sciendo DOI: 10.2478/ats-2023-0005 AGRICULTURA TROPICA ET SUBTROPICA, 56 OV, 41–49, 2023

*Original Research Article*

# Nutrient evaluation of different avian species eggs from Minna, Niger State Nigeria

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## Abstract

The proximate composition and mineral contents of eggs from quail (*Coturnix japonica)* turkey (*Meleagris gallopavo)* commercial chicken (*Gallus domesticus*), local chicken (*Gallus domesticus*) guinea fowl, (*Numida meleagris*) and duck (*Cairina moschata*) obtained in Minna, Nigeria were studied. Standard laboratory procedures were used in determining the nutrients and mineral compositions of the egg samples. The local chicken eggs had significantly higher crude fat (11.73 ± 0.18%), ash (1.38 ± 0.01%), zinc (3.23 ± 0.11 mg/100 g), and manganese (0.44 ± 0.01 mg/100 g) contents, it also showed the lowest phosphorus (120.00 ± 3.50 mg/100 g, iron (19.70 ± 0.60 mg/100 g) and vitamin A concentration ($1.62 \pm 0.59 \times 10^3$ µg/L). Quail egg had the highest ($p < 0.05$) vitamin A ($4.16 \pm 0.16 \times 10^3$ µg/L) and protein (13.49 ± 0.33%) contents. The moisture content was significantly higher in guinea fowl eggs (80.28 ± 0.41%) than in others. The outcome of this study indicated that some eggs which are seemingly underutilised may provide an enormous supply of nutrients needed for adequate human nutrition and health. Hence, if properly exploited they may substantially improve the quality of diet.

**Keywords:** Carotenoid; vitamin A; mineral contents; chicken; duck; quail; turkey; guinea fowl; human consumption

## INTRODUCTION

The importance of adequate nutrition in the general growth and development of the body as well as the maintenance of life's bio-psychological processes for overall health has been established (Latham et al., 2019). Good nutrition is also known to be derived directly from the quality of food consumed by any individual, hence the emphasis on a balanced diet (Olorunfemi et al., 2016). An egg provides the body with up to six grams of 97% digestible protein with a biological score of 94%. Thus, the proteins provided are turned into body tissues at 94% efficiency (Angelovičová and Polačková, 2015). Eggs also provide minerals such as iron, zinc, and iodine; vitamins such as vitamins A, $B_{12}$, and E, riboflavin, and folate, all except vitamin C. Vitamin D, a nutrient supplied by only a few food items, is also provided by eggs. Children's diet is often short of zinc and iron, which are both provided by eggs. Iodine, important in thyroid gland functions, is supplied by the egg (25 µg/egg) (Yalçin and Yalçin, 2013).

Apart from the nutritional values of eggs, they also serve other functions in cooking, making them commonly found in the kitchen. They can be used in food preparation to thicken custards, puddings, and sauces. They are also used to emulsify and stabilize mixtures such as mayonnaise and salad dressings, as crystallization retardant for frosting and boiled candies, as binders for lasagna and meatloaf, and as clarifiers for soups. Bread and cookies are coated or glazed with eggs; soufflés, sponge cakes, and some other types of baked products are also made with eggs present (Koelkebeck, 2003).

Chicken (*Gallus domesticus*) eggs are the most commonly consumed as food. Avian eggs are edible and those of ducks (*Anas platyrhynchos*), guinea fowl (*Numida meleagris*), quails (*Coturnix japonica*), turkey (*Meleagris gallopavo*) and ostriches (*Struthio camelus*) are occasionally used as gourmet ingredient (Applegate, 2000). In England and some Scandinavian countries such as Norway, gull egg is a delicacy. Pheasant and emu eggs are also edible, but less widely available (Roux and Martin, 2006). Other animals like reptiles, amphibians and fish have some of their eggs consumed as food by humans from thousands of years ago (Kiple, 2007). The eggs of birds and reptiles consist of a protective eggshell, albumen (egg white), and vitellus (egg yolk), which are contained within various thin membranes.

