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# Interspecific Variations in Egg Chemical Composition among Selected Captive Avian Species

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## SUMMARY

This research was intended to know interspecific differences between selected avian species, including ostrich *Struthio camelus*, duck *Anas platyrhynchoss*, green pheasant *Phasianus versicolor*, ring-necked pheasant *Phasianuscolchicus*, chicken *Gallus gallus*, turkeys *Meleagris gallopavo*, and Japanese quail *Coturnix coturnix japonica*. Rearing conditions were standard, providing similar hygienic, managerial, and environmental conditions to all birds. For our research, we collected 150 eggs. When compared to eggs from other bird species, *Gallus gallus* eggs exhibited significantly higher moisture levels in the egg white, yolk, and shell. *Pavo versicolor* eggs and *Meleagris gallopavo* eggs have considerably more protein in the egg white. In contrast, Meleagris gallopavo eggs exhibited higher yolk protein levels, *but Phasianus colchicus* eggs had lower yolk protein levels. Notably, eggs from *Gallus gallus* contained more fat in the yolk than eggs from *Struthio camelus*. Furthermore, *Gallus gallus* eggs showed increased ash content in both the egg white and yolk.

**Keywords:** Japanese quail, ostrich, albumen, yolk, crude protein

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## INTRODUCTION

Egg quality is highly influenced by various factors such as diet, housing and health of the birds (Hurnik *et al*., 1997). Shell quality gives an early introduction of the egg quality to the consumer (Okoli and Udedibie, 2000). Gaseous exchange and evaporation during incubation and hatching are controlled by shell thickness (Bennet, 1992). The loss of more water content from thin shelled eggs makes it harder for chicks to hatch (Roque and Soares 1994).

The quality of an avian egg not only relies on its physical properties but also on the chemical constituents of its yolk, albumen and egg shell (USDA, 2002). Entire eggs' composition is comprised of water (75%), proteins (12%), lipids (12%), sugars and minerals (1%) (Kovacs-Nolan *et al*., 2005). The incubation procedure, development of chick and hatching process are significantly influenced by the chemical composition of an egg (Narushin and Romonav 2002; Tariq, 2020). Before lying, different supplements that are required for the developing life are inculcated in

the egg (Angel 1994). The bio-ceramic organization of egg shell comprises of its mineral part, the egg white is made out of water and proteins with little sugars and the yolk contains high fat substance, around half water and is the most concentrated source of nutrients in the avian egg (Rodriguez-Navarro *et al.*, 2002). The proportion of avian egg shell is about 1.6% of the total egg weight and contains about 95.1 % inorganic matter and 3.3 % protein (Ihekoronye and Ngoddy, 1985).

Egg shell contains calcium, protein, magnesium carbonate, selenium, strontium and fluorine. The presence of 10% collagen in the egg shell membrane has made it a great source of medications (ADAS, 2002). The avian eggshell contains water, protein, crude fat, ash, calcium, phosphorus, sodium, magnesium, potassium, sulfur and negligible amount of copper, iron and zinc (Al-awwal and Ali, 2013).

The egg yolk contains around 80% of the calories and almost all fats present in the egg (Stadelman and Cotterill, 1995). Triacylglycerides, sugars, proteins and phospholipids are the principle constituents of egg yolk (Severa *et al.*, 2010). Egg yolk comprises of water (half), proteins (15–17%), lipids (31–35%), and sugars (1%) and is secured with the vitelline film. The presence of 1% carotinoids in the egg yolk gives the yellowish shading to it. The lipids introduce in egg are essentially gathered in the yolk while its proteins are distributed among the yolk and egg white. Livetins, phosvitin lipovitellins and low-thickness lipoproteins constitutes the protein part of the egg yolk (Stadelman and Cotterill, 2001).

The lipid profile of fresh egg yolk is made out of 13.2 g monounsaturated unsaturated fats, 3.4 grams poly-unsaturated fats, 8.7 grams immersed unsaturated fats and 1.120 mg cholesterol for every 100 grams of egg weight (Holland *et al.*, 1997). The poly unsaturated profile of the yolk varies generally among various avian species (Surai *et al.*, 1999). The lipids contain fundamental parts for tissue generation and have an incredible part in developing life survival (Shand *et al.*, 1993; Noble *et al.*, 1996).

