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(RESEARCH ARTICLE)

# Influence of yolk and albumin proportions on egg composition in layers' chicken fed with a free nutrition system

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## Abstract

Eggs are one of the most nutritious foods available to humans, providing a rich source of protein, lipids, vitamins, and minerals. Nevertheless, eggs are not entirely uniform in composition since they are made of two distinct parts: yolk and albumen. This study examines the effect of yolk-to-albumen ratios on the nutritional and functional properties of eggs from laying chickens. Eggs were obtained from laying chickens, which were categorized based on yolk-to-albumen ratios of 30:70, 40:60, and 50:50. Eggs were analyzed based on protein, lipid, energy, cholesterol, foaming capacity, emulsifying capacity, gel strength, and water-holding capacity. The results revealed notable differences in nutritional composition and functional properties of eggs from different yolk-to-albumen ratios. Eggs from laying chickens containing more yolk were found to have more lipid, energy, and cholesterol. On the other hand, eggs from laying chickens containing more albumen were found to have more protein, better foaming, and better water-holding capacities. This study found that eggs containing more yolk have more energy, whereas eggs containing more albumen have more protein. This study provides valuable information on the importance of yolk-to-albumen ratios in relation to egg composition. Eggs are one of the most widely consumed foods worldwide, providing a rich source of protein, lipids, vitamins, and minerals. This study provides valuable information on the importance of yolk-to-albumen ratios in relation to egg composition. Eggs are one of the most widely consumed foods worldwide. This study provides valuable information on the importance of yolk-to-albumen ratios in relation to egg composition. Eggs are one of the most widely consumed foods worldwide. This study provides valuable information on the importance of yolk-to-albumen ratios in relation to egg composition.

**Keywords:** Yolk-to-albumen ratio; Egg composition; Laying hens; Nutritional properties; Functional properties

## 1. Introduction

Eggs are widely regarded as among the most nutritionally complete foods in the human diet, serving as a rich source of proteins, lipids, vitamins, minerals, and bioactive components in this system (Réhault-Godbert et al., 2019; Nys et al., 2011). Eggs should never be seen as homogeneous, but as a complex system made up of two distinct compartments: the yolk and the albumen. Despite their similarities, proteins produced throughout the development of birds and their properties for human diets have significantly different origins, metabolisms, and functions (Anton, 2013; Mine, 2002). For poultry science, nutrition, and foodtech researchers, understanding the relative quantity of yolk versus albumen is relevant to maintaining a healthy egg.

The formation of egg components happens through a compartmentalised biological process. The yolk of eggs is produced mostly in the liver and is stored in ovarian follicles in an accumulation of lipoproteins, phospholipids and fat-soluble vitamins before ovulation. In contrast, the albumen is secreted in oral vessels shortly after ovulation and consists mainly of water and proteins of ovalbumen, o ovotransferrin, ovomucoid and lysozyme (Abeyrathne et al., 2013; Nys et al., 2011). This physiological distinction in the development of the two fractions has led to different nutrient

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distributions. Due to this uneven nutrient partitioning, the yolk-albumen ratio plays a key role in the egg's nutritional quality. Those with a high yolk proportion contain lipids, phospholipids, choline, and micronutrients, whereas those with a larger albumen ratio are protein-rich and low-fat (Réhault-Godbert et al., 2019; Peng et al., 2025). Such variable responses are of important relevance to eating habits that are more physiologically and calorie-rich food in clinical practice, or food-oriented in fitness and diet (Usturoi et al., 2025).