Eggs can be prepared by boiling, roasting, frying, and toasting among others. However, so many people consume it raw for different health and nutritional reasons. Some believe the nutrients are better harnessed doing so and this has become quite popular in the recent past. According to the Food and Drug Administration (FDA), approximately 79,000 people experience food-related illness each year with about 30 deaths from salmonella bacteria from raw eggs. Salmonella finds its way into eggs as a result of the reproductive organs of some egg-laying birds being contaminated with *Salmonella typhimurium* and *Salmonella enteritidis* (Limmahakhun, 2020). When eaten raw or undercooked, sickness may ensue. Research suggests that the body only absorbs 51% of the protein contained in eggs when eaten in their raw form, it is therefore recommended that cooked eggs be consumed.

While it is true that other birds produce edible eggs, they are commonly neglected in many countries. Nigeria, for instance, depends more on eggs from domestic and commercial chickens; thus, the poultry industry is dominated by chickens, 91% (of the 150 million poultry population) of which are chicken eggs. Guinea fowl, duck, turkey and other eggs were 4%, 3%, and 2%, respectively (Makram et al., 2017). The development, utilisation and consumption of other types of bird eggs may be encouraged if the knowledge of how they compare in terms of proximate and mineral contents. The obtained data would be useful in the nutrient composition database for assessing dietary intake which may become a major prerequisite for solving malnutrition challenges in underdeveloped and developing countries. This study will therefore unravel the enormous supply of nutrients in six different avian species eggs obtained from Minna, Niger State which may be needed for adequate nutrition in maintaining optimal health.

## MATERIALS AND METHODS

### Collection and identification of eggs

Fresh raw eggs of selected avian species were obtained from two locations in Minna Niger State, Nigeria: those of local chicken (locally grown chicken, extensively reared), guinea fowl and duck (eggs were obtained from Kure Ultra Model Market, while quail, turkey and commercial chicken (reared in the intensive system and popularly called "Agric fowl" in Nigeria) eggs were collected from the Abu Munir farm. The identity of the samples was ascertained in the Department of Biology, Federal University of Technology, Minna, Nigeria.

### Chemicals

All chemicals used were of laboratory grade and were of BDH Ltd, Poole, England unless otherwise stated.

### Preparation of egg samples

Pulverised forms of the samples, stored in clean, dry, and well-labelled containers, were obtained by cracking the eggs, emptying the content into beakers, homogenising, freeze-drying the homogenised mix, and finally pulverising to obtain fine egg powder.

### Proximate analysis

AOAC Methods of Chemical Analysis (2005) were adopted in carrying out the proximate analysis for moisture, ash, protein, and fat contents of the six types of avian egg samples. Carbohydrate content was estimated by difference.

### Mineral analysis

One gram of egg sample was ashed at 500 °C for 2 hours in a crucible and then allowed to cool. Into the crucible containing the ash, 4 ml of concentrated $HNO_3$ was added, and the excess of the acid was evaporated on a hot plate set at 100–120 °C after which ashing of the crucible content was done again in the furnace for one hour at 500 °C. The crucible was cooled after that, and 10 ml of 0.1M HCl was used to dissolve the ash before it was transferred quantitatively into a 50 ml volumetric flask. The mineral elements were determined by Atomic Absorption Spectrophotometry (Model Accusy

211 Bulk Scientific USA), sodium and potassium by a flame photometer (Model FP6410 Harris Medical Essex, England), phosphorus was determined by colorimetric method using the vanadomolybdate (yellow) method (AOAC, 2005).