Due to the unique biochemical composition of egg albumen, it has a great role in human wellbeing and various types of treatments. The albumen contains proteins (11%), water (88%), ash, carbohydrates and trace amount of lipids. The significant proteins of an egg white are ovomucin, lysozyme, ovomucoid, ovotransferrin and ovalbumen while the minor proteins in egg albumen are ovoinhibitor, ovoglycoprotein, ovoflavoprotein, ovomacroglobulin, cystatin and avidin (Kovacs-Nolan *et al.*, 2005). Ovalbumen accounts 54% of the total albumen proteins, having an atomic weight of 45 kDa with 386 amino acids and is synthesized in the hen's oviduct (Stadelman *and* Cotterill 2001; Huntington *and* Stein 2001). All the proteins of egg albumen are well known for their many sided unique properties (Stadelman *and* Cotterill 2001). Ovotransferrin performs iron scavenging and iron delivery functions in the body by attaching two iron molecules (Abdallah and Chahine, 1999). It is likewise known for its solid antimicrobial activity and along these lines utilized as antimicrobial agents to enhance the security of food products (Ko *et al.*, 2008; Ibrahim *et al.*, 2000); Zhang *et al.*, 2011). Lysozyme is utilized as antimicrobial agent, anti-inflammatory agent, and antiviral agent and also has some other therapeutic effects (Radziejewska *et al.*, 2008; Kovacs-Nolan, 2005; Mine *et al.*, 2004). The significant protein of albumen, the ovalbumen has a solid potential as a drug carrier and tumor silencer (Kratz, 2008; Kovacs-Nolan *et al.*, 2000). Albumen

proteins, for example, ovotransferrin, ovalbumen, ovomucoid, and ovomucin derived peptides having strong anticancer, antimicrobial, immunomodulatory, cytotoxic,cancer prevention and antioxidant activities are profoundly utilized as a part of nutraaceuticals, pharmaceuticals, and food industries (Abeyrathne *et al*., 2013; Moon *et al*., 2013; Ibrahim *et al*., 2000). The importance of egg chemical composition, the current research was designed know interspecific differences in egg biochemical composition among selected captive species.

## MATERIALS AND METHODS

The current study was conducted at the "Avian Conservation and Research Center", which is part of the "Department of Wildlife and Ecology at the University of Veterinary and Animal Sciences" in Lahore. The goal of this research was to examine the chemical makeup of eggs from various avian species including ostrich *Struthio camelus,*ducks *Anas platyrhynchoss,* green pheasant *Phasianus versicolor,* ring necked pheasant *Phasianuscolchicus*, chicken *Gallus gallus*, turkeys *Meleagris gallopavo* and Japanese quail *Coturnix coturnix japonica*.

### PREPARATION OF EGGS FOR ANALYSES

The collected fresh eggs were carefully cracked and its contents were emptied into a beaker. Egg samples were then weighed using electronic balance. The samples were homogenized and kept in a dry, clean sample bottles and then used for the analyses.

### PROXIMATE CHEMICAL COMPOSITION

Moisture (%) in egg albumen, yolk and shell, ash (%) in albumen and yolk, protein (%) in albumen and yolk and fat (%) in yolk were determined following AOAC (2005). Crude nitrogen was determined by Kjeldahl method and crude protein by using the formula;

$$\text{Crude protein} = \text{Crude nitrogen} \times 6.25$$

### DETERMINATION OF MOISTURE CONTENT

Loss in weight on drying samples of egg albumen, yolk and shell was determined to calculate % of moisture and dry matter. Cleaned empty petri dishes with lid were weighed first, samples of egg albumen, yolk and shell were taken in these petri dishes and then weighed again along with samples. The samples were dried in hot air oven at 70°C for 24 hours. After drying, the petri dishes were transferred to the desiccator for cooling. The petri dishes with dried samples were weighed and initial readings were recorded. The samples were again placed in hot air oven at 70°C for 30 minutes. The petri dishes were cooled again in the desiccator for 30 minutes and then weighed again. To determine the % of moisture and dry matter, the following formulae applied.

