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Biochemical characterization of egg components from different Poultry species

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Abstract
Poultry eggs represent an important and affordable source of high-quality nutrients essential for human health. Although broiler hen eggs are most commonly consumed, eggs from indigenous (desi) hens and ducks are also widely available and nutritionally significant. The present study was undertaken to comparatively evaluate the nutritional composition of three varieties of poultry eggs—broiler hen egg, desi hen egg, and duck egg—with special emphasis on egg weight distribution, albumin protein content, yolk lipid and cholesterol levels, and calcium carbonate content of eggshells. Freshly laid eggs of the three avian species were analyzed for total protein in albumin (Lowry method), total lipids in yolk (Bligh and Dyer method), yolk cholesterol (Bair and Marion method), and calcium carbonate content of eggshells using titrimetric analysis. All estimations were performed in quadruplicate and results were expressed as mean ± standard deviation. The results revealed that duck eggs possessed the highest total egg weight and yolk proportion, while poultry eggs contained the highest amount of albumin. Protein concentration in albumin was found to be comparable among all egg varieties, with desi eggs showing slightly higher protein density. Poultry eggs exhibited higher lipid and cholesterol content in yolk, whereas duck eggshells showed the highest calcium carbonate content. The study concludes that desi hen eggs offer superior protein quality, poultry eggs are richer in lipids and cholesterol, and duck eggs provide a valuable source of calcium carbonate through their shells. These findings highlight the nutritional diversity among poultry eggs and their potential applications in human nutrition and animal feed supplementation.

Keywords: Poultry eggs; Desi hen egg; Duck egg; Albumin protein; Yolk lipid; Cholesterol; Calcium carbonate; Nutritional comparison

Introduction

Microplastics have become integral contaminants of marine ecosystems due to the extensive global production and indiscriminate disposal of plastic materials. These particles originate either as primary microplastics, intentionally Poultry eggs refer to the eggs of avian species commonly consumed as table eggs, including hen, duck, and other domesticated birds. Eggs constitute an indispensable component of the human diet due to their high nutritional density, affordability, and wide acceptability across different cultures, religions, and ethnic groups worldwide (Stadelman and Cotterill, 2001) [1]. Among various poultry eggs, chicken eggs are the most commonly consumed; however, eggs from other avian species such as ducks and indigenous (desi) hens also possess considerable nutritional and functional value.

Eggs are recognized as a complete food, providing high-quality proteins, essential fatty acids, vitamins, and minerals required for normal growth, development, and physiological functions. Poultry eggs are particularly rich in albumin proteins, lipids, phospholipids, fat-soluble vitamins (A, D, E, and K), water-soluble vitamins (B-complex and B12), selenium, and choline. These nutrients play a vital role in maintaining metabolic homeostasis, immune function, neural development, and muscle growth. Several studies have highlighted the role of egg-derived proteins and fatty acids in reducing the risk of chronic diseases such as cardiovascular disorders, diabetes, arthritis, and certain types of cancers (Simopoulos, 2000) [2].

Egg yolk contains bioactive compounds with antioxidant properties that are known to reduce oxidative stress and help prevent age-related macular degeneration (Ruxton *et al.*, 2010) [3]. Structurally, a poultry egg consists of three major components: eggshell (9–12%), egg white or albumin (approximately 60%), and yolk (30–33%). The whole egg comprises nearly 75% water, 12% proteins, 12% lipids, and about 1% carbohydrates and minerals (Kovacs-Nolan *et al.*, 2005) [4].

Despite the high nutritional and functional potential of egg components, their industrial utilization remains limited. Egg proteins are currently used in food processing as antimicrobial, foaming, emulsifying, and immunomodulatory agents (Abeyrathne *et al.*, 2013) [5]. Eggshells, a major agro-waste, are a rich source of calcium carbonate and can be utilized in animal feed formulations and other biotechnological applications.

