characterization of processed protein sources (PAP) in feed in the European Union. Also, light microscopy is the only the most reliable and accepted method in the EU comparing to the other methods (Liu et al. 2011). However, neither of these two methods can meet all the requirements for the correct identification of prohibited processed proteins of animal origin. Light microscopy combined with computer imaging is recommended based on the identification of components in the feedstuff such as bone fragments, muscle tissue, hair, feathers, and fish bones (Ottoboni and Pinotti, 2017). In this review, the potential of using computerized image analysis and microscopy in differentiating different processed proteins of animal origin was investigated.

Keywords: Light microscopy; BSE; poultry feedstuff