$$\text{Moisture \%} = \frac{\text{wet weight of sample with petri dish (w1)} - \text{dry weight of sample with petri dish (w2)}}{\text{Weight of the sample w}} \times 100$$

$$\text{Dry matter} = 100 - \text{moisture \%}$$

DETERMINATION OF CRUDE PROTEIN

For crude protein determination, one gram of each well grinded and moisture free dried samples of egg albumen, yolk and shell were taken in 500 ml Kjeldahl digestion flasks. 5 grams of digestion mixture composed up of ($CuSO_4$ 5g, $K_2SO_4$ 94g and $FeSO_4$) and 20 ml of 98% concentrated $H_2SO_4$ were also added to the flasks. The samples were heated in Kjeldahl apparatus for digestion until the mixture turned into light green in color. The digested samples were then cooled and 250 ml of each sample was prepared by adding distilled water. 10 ml of sample solution was taken and 10 ml of 40% NaOH solution was also added into it. Ammonia liberated was collected in 10 ml of 0.01 N $H_2SO_4$ with one drop of methyl red as indicator. The sample was titrated with 0.01 N NaOH until the color was turned into light blue. The reading of titration burette were recorded and then further used in the formula for determining the crude protein %.

$$\text{“Crude protein (\%)} = \frac{V \times 0.00014 \times D \times 100 \times 6.25\text{”}}{W \times A}$$

While,

V is equal to Volume of 0.01 N $H_2SO_4$ taken – Volume of 0.01 N NaOH used

D is equal to Dilution factor (volume made in volumetric flask after digestion)

W = Weight of sample

A = Aliquot taken

6.25 = nitrogen factor for crude protein

DETERMINATION OF ASH CONTENTS

For determination of ash contents, a process known as charring was used. 5 grams samples of egg albumen and yolk were taken in separate china dishes and weighed. Both the samples were kept over the hot plate so that the samples were completely burnt up and until the smoke that comes out from its burning ends. The burnt samples were then transferred into the muffle furnace and heated at 65°C for 4 – 6 hours. The china dishes were transferred to desiccator for cooling and then weighed. For determining ash contents the following formula was used.

$$\text{Ash \%} = \frac{\text{wet weight of sample with china dish (w1)} - \text{ash weight of sample with china dish (w2)}}{\text{Weight of the sample (w)}} \times 100$$

DETERMINATION OF FAT CONTENTS

For determination of fat %, 5 grams of yolk was taken in a cylinder with cap. 20 ml diethyl ether was added to the cylinder so that it will dissolve all the lipids of the egg yolk in it. Also 3ml of liquid ammonia was added to it so that the proteins do not interfere in the extraction of fats. The cylinder was then well shacked and kept on a plane surface for 15 minutes. Two layers were formed in the cylinder. The upper layer was extracted by a pipette into the beaker. The pipette was then rinsed with 20ml ethyl ether and added into the cylinder again. Again after shaking two layers were formed in which the upper layer is extracted and added to the beaker. The process was repeated again for the third time extraction. The sample in the beaker after weighing was kept in an open place so that the moisture evaporates and then

kept in incubator at 58.4°C. The beaker was then weighed again and the fat % was determined by using the following formula:

$$\text{Fat \%} = \frac{\text{wet weight of sample with beaker (w1)} - \text{dry weight of sample with beaker (w3)}}{\text{Weight of the sample w2}} \times 100$$

STATISTICAL ANALYSIS

The obtained data was subjected to statistical software SAS 9.1 and Analysis of Variance (ANOVA) was applied to compare the means through Duncan's Multiple Range Test.

