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MEAT AND BLOOD SPOTS AS A QUALITY TRAIT ON TABLE EGGS: CAUSES AND SOLUTIONS

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Abstract: Eggs are considered one of the most complete foods in the human diet, with their composition particularly rich in vitamins, minerals, fatty acids, and excellent biological value proteins. With widespread use in the food industry due to both its nutritional value and functional properties, the production of quality eggs is critical in terms of food safety and therefore consumer health. However, egg quality has different meanings for consumers and consumers' perception of quality varies depending on the purpose of use and their own preferences. One of the most important defects affecting consumer preferences in terms of internal quality characteristics in eggs is meat and/or blood spots. Although the formation of meat and blood spots depends on factors such as the hen age, health status, feeding and management, it also emerges as a hereditary trait, especially in brown layers. According to different production systems, producers try to reduce the formation of meat-blood spots in eggs with management and feeding strategies to alleviate environmental stress. In addition, thanks to the developments in genetics and biotechnology, researchers and breeding companies have started to focus on the genetic background of meat-blood spot inclusions and to identify the genes affecting their formation. In this review, the occurrence and causes of meat-blood spots, one of the internal quality characteristics affecting consumer preferences in table eggs, were explained and suggestions to reduce the incidence were presented.

Keywords: Egg, Internal quality, Meat-blood spots, Genetic, Environmental stress

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1. Introduction

Eggs are a high-quality source of protein containing all the essential amino acids required by the human body. When consumed as part of a healthy diet, it meets a significant portion of the recommended daily doses of fatty acids such as omega 3 and omega 6, vitamins A, B, D, E and K, iron, phosphorus, selenium and zinc minerals as a single food product. In addition, it is an indispensable food in every age group due to its antioxidants such as lutein and zeaxanthin and choline content, which is found in the structure of cell membranes and is important for brain health (Rehault-Godbert et al., 2019; Fernandez, 2022).

In the poultry sector, production has increased rapidly thanks to scientific developments especially in the field of breeding and parallel to this, advances in technology, and it has been ensured that eggs are produced quite economically compared to other animal protein sources. In the last thirty years since the 1990s, world egg production has increased by 150% and reached approximately 90 million tonnes (Anonymous, 2024). In Türkiye, hen egg production, which was around 1.73 billion in March 2023, increased by 3.3% in one year, reaching 1 billion 790 million 81 thousand in March 2024, and 20.94 billion on an annual basis (TUIK, 2024). When the global per capita egg consumption is analyzed, although there are great differences between countries (India: 66 and Mexico: 410), the average egg consumption per capita is determined as 189* (FAO, 2023; OECD-FAO Agricultural Outlook 2023-2032- *Found by calculation for an average size egg, 57 g), while this figure is 196 in Türkiye (Anonymous, 2023). As can be understood from the statistical data, eggs, which are produced and consumed in such high quantities, are also one of the important and widely used raw materials of the food industry. Therefore, "egg quality" comes to the fore regarding consumer health in the context of food safety-nutrition-food assurance.

Egg quality is determined by observation, measurement and calculation methods before and after the eggs are broken. Eggs are divided into certain quality classes according to these characteristics called external quality (egg weight, shell quality and cleanliness, shell color, egg shape, etc.) and internal quality (albumin and yolk index, air cell size, meat and blood stains, etc.) and then offered to the market. Egg quality standards and grading ranges of these standards vary according to country. In our country, according to the legislation of the European Union, eggs are classified as A quality - Extra fresh, A quality - Fresh, and B quality - Eggs for the food industry.

In the United States, it is divided into AA, A and B grades, while in China it is divided into four categories: AA - Super Grade, A - First Grade, B - Second Grade and C - Third Grade (USDA, 2000; EU, 2008; Jiang et al., 2022). As in quality standards, eggs are divided into certain classes regarding weight and are offered for the use of consumers and the food industry.

From the consumers' point of view, quality is a subjective concept that varies from person to person and from society to society. The shell color, one of the external quality characteristics, does not make a difference in egg quality and nutritional value. Although there is no classification regarding shell color in the egg communique, some consumers prefer white-shelled eggs, while others buy eggs with dark shell color with the thought that brown-shelled eggs are more natural. Eggs are therefore packed separately in brown and white according to the shell color. In Figure 1, the eggshell color preferences of consumers according to countries are presented. For example, white shell eggs are consumed more in the USA and the UK, while brown shell color is preferred in Australia, Spain and France. In Türkiye, white-shelled eggs are purchased by 80% (Yıldırım, 2024).

Yolk color, one of the internal quality criteria of eggs, is a feature that is not included in egg standards like shell color, but is evaluated visually and creates a perception of quality. Consumers may prefer egg yolk colors ranging from dark orange peel to lemon yellow, which they consider more nutritious.

Another trait that affects consumers' preferences when purchasing eggs is the presence of meat and/or blood spots on the yolk or albumen. These spots, which can be seen especially in brown-shelled eggs after breaking the egg, are perceived as harmful/inedible/unacceptable by consumers. Therefore, they may change their purchasing preferences according to consumption/brand or shell color.