### Determination of vitamin A

Hundred milliliters (100 ml) of petroleum ether was used to extract 10 g of each egg sample. Two hundred microliter (200 $\mu l$) aliquots of the extracts were placed in test tubes in duplicate; 200 $\mu l$ of distilled water for blanks as the standard solution was similarly provided. Potassium hydroxide (200 $\mu l$) was added to all the tubes of both samples and blank with thorough mixing on the vortex mixer for 10–20 seconds. The tubes were placed in a water bath at approximately 55–60 °C for 20 minutes. Afterward, the samples were cooled to room temperature for 20 minutes, then 200 $\mu l$ of xylene kerosene mixture was added. The sample in each tube was mixed vigorously for a minimum of 30 seconds on the vortex and then centrifuged for 5 minutes at 600–1000 × g to extract retinol. A micropipette connected to a rubber tube was used to suck out the xylene-kerosene supernatant whose optical absorbance was later read at 328 nm. The extract was transferred to 10 × 72 mm glass tubes from the cuvette, for irradiation which was carried out for both samples and blank using an ultraviolet irradiation source for at least one hour. The irradiated samples and blank were transferred to the cuvettes and again the optical absorbance was taken at 328 nm (Onwuka, 2005). The retinol was calculated using the formula

$$\text{Retinol } (\mu l/\text{L}) = A^{o}\ (328) - A_2 \times 627 \times 10$$

A = optical absorbance after ultraviolet irradiation.

### Extraction of carotenoid

Ten grams (10 g) of sample from the homogenized wet whole egg was stirred with 20 ml of 85% acetone for 30 minutes. The absorbance of the samples at 633 nm, 644 nm, and 452 nm was read in a spectrophotometer (Onwuka, 2005). With the result obtained, the carotenoids were calculated using the following formula:

$$\text{Ca} + \text{b} = 6.4\, D_{633} + 18.8\, D_{644}$$

$$\text{Carotenoid} = 4.75 D_{452} - 0.226\ \text{Ca} + \text{b}$$

Where Ca + b = chlorophyll a and b, and D- absorbance at different wavelengths.

### Data analysis

All data are presented as the mean of triplicate determinations ± standard error of the mean (S.E.M.). Statistical analysis was done using one-way analysis of variance and the Duncan Multiple Range Test (SPSS 23.0 version statistical package program, SPSS Inc., Chicago IL). Differences in the mean were considered statistically significant at $p < 0.05$.

## RESULTS

The proximate composition of six species of avian eggs is presented in Table 1. The result showed that quail and local chicken eggs had significantly ($p < 0.05$) highest dry matter content than the other types of avian eggs while guinea fowl eggs had significantly highest moisture content. The fat content in guinea fowl eggs was significantly ($p < 0.05$) lower but significantly ($p < 0.05$) higher in local chicken and turkey eggs than the other egg samples. Local chicken and turkey eggs also showed homogeneity ($p > 0.05$) in carbohydrate content. The carbohydrate content was however significantly higher in duck eggs than in the other species. It was also observed that local chicken and quail eggs had significantly ($p < 0.05$) higher ash and protein contents, respectively.

Table 2 presents the mineral composition of the six species of avian eggs. The result showed that the quail eggs had the lowest ($p < 0.05$) sodium ion content, but significantly higher phosphorus and potassium ion concentrations both comparable ($p > 0.05$) to that of