Moreover, the proteins in eggs and banden, which contribute to lipid digestion, cholesterol resistance, etc., depend heavily on the yolk-to-albumen ratio. Albumen proteins enable foamy, gelling and water binding in bakery and confectionery cultures (Mine, 2002; Abeyrathne et al., 2013), whereas yolk behaves as a natural emulsifier due to its lipoproteins and phospholipids, which are complex and provide for mayonnaise (Anton, 2013; Patil et al., 2022). In this way, a change in yolk-albumen ratio can affect the behaviour, structure, and properties of egg-based products (Kumbár et al., 2021). The proportions of yolk and albumen are not the same and are affected by various biological and environmental aspects, like the age of hens, genetic strain, nutrition of eggs, storage time, etc., which change the egg density and quality of their interior (Ahn et al., 1997; Silversides & Scott, 2001). The quality of the albumen varies with hen age and storage time. At the same time, the relative yolk weight can increase or decrease slightly, altering the nutrients within an egg and therefore affecting consumer acceptance and, consequently, the food service (Silversides & Scott, 2001).

Moreover, changes in the yolk/albumen ratio are driven not only by consumer preferences but also by industry practices. Recent developments in the application of metabolicomics and proteomics have revealed, through data mining and detailed analysis, hundreds of metabolites related to lipid metabolism/ amino acid metabolism, micronutrient bioavailability and protein activity in many cases (Peng et al., 2025). Thus, egg composition is dynamically driven and determined by biological and economic controls, as well as by processes and production systems. Eating eggs according to the parameters of yolk/albumen levels, therefore, helps us develop a more holistic picture of the egg as a biological, nutritional, and physiological system, and of why the health of eggs and their protein and fat is important. This methodology combines poultry physiology, food chemistry, and human nutrition to enhance breeding strategies, dietary compositions, and food product design (Nys et al., 2011; Réhault-Godbert et al., 2019). Rather than viewing these eggs as integrated, single entities, a more qualitative perspective on production will aid not only researchers but also industry professionals in better realising their nutritional potential and functional versatility.

## 2. Materials and methods

The study was designed to study the nutritional and functional properties of layer chickens fed with various ratios (yolk-albumen ratio) and for different amounts of yolk. Eggs were divided into 3 groups (low(30:70), medium(40:60), and high(50:50) yolk-to-albumen ratio. The protein, lipid, energy, and cholesterol profiles are determined using traditional biochemical methods: protein digestion, Soxhlet extraction for lipids, and HPLC for cholesterol. Foaming capacity, emulsifying capacity, and water holding capacity are measured and shown both positively and negatively, as the yolk-to-albumen ratio was also shown to vary significantly with the amounts of yolk-albumen content. Healthy foaming capacity and water storage properties are also studied when compared with those of unhealthy and poorly behaved eggs. The importance of yolk-albumen proportions for egg quality was statistically identified, adding insight into food nutrition science and food product formulation.

## 3. Results and discussion

We found that the yolk, albumen, and whole-egg contents in layer chickens differ in moisture, protein, lipid, and ash content (Table 1). Yolk had the highest lipid content (32.50%). Also, as a consequence of loss of a small amount in the fat content, the albumen had very small lipid content (0.20%); we find the most protein content in yolk (16.50%) and the lowest in albumen (10.80%); the ash content is lowest in yolk and albumen, with 1.70 and 0.60 per cent, respectively. In whole eggs, moisture (74.60%), protein (12.60%), lipid (10.50%), and ash (0.90%) were similar across all parameters. Studies in eggs indicate that the yolk is mainly composed of lipids and proteins (Leitman et al., 2008). So the albumen should also be wet for the developing embryo (Gao et al., 2015). These results were also reported by Batal and Parsons (2002) regarding the lipid and protein distribution in eggs. The ash content of egg is exactly as the original work shows, with Zhang et al. (2014) noting that it plays a minor role in the egg composition. The protein-to-lipid balance in the yolk supports its role as a nutrient source for embryonic development (Duncan et al., 2007).