In this review, the occurrence and causes of meat-blood stains, one of the internal quality characteristics of table eggs, and a preference criterion for table eggs are explained and suggestions to reduce the incidence are presented.

2. Definition and Formation of Meat and Blood Spots

The presence of meat and blood spots may be observed together or separately before and after breaking, depending on the eggshell color.

2.1. Meat Spots

Seen in the albumen. While albumen is forming in the oviduct, a tissue particle breaks off from the magnum and sticks to the albumen, causing a brown spotted appearance. However, it is possible for a drop of blood adhering to albumen to coagulate and appear like a meat spot.

2.2. Blood Spots

More common on the yolk. During ovulation, a rupture of the yolk follicle membrane from an area outside the stigma where it attaches to the ovary or a hemorrhage occurring before the formation of albumen causes a red-spotted appearance on the yolk (Jeffrey, 1945; Altan, 2015).

3. Causes and Solutions of Meat-Blood Spot Formation

3.1. Related to Chicken

3.1.1. Genotype of chicken

Shell color, which allows species identification, is characteristic and genetically controlled. Brown layers tend to produce a higher proportion of meat and blood-spotted eggs than white layers (Stadelman et al., 1952). The following table presents some literature data on the incidence of meat-blood spots in brown-egg strains.

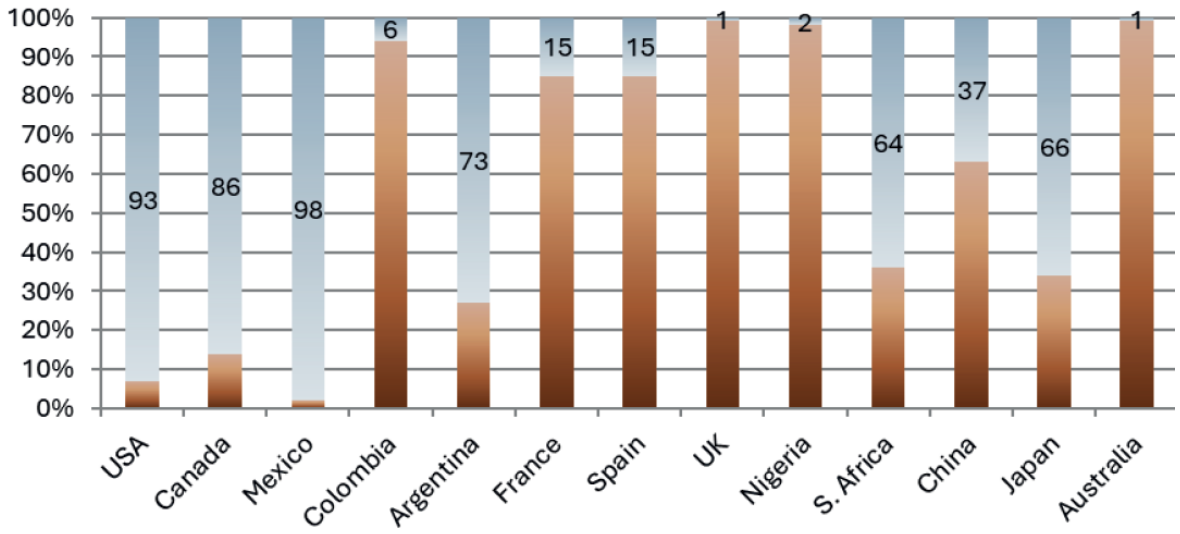

Figure 1. Eggshell color preferences of consumers by country.

Table 1. Some studies on the incidence of meat-blood spots in brown layers (%)

Reference	Genetic Material	Hen Age (week)	Incidence of Blood Spot (%)	Incidence of Meat Spot (%)
		26	10.00	10.00
Sokolowicz et al., 2018	Hy-Line Brown	42	10.00	30.00
		56	26.67	46.67
Safaa et al., 2008a	Hy-Line Brown	56	12.00 - 15.00	
Safaa et al., 2008b	Lohman Brown	58-73	12.50 - 18.10	
		20-29	10.00-13.30	18.30-21.60
Roll et al., 2009	ISA Brown	40-59	20.00-23.30	20.00-35.00
		66-78	29.50	16.10-24.10
Rizzi, 2020	Hy-Line Brown	28-44	35.00-40.00	15.00-20.00
Lordelo et al., 2020	Branca, Amarela, Preta, Pedres	-	8.20-23.88	18.75-31.34

However, genetically, the heritability of flesh and blood spots is low, i.e. less than 15% of the observed variation can be attributed to genetics. Therefore, it can be said that the incidence of meat and blood spots in eggs has decreased by more than 50% in the last 60 years, although progress via selection is low (Flock, 2019; van de Braak, 2023).

3.1.2. Age of the hen

Meat and blood spots are more common in the eggs of older chickens. With advancing age, the degeneration of the hen's oviduct, stress, diseases, or feed-related problems decreases the level of tolerance.

3.1.3. Stress

Sudden stress factors that cause the flock to be disturbed (in the afternoon and during the night, during vaccination or catching), fighting, fear, etc. increase the rate of meat and blood spots (van de Braak, 2023). One of the most important reasons for the formation of blood stains on the egg yolk is the increased activity due to such factors during ovulation in hens.