**Table 1.** Nutrient composition of six species of avian eggs

| Egg | Concentration (%) | | | | | |
|---|---|---|---|---|---|---|
| | Moisture | Dry Matter | Fat | Ash | Protein | Carbohydrate |
| **Quail** | 71.17 ± 0.60[a] | 28.83 ± 0.21[d] | 10.20 ± 0.27[b] | 1.27 ± 0.04[c] | 13.49 ± 0.33[e] | 3.88 ± 0.06[d] |
| **Commercial chicken** | 74.37 ± 0.01[c] | 25.63 ± 0.00[b] | 10.59 ± 0.02[b] | 1.17 ± 0.01[b] | 10.65 ± 0.10[c] | 3.21 ± 0.00[b] |
| **Duck** | 73.13 ± 0.24[b] | 26.87 ± 0.08[c] | 10.61 ± 0.08[b] | 1.17 ± 0.01[b] | 10.46 ± 0.10[bc] | 4.63 ± 0.06[e] |
| **Local chicken** | 71.81 ± 0.24[a] | 28.19 ± 0.07[d] | 11.73 ± 0.18[c] | 1.38 ± 0.01[d] | 11.44 ± 0.07[d] | 3.63 ± 0.11[c] |
| **Guinea fowl** | 80.28 ± 0.41[d] | 19.72 ± 0.17[a] | 9.27 ± 0.25[a] | 1.09 ± 0.03[a] | 7.71 ± 0.11[a] | 1.64 ± 0.04[a] |
| **Turkey** | 73.33 ± 0.18[bc] | 26.67 ± 0.07[c] | 11.59 ± 0.07[c] | 1.29 ± 0.02[c] | 10.12 ± 0.10[b] | 3.67 ± 0.03[c] |

Values are mean ± standard error of the mean (SEM) of triplicate analysis (n = 3). Means ± SEM followed by a different superscripted letter(s) along a column are significantly different ($p < 0.05$).

**Table 2.** Mineral composition of six types of avian eggs

| Minerals | Concentration (mg/100 g) | | | | | |
|---|---|---|---|---|---|---|
| | Commercial chicken | Local chicken | Guinea Fowl | Duck | Turkey | Quail |
| **Na** | 145.00 ± 1.70[bc] | 138.70 ± 1.40[b] | 144.40 ± 1.32[b] | 138.70 ± 0.50[b] | 150.90 ± 3.32[c] | 129.50 ± 0.70[a] |
| **K** | 130.90 ± 0.90[a] | 132.30 ± 1.40[a] | 144.10 ± 1.33[c] | 130.30 ± 2.45[a] | 138.60 ± 0.61[b] | 145.40 ± 1.61[c] |
| **Ca** | 37.00 ± 0.18[a] | 55.00 ± 1.80[c] | 35.00 ± 1.20[a] | 64.00 ± 2.70[d] | 53.00 ± 0.80[bc] | 49.00 ± 1.70[b] |
| **P** | 120.00 ± 3.50[a] | 135.00 ± 2.00[b] | 202.00 ± 1.60[d] | 165.50 ± 4.90[c] | 144.70 ± 3.90[b] | 212.00 ± 2.00[d] |
| **Fe** | 11.70 ± 0.82[a] | 19.70 ± 0.60[c] | 12.10 ± 0.20[a] | 13.80 ± 0.95[ab] | 14.90 ± 0.10[b] | 12.60 ± 0.68[a] |
| **Zn** | 2.34 ± 0.28[b] | 3.23 ± 0.11[c] | 3.10 ± 0.15[c] | 2.28 ± 0.13[b] | 2.28 ± 0.09[b] | 1.59 ± 0.06[a] |
| **Cu** | 1.06 ± 0.08[c] | 0.64 ± 0.04[ab] | 0.51 ± 0.02[a] | 0.71 ± 0.03[ab] | 0.74 ± 0.06[b] | 1.19 ± 0.11[c] |
| **Mn** | 0.28 ± 0.02[ab] | 0.44 ± 0.01[d] | 0.24 ± 0.02[a] | 0.27 ± 0.03[ab] | 0.34 ± 0.02[bc] | 0.36 ± 0.02[c] |

Values are mean ± standard error of the mean (SEM) of triplicate analysis (n = 3). Means ± SEM followed by a different superscripted letter(s) across a row are significantly different ($p < 0.05$).