## RESULTS

CHEMICAL COMPOSITION OF EGGS OF VARIOUS SPECIES

***Ostrich Struthio camelus***

Average albumen moisture of *S. camelus* eggs (n = 10) was 87.74 ± 0.44 %, yolk moisture was 47.02 ± 1.10 %, shell moisture was 1.93 ± 0.09 %, crude protein in albumen was 10.56 ± 0.36 %, yolk crude protein percentage was 16.40 ± 0.26 %, yolk fat percentage was 30.63 ± 0.83 %, albumen ash was 1.05 ± 0.10 % while the yolk ash percentage was recorded 1.08 ± 0.01

***Green pheasants Phasinus versicolor***

Albumen moisture, yolk moisture, moisture in shell, crude protein in albumen, crude protein in yolk, fat in yolk, ash in albumen and ash in yolk of *P. versicolor* eggs (n = 10) was recorded 87.42 ± 0.35 %, 49.23 ± 0.90 %, 15.77 ± 0.65 %, 11.00 ± 0.15 %, 15.78 ± 0.27 %, 31.07 ± 0.92 %, 0.77 ± 0.04 % and 1.57 ± 0.05 %, respectively.

***Ring necked pheasants Phasianuscolchicus***

Average albumen moisture in the eggs (n = 10) of *P. colchicus*egg was recorded 7.69 ± 0.31 %. Mean yolk moisture was 50.37 ± 0.30 %, shell moisture was 15.45 ± 0.46 %, albumen crude protein was 10.33 ± 0.17 %, yolk crude protein was 15.44 ± 0.06 %, yolk fat percentage was 31.46 ± 0.24 %, albumen ash was 0.84 ± 0.06 % and yolk ash was 1.55 ± 0.05 %.

***Turkey Meleagris gallopavo***

Average albumen moisture, yolk moisture, moisture in shell, crude protein in albumen, crude protein in yolk, fat in yolk, ash in albumen and ash in yolk of *M. gallopavo* eggs (n = 10) was 86.53 ± 1.34 %, 45.10 ± 1.63 %, 6.51 ± 0.94 %, 10.75 ± 0.11 %, 17.50 ± 0.32 %, 32.37 ± 0.84 %, 1.03 ± 0.05 % and 1.8 ± 0.20 %, respectively

***Ducks Anas platyrhynchos***

Average albumen moisture in the eggs (n = 10) of *A. platyrhynchos*was recorded 87.06 ± 1.34 %, yolk moisture was 43.57 ± 1.37 %, shell moisture was 3.46 ± 0.04 %, crude protein in albumen was 11.13 ± 0.04 %, crude protein in yolk was 16.16 ± 0.04

%, yolk fat was 32.54 ± 0.35 %, albumen ash was 1.16 ± 0.04 % and yolk ash was 3.22 ± 0.04

***Chicken Gallus gallus***

Average albumen moisture, yolk moisture, moisture in shell, crude protein in albumen, crude protein in yolk, fat in yolk, ash in albumen and ash in yolk of *G. gallus* eggs (n = 10) was 88.86 ± 0.09 %, 55.37 ± 0.43 %, 16.85 ± 0.47 %, 10.60 ± 0.30 %, 16.51 ± 0.28 %, 35.97 ± 1.15 %, 5.87 ± 0.09 % and 3.31 ± 0.06 %, respectively

***Grey francolin Francolinus pondicerinus***

Average albumen moisture in the eggs of *F. pondicerinus* eggs (n = 10) was 87.79 ± 0.14 %, yolk moisture was 49.68 ± 0.13 %, shell moisture was 10.16 ± 0.11 %, crude protein in albumen was 10.76 ± 0.19 %, yolk crude protein was 15.61 ± 0.26 %, yolk fat was 31.20 ± 0.41 %, albumen ash was 1.04 ± 0.05 and yolk ash was 1.73 ± 0.06.

Variations in chemical composition of eggs among selected avian species are mentioned in table 1.The moisture percentage in albumen, yolk and shell was significantly ($p<0.05$) higher in the eggs of *Gallus gallus* than all other species. Non-significant variations in the moisture content of albumen were recorded between the eggs of *Struthiocamelus, Phasianuscolchicus, Phasianus versicolor, Anas platyrhynchos* and *F. pondicerinus*. The yolk moisture varied significantly ($p<0.05$) among all the selected avian species except *P. colchicus* and *F. pondicerinus* eggs. Significantly ($p<0.05$) lower moisture in shell was observed in the eggs of *S. camelus* followed by *A. platyrhynchos, M. gallopavo and F. pondicerinus*. Significantly ($p<0.05$) higher crude protein in albumen was recorded in the eggs of *P. versicolor* and *M. gallopavo.*