Materials And Methods

Materials

Freshly laid eggs of three avian species were collected and used for the present investigation:

1. Poultry egg (Broiler hen's egg)
2. Desi hen's egg
3. Duck egg

Methods

The eggs were carefully weighed, and their components—albumin, yolk, and shell—were separated and analyzed for the following biochemical parameters:

a. Estimation of Total Protein

Total protein content in the egg albumin was estimated using the Lowry *et al.* (1951) [6] method, employing bovine serum albumin as a standard.

b. Estimation of Total Lipids

Total lipids were extracted from the egg yolk using a chloroform–methanol mixture (2:1) following the method of Bligh and Dyer (1959) [7].

c. Estimation of Yolk Cholesterol

Cholesterol content in the egg yolk was determined using the method described by Bair and Marion (1978) [8].

d. Estimation of Calcium Carbonate from Eggshells

Eggshells were washed, oven-dried for 48 hours, powdered, and analyzed for calcium carbonate content by titrimetric method as per the referenced protocol.

All estimations were performed in quadruplicate (n = 4), and results were expressed as mean ± standard deviation (SD).

Results

1. Egg Weight and Distribution of Egg Components

The total weight of eggs and the individual weights of albumin, yolk, and shell were recorded prior to biochemical analysis. The results are presented in Table 1. Among the three egg varieties, duck eggs showed significantly higher total weight compared to poultry and desi eggs. Poultry eggs contained the highest proportion of albumin, accounting for approximately 65.76% of the total egg weight, whereas duck eggs showed the highest yolk content (approximately 35%).

Table 1: Total weight, albumin, yolk, and shell content of three varieties of poultry eggs

Type of Egg	Total weight of egg (gm)	Total weight of albumin (gm)	Total weight of yolk (gm)	Total weight of shell (gm)
Poultry egg (n = 4)	58.01 ± 2.76	38.15 ± 1.71	16.19 ± 1.98	7.27 ± 0.59
Desi egg (n = 4)	43.75 ± 2.82	24.24 ± 1.96	11.41 ± 0.74	6.30 ± 0.90
Duck egg (n = 4)	70.78 ± 3.84	33.54 ± 2.09	25.42 ± 1.23	8.62 ± 1.52

2. Total Protein Content in Egg Albumin

Total protein content of egg albumin was estimated using Lowry's method and expressed as mg protein per ml of albumin. The results are summarized in Table 2. The protein concentration was found to be nearly similar among all three egg varieties. However, despite having a lower albumin volume, desi eggs exhibited marginally higher protein concentration, indicating superior protein density.

Table 2: Total protein content (mg/ml) in albumin of three varieties of poultry eggs

Sr. No.	Type of Egg	Total protein content (mg/ml)
1	Poultry egg (n = 4)	18.91 ± 1.86
2	Desi egg (n = 4)	18.00 ± 1.92
3	Duck egg (n = 4)	18.24 ± 2.01

3. Calcium Carbonate Content of Eggshells

Eggshells were dried, powdered, and analyzed for calcium carbonate content using a titrimetric method. The percentage of calcium carbonate present in one gram of eggshell powder is presented in Table 3. Duck eggshells showed the highest calcium carbonate content (97.3%), followed by poultry and desi eggs, indicating their potential use as a calcium-rich supplement in animal feed formulations.

Table 3: Percentage of calcium carbonate ($CaCO_3$) in eggshells of three poultry egg varieties

Sr. No.	Type of Egg	% Calcium carbonate in eggshell
1	Poultry egg (n = 4)	92.2%
2	Desi egg (n = 4)	85.4%
3	Duck egg (n = 4)	97.3%

4. Total Lipid Content in Egg Yolk

Total lipid content was estimated from egg yolk using the Bligh and Dyer extraction method. The results, expressed as percentage lipid content of yolk, are shown in Table 4. Poultry eggs exhibited the highest lipid content, followed by duck and desi eggs. These differences may be attributed to species-specific metabolism and dietary patterns of birds.