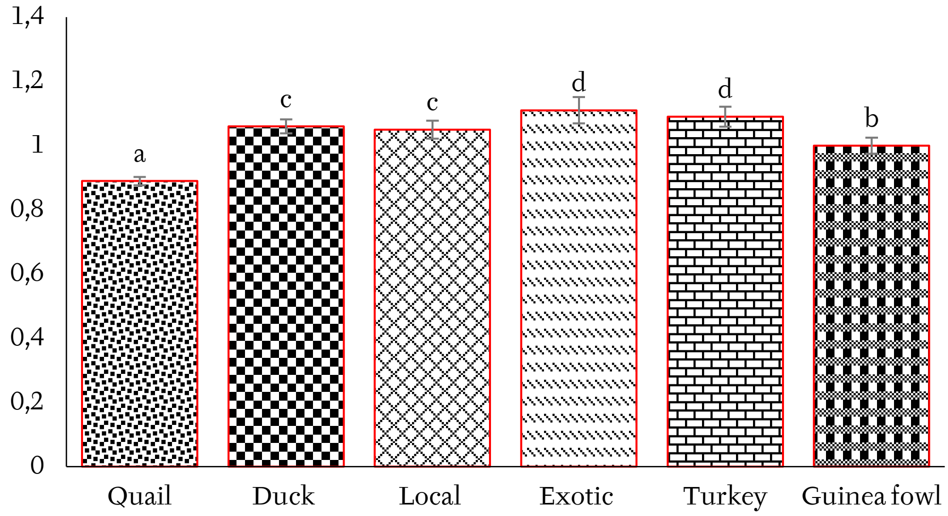


**Figure 1.** Na/K ion ratio of the six types of avian eggs

the guinea fowl eggs. The calcium ion concentration in duck eggs was significantly ($p < 0.05$) higher than in other avian species eggs. Iron, manganese and zinc contents were significantly ($p < 0.05$) higher in local chicken eggs than in other avian eggs except that guinea fowl eggs had comparable zinc concentrations. The Na/K ion ratio as shown in Figure 1, was significantly ($p < 0.05$) lowest in quail eggs followed by that of guinea fowl eggs but significantly ($p < 0.05$) higher in commercial chicken and turkey eggs in comparison to other avian eggs.

Figure 2 shows the vitamin A content of the six avian species eggs analysed. Observed in the result was that quail egg had significantly ($p < 0.05$) higher vitamin A concentration followed by duck egg. However, local chicken egg contained the lowest amount of vitamin A. The carotenoid content of the different avian species eggs is presented in Figure 3. It revealed that turkey egg was significantly ($p < 0.05$) higher in carotenoid content followed by local chicken and guinea fowl eggs which had similar carotenoid content.

## DISCUSSION

The nutrient composition of the different types of avian eggs in this study (Table 1) revealed a high moisture content and this finding corroborates with the reports of Song et al. (2000) and Onyenweaku et al. (2018), but in contrast with the report from the study of Isidahomen et al. (2014) as these authors reported low moisture content in eggs. The significantly higher moisture content of guinea fowl eggs may be attributable to the restriction on the evaporative loss of water by the rigid porous structure of the shell. There exists an inverse proportionality between moisture and dry matter contents. High moisture content results in lower dry matter and *vice versa*. The dry matter content is referred to as the percentage of solids in a mixture of substances. The higher this proportion, the more