3.1.4. Diseases

Infectious Bronchitis in chickens causes not only egg quality deterioration but also a high incidence of meat and blood spots. In addition, nutritional diseases caused by the presence of mycotoxins in feed or some vitamin and mineral deficiencies also increase the incidence of meat and blood spots. It should also be taken into consideration that some drugs used to maintain/improve flock health reduce the absorption of vitamins and/or minerals (van de Braak, 2023).

3.2. Related to Housing

3.2.1. Rearing system

Eggs obtained from free-range systems have a higher rate of meat and blood spots than cage eggs. It is also difficult to prepare a balanced and low-cost ration, especially in organic egg production systems. The prohibition of the use of synthetic amino acids and therefore the lack of essential amino acids cause "health and welfare problems such as feather pecking and cannibalism". On the other hand, the use of hybrids adapted to cage conditions in free-rearing systems also causes significant problems due to environmental stress factors such as fear of open space and predators and other external stimuli (vehicle, machinery noise, etc.). In conclusion, although it is suggested that chicken welfare is better ensured in organic and free-range egg production models which are cage-free rearing systems, it cannot be expected that the incidence of meat-blood spots in the egg content will be similar to cage eggs unless potential environmental stimulus are reduced (Altan et al., 2009).

Another factor that increases the formation of meat spots in cage-free rearing systems is the use of high perches (Nalbandov and Card, 1944). In addition, disruptions in the supply of drinking water in the poultry house also lead to the formation of meat and blood spots.

3.2.2. Temperature

High temperatures or sudden changes in the temperature inside the poultry house, especially in summer, increase the rate of blood spots in eggs (Nalbandov and Card, 1944).

3.2.3. Lighting

Sudden increases in the duration of light, darkness even for short periods, and incorrect lighting programs such as continuous lighting increase the rate of blood-spotted eggs (Lee, 2016, as cited in Kim et al., 2022).

3.3. Related to Feed

3.3.1. Vitamin deficiency

Vitamins A and K and biotin deficiencies in the diet cause meat and blood spots (Bearse et al., 1960; van de Braak 2023).

3.3.2. Mineral deficiency

Magnesium mineral deficiency in the diet increases the formation of meat and blood spots (van de Braak 2023).

3.3.3. T2 toxicity

Feeds containing mold or high levels of mycotoxins should not be used (Shane, 2007).

4. Determination of Meat and Blood Spots in Egg Content

The meat and blood stains in the egg content can be evaluated in 2 ways: before or after the eggs are broken.

In a laboratory, meat and blood spots can be easily detected by observation by breaking a certain number of sample eggs onto a glass sheet with a reflective mirror. To obtain more reliable results in the breaking method since cracking a large number of eggs would cause economic loss, this method is usually applied to test the accuracy of the candling. In commercial egg facilities, the preliminary control process of the eggshell is carried out in automatic candling systems. Then, internal quality is evaluated and eggs including meat and blood spots are separated. The visible and near-infrared (VIS/NIR) spectroscopy method, which is a much more advanced technology used in the classification of eggs in large commercial laying facilities, gives fast results in the detection of meat and blood spots through sensors. However, the similarity of the optical properties of the protoporphyrin pigment, which gives the color to the shell in brown-shelled eggs, and the hemoglobin in the blood cell makes it difficult to identify blood spots (Ketelaere et al., 2005).

5. Conclusion

In our country, the quality standards of shelled eggs are determined as A (Extra fresh and non-extra fresh eggs offered directly for human consumption) and B (Eggs suitable for the preparation of egg products) classes (TS 1068, October 2015). In this standard, the phrases "for class A: eggs may contain very small blood and meat spots not more than 1% of the total number of eggs" and "for class B: eggs may contain very small blood and meat spots not more than 3% of the total number of eggs" are mentioned. Eggs containing more than 3% meat-blood spots are classified as inedible and constitute a significant economic loss for the egg industry.

As can be seen in the table, the incidences of meat and blood spots in eggs obtained from brown genotypes are quite high in many studies in the literature. Depending on consumer preferences, especially in free-range systems where brown-shelled egg production is carried out, should be paid attention to stress factors related to the management of the poultry house and external environment. In addition, maintaining the hygienic quality of feed and controlling vitamin/mineral levels are the primary solutions to reduce the presence of meat and blood spots in eggs.

On the other hand, increasing consumer interest in food safety and high-quality eggs has motivated researchers and breeding companies to study the genetic background of meat-blood spot inclusions. Further studies are being carried out to identify genes affecting meat-blood spot defects in egg albumen and yolk. In conclusion, research on the identification of quantitative trait loci affecting the incidence of meat-blood spots and the identification of candidate genes is promising for commercial selection programs.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	Ç.Ş.	H.C.G.
C	50	50
D	50	50
S	30	70
DCP	70	30
DAI	60	40
L	70	30
W	70	30
CR	30	70
SR	70	30

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision.

Conflict of Interest

The authors declare that there is no conflict of interest.

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