Table 4: Total lipid content (%) in yolk of three varieties of poultry eggs

Sr. No.	Type of Egg	Total lipid content (%)
1	Poultry egg (n = 4)	55.45
2	Desi egg (n = 4)	50.56
3	Duck egg (n = 4)	54.08

5. Cholesterol Content of Egg Yolk

Cholesterol content in egg yolk was estimated and expressed as mg per gram of yolk. The results are presented in Table 5. Poultry eggs showed slightly higher cholesterol levels compared to desi and duck eggs. Variations in cholesterol content are known to be influenced by genetic factors and the dietary intake of birds.

Table 5: Cholesterol content (mg/g yolk) in three varieties of poultry eggs

Sr. No.	Type of Egg	Cholesterol content (mg/g yolk)
1	Poultry egg (n = 4)	0.12 ± 0.013
2	Desi egg (n = 4)	0.10 ± 0.01
3	Duck egg (n = 4)	0.13 ± 0.017

Discussion

The present study provides a comparative assessment of the nutritional composition of poultry egg (broiler hen), desi hen egg, and duck egg, highlighting significant variations in their biochemical constituents. Differences observed among egg varieties may be attributed to species-specific physiology, genetic makeup, and dietary patterns of the birds.

The significantly higher total weight of duck eggs observed in the present study corroborates earlier findings that duck eggs are larger and contain a higher proportion of yolk compared to chicken eggs (Bair and Marion, 1978) [8]. The higher yolk proportion in duck eggs contributes to increased lipid content, making them an energy-dense food source. In contrast, poultry eggs showed the highest albumin proportion, which is advantageous for applications requiring high-quality egg white proteins, such as food processing and nutraceutical formulations (Abeyrathne *et al*., 2013) [5].

Protein estimation of egg albumin revealed comparable protein concentrations across all three egg varieties. However, desi eggs exhibited a relatively higher protein density despite having a lower albumin volume. This suggests that desi hen eggs may offer superior protein quality, which is essential for muscle development, immune function, and tissue repair (Kovacs-Nolan *et al*., 2005) [4]. Similar observations have been reported in indigenous poultry breeds, which are known to produce eggs with higher protein efficiency (Ruxton *et al*., 2010) [3].

Lipid analysis indicated that poultry egg yolk contained the highest lipid percentage, followed by duck and desi eggs. Elevated lipid content in poultry eggs may be associated with formulated commercial feed provided to broiler hens (Aquino and da Silva, 2010) [10]. Cholesterol estimation further supported this observation, as poultry eggs showed slightly higher cholesterol levels. However, recent nutritional studies suggest that moderate egg consumption does not significantly increase cardiovascular risk in healthy individuals (Simopoulos, 2000) [2].

Eggshell analysis demonstrated that duck eggshells possess the highest calcium carbonate content, followed by poultry and desi eggs. This finding highlights the potential utilization of duck eggshell waste as a valuable calcium source in animal feed, aquaculture, and agricultural supplements (Stadelman and Cotterill, 2001) [1]. Efficient utilization of eggshells can contribute to waste reduction and sustainable poultry practices.

Conclusion

Poultry farming has emerged as a vital small-scale industry due to the increasing demand for affordable and nutritionally rich food. Although broiler hen eggs are most commonly consumed, the present investigation indicates that desi hen eggs are nutritionally superior in terms of protein concentration, while duck eggs provide higher calcium carbonate through eggshells. Desi eggs, with their higher protein density, can significantly contribute to immune enhancement and muscle development. Duck eggshells, owing to their high calcium carbonate content, can be effectively utilized in animal feed, fish meal preparation, and waste valorization strategies. Promoting the rearing of desi hens can enhance nutritional security and improve the economic status of small poultry farmers.

Further research is required to develop cost-effective technologies for efficient separation and utilization of egg components and to explore the functional efficacy of egg-derived biomolecules in food and pharmaceutical applications.

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