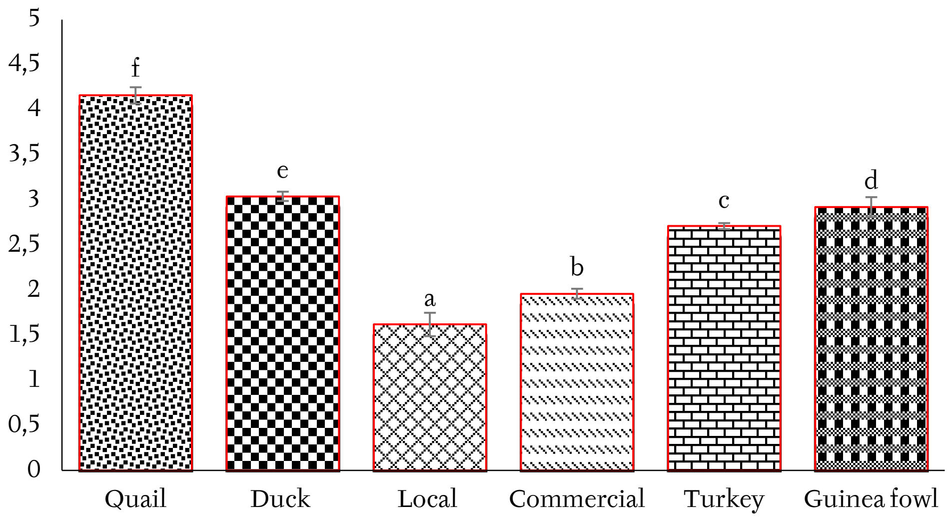


**Figure 2.** Vitamin A concentrations in six avian species eggs

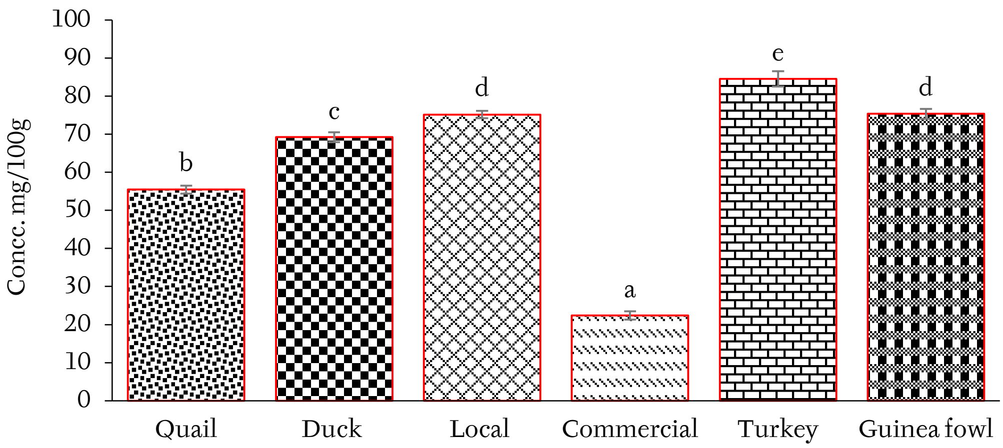


**Figure 3.** Carotenoid concentrations of six avian species eggs

available the nutrients become. This phenomenon was observed in the present study when guinea fowl eggs had the highest moisture content as well as the lowest dry matter content as such, they had significantly lower contents of other nutrients (ash, fat, protein and carbohydrate).

The significantly higher dry matter (and lower moisture) contents in quail and local chicken eggs present them rich in other nutrients (especially fat and protein). The lowest fat and protein content was determined in guinea fowl eggs. Fakai et al. (2015) reported that all six avian species eggs under investigation in their findings had higher fat content compared to protein content. In contrast to the present finding, Ogunwole et al. (2015) and Onyenweaku et al. (2018) in their separate studies also reported higher protein content of different egg species. The variation observed in the studies may be attributed to differences in the pattern of the study design, employed methodology, bird species, composition of feed, egg storage conditions as well as several other environmental instigated factors.