Non-significant variations in the percentage of crude protein in albumen were observed between the eggs of *S. camelus, A. platyrhynchos, G. gallus* and*F. pondicerinus. M. gallopavo* eggs showed significantly ($p<0.05$) higher crude protein in yolk while significantly ($p<0.05$) lower crude protein in yolk was recorded for the eggs of *P. colchicus*. Significantly ($p<0.05$) higher concentrations of fat in egg yolk of *G. gallus* was recorded during present analysis the same was lower percentage in the egg yolk of *S. camelus.* Eggs of *G. gallus* contained significantly ($p<0.05$) higher ash in albumen and yolk content while non-significant variations for the percentages of ash in albumen and yolk were recorded for the eggs of *P. versicolor and P. colchicus.* The ash content in yolk was also significantly ($p<0.05$) higher in the eggs of *A. platyrhynchos.*

## DISCUSSION

*Gallus gallus* eggs had higher albumen levels, followed by *Pavo versicolor, Meleagris gallopavo, Phasianus colchicus, Struthio camelus*, and *Anas platyrhynchos*. Similarly, there were significant (p0.05) differences in yolk weight between *Struthio camelus* eggs, *Pavo versicolor* eggs, *Phasianus colchicus* eggs, *Anas platyrhynchos* eggs, and *Francolinus pondicerinus* eggs. *Pavo versicolor* eggs showed significantly lower shell weight (p0.05), while *Struthio camelus* eggs had the greatest. The percentages of albumen, yolk, and shell yielded similar results.

When compared to all other bird species, the eggs of *Struthio camelus* had considerably (p0.05) greater values of albumen height, yolk height, yolk breadth, and shell thickness. Except for the eggs of *Struthio camelus* and *Francolinus pondicerinus*, we found no significant differences in yolk diameter among all bird species. Similarly, we found no differences in shell thickness between *Pavo versicolor*, *Phasianus colchicus*, *Meleagris gallopavo*, and *Gallus gallus* eggs. We also discovered significantly (p0.05) lower albumen and yolk pH values in *Anas platyrhynchos* and *Francolinus pondicerinus* eggs. Furthermore, we found no significant differences in Haugh units between *Meleagris gallopavo*, *Pavo versicolor*, and *Phasianus colchicus* eggs. It should be noted that Hussain *et al*. (2013) found significant (p0.05) variations in egg quality measures in their study as well.

The moisture percentage in albumen, yolk and shell was significantly ($p<0.05$) higher in the eggs of *G. gallus* than all other species. Similar values for moisture in albumen 86.90±0.16 % and yolk 55.60±0.16 % were recorded by Bashir *et al*. (2015). Significantly ($p<0.05$) higher crude protein in albumen was recorded in the eggs of *P. versicolor* and *M. gallopavo* during present study. Similarly, Mroz *et al*. (2014) also reported the same percentage of protein in albumen of *M. gallopavo* eggs. Significantly ($p<0.05$) higher crude protein in yolk was observed in the eggs of *M. gallopavo* while significantly ($p<0.05$) lower crude protein in yolk was recorded in the eggs of *P. colchicus*. These outcomes verify the answer of Mroz *et al*. (2014) who reported same percentage of protein in *M. gallopavo* egg-yolk. The significantly ($p<0.05$) higher concentrations of fat in yolk was observed in the eggs of *G. gallus* during present analysis while the same was lowest in the egg yolk of *S. camelus*. Our results confirm the findings of Horbanczuk (2002) and Dudusola (2010) who recorded fat in egg yolk percentage of 32.6 %.

Eggs of *G. gallus* contained significantly ($p<0.05$) higher ash in albumen and yolk 3.31±0.06 % content during present investigation. Similar findings have been reported by Matt *et al.*, (2009) who documented egg yolk 3.42±0.23 % in *G. gallus*. The majority of egg white is made up of water (88%) and protein (11%), with the remainder made up of carbohydrates, ash, and trace amounts of lipids (1%) (Kovacs-Nolan *et al*., 2005).

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