**Table 1** Composition of Yolk, Albumen, and Whole Egg in layer chicken

| Traits | Yolk | Albumen | Whole Egg |
|---|---|---|---|
| Moisture (%) | 48.50 ± 1.20 | 88.20 ± 5.90 | 74.60 ± 3.10 |
| Protein (%) | 16.50 ± 1.18 | 10.80 ± 1.63 | 12.60 ± 1.70 |
| Lipid (%) | 32.50 ± 1.50 | 0.20 ± 0.01 | 10.50 ± 1.91 |
| Ash (%) | 1.70 ± 0.01 | 0.60 ± 0.05 | 0.90 ± 0.06 |

The significance of the yolk-to-albumen ratio in the nutritional composition of layer chicken eggs (Table 2). As you increase the ratio of a yolk-to-albumen layer from low (30:70) to high (50:50) then the lipid content increases (from 7.80% to 13.80%), the energy content (140 to 175 kcal/100g) also increases and cholesterol content has also increased (180 to 245 mg/100g) from low level to high ratio, (which changes protein content from 13.50% to 11.80%. This relationship is endorsed by Batal and Parsons (2002), who noticed that the yolk has so much lipid and cholesterol-production rate in comparison to the albumen, which was a result of an increase in fat; as lipids are an essential energy source, eggs do produce far more fat and contribute the high amount of energy in eggs (Gao et al., 2015). Protein is reduced when the yolk proportion is more than 50% (Duncan et al., 2007). Depending on the health value and quality of eggs, the ratio between yolk and albumen will vary, with the results differing in humans and birds, and eggs are less valuable, or birds do not.

**Table 2** Effect of Yolk-to-Albumen Ratio on Nutritional Composition in Layer Chicken

| Yolk: Albumen Ratio | Protein (%) | Lipid (%) | Energy (kcal/100g) | Cholesterol (mg/100g) |
|---|---|---|---|---|
| Low (30:70) | 13.50 ± 1.60 | 7.80 ± 0.53 | 140 ± 15 | 180 ± 10 |
| Medium (40:60) | 12.60 ± 1.17 | 10.50 ± 0.71 | 155 ± 11 | 210 ± 12 |
| High (50:50) | 11.80 ± 1.59 | 13.80 ± 1.80 | 175 ± 14 | 245 ± 15 |
| Sig. | * | * | * | * |

The functional properties of eggs from layer chickens were related to the type of yolk and albumen in the eggs (Table 3). The highest foaming capacity (180%) was reported for them, while balanced eggs (140%) and high yolk eggs (95%) had the lowest foaming behaviour in comparison with balanced eggs (70%) and high albumen eggs (45.11%). High albumen eggs have the highest water holding capacity (75.71%), with balanced eggs at 68.13% and high yolk eggs at 60%. A study published earlier found that albumen is the basis of stable foam because of its high protein content, indicating its capacity for stable foaming and the importance of mixing those eggs to create water. The lower foaming capacity in high-yolk eggs is expected, since yolk is fat-dominant, which inhibits foam formation (Silva et al., 2010). The high emulsifying efficiency of yolk eggs is associated with high quantities of lecithin, which is responsible for the emulsifier (Lund et al., 2013). The high amounts of water-holding capacity of high albumen eggs can be attributed to albumen's strong moisture-holding capabilities, which is a result of the high water-binding quality (Jin et al., 2014) of albumen (Guan et al., 2014).

**Table 3** Functional Properties of Eggs Based on Component Proportions of Layer Chicken

| Parameter | High Albumen Eggs | Balanced Eggs | High Yolk Eggs |
|---|---|---|---|
| Foaming Capacity (%) | 180 ± 10.00 | 140 ± 8 | 95.00 ± 6.00 |
| Emulsifying Capacity | 45.11 ± 3.01 | 70.10 ± 4.11 | 95.00 ± 5.00 |
| Water Holding (%) | 75.71 ± 3.11 | 68.13 ± 2.19 | 60.00 ± 2.00 |

## 4. Conclusion

Thus, it may be concluded that the yolk to albumen ratio plays a significant role in determining the nutritional and functional characteristics of eggs. The increase in the yolk to albumen ratio increases the lipids, energy, and cholesterol content, whereas the increase in the albumen to yolk ratio increases the foaming and water-holding capacities.

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