From the present study, it is clear that eggs are rich in proteins and being relatively cost-friendly and accessible, they may become a route of escape for the poor and low-income class who may not be able to afford other more expensive sources of protein. This will therefore help combat and reduce the high incidence of protein energy malnutrition (PEM), especially in children (the ones under-five years of age) in underdeveloped and developing regions of the world such as Africa. The consumption of eggs especially by children facilitates their proper body and mental development as well as functioning. This is because all the essential amino acids necessary for growth and development are available in eggs (Kudre et al., 2018; Attai et al., 2020). However, despite the importance of egg consumption, some caution should be taken when consumed by adults. Eggs, like seen in this study contain high concentrations of fat. Reports show that eggs contain a high amount of cholesterol (an egg may contain about 186 mg of cholesterol), and high cholesterol is implicated in cardiovascular diseases (Ossamulu et al., 2014a; US Department of Agriculture, 2018: Rosenson and Song, 2019). By way of caution, it is recommended that at most one egg per day is recommended for a healthy adult (Pang et al., 2020). The low fat content in guinea fowl eggs reported in this finding is in contrast with that obtained in the study of Onyenweaku et al. (2018), who reported higher lipid contents in both raw and boiled guinea fowl eggs than in the other eggs studied. However, it agrees with the work of Dudusola (2010) who evaluated the internal and external qualities of guinea fowl and quail eggs. The author reported lower fat content in guinea fowl eggs than in quail eggs. The observed disparities may be due to the type and composition of feed administered or the genetic makeup of the birds. Low fat content of guinea fowl eggs may therefore make them suitable for patients with fat-related ailments.

The ash content unlike fat and protein was low for all the eggs under investigation and was not in agreement with the report of Adeyeye and Aremu (2010) and Makram et al. (2017). Ash content represents the summation of the inorganic residue after the removal of water and organic matter through high heating (500–600 °C) and this measures the total amount of minerals within the given food. The high ash content in local chicken, turkey and quail eggs, is reflected in their mineral composition (Table 2). This was in consonance with a report from the study of Onyenweaku et al. (2018). Eggs have a rich and vast array of vital minerals (micro and macro elements) such as sodium, potassium, phosphorus, iron, magnesium, and manganese among others. Each mineral plays a specific role in the body, however, they may function in combatting micronutrient deficiencies (anaemia, scurvy, rickets among others) prevalent in underdeveloped regions. The significantly ($p < 0.05$) higher content of zinc (in local chicken and guinea fowl eggs) and iron (in local chicken eggs) presents them very vital in the formulation of children's diet since both minerals are often in short supply in children's nutrition (Yakoob et al., 2011). Manganese is required in low quantities (2–5 µg/day), although no RDA has been established so far. However, the eggs were rich in manganese judging from the required daily intake. Nevertheless, egg consumption should be guided because high levels of manganese inhibit iron absorption (Baker and Halpin, 1987).

The different species of avian eggs had high concentrations of sodium ions. Sodium is important in the regulation of the volume of plasma and extracellular fluids although harmful when in excess in the body and has been implicated in high blood pressure, and nervous and cardiovascular-related diseases (Fuchs and Whelton, 2020; Wang et al., 2020). A higher concentration of potassium ions would be required to balance the high amount of sodium being that potassium is a major intracellular ion functioning in the maintenance of water, electrolytes, balancing of pH, cell membrane transfer, and nerve impulse transmission (Downs et al., 2021). The Na-K ion ratio (Figure 1) is a better index to ascertain the risk of high blood pressure than either sodium or potassium concentration alone. The recommended ratio of Na/K is between 1:2 and 1:3 (The American Health Association (AHA), 2008; Ossamulu et al., 2014b). Of all the eggs analysed in this study, only quail egg had Na/K less than one which was close to the recommended. The implication of this is that overconsumption of eggs may predispose one to hypertension and other related disorders. Therefore, in consuming these eggs, it is suggested that potassium-rich foods be taken alongside so as to improve the K ion in other to balance the Na/K. Other minerals in the eggs were within the range reported in the USDA database (USDA, 2016).

The vitamin A content of quail egg was significantly higher than in others (Figure 2). It was about two and three times the amount found in commercial and local chicken eggs, respectively. The variation in vitamin A content in all the eggs may be due to the genetic makeup of the birds and feed composition (Ariza et al., 2021). Kovalchuk and Duma (2016) reported that the concentration of vitamin A in the egg yolk increases with an increase in the concentration of fat-soluble vitamins in the feed of the birds. Vitamin A is a fat-soluble vitamin important for vision, immune function, reproductive health as well as proper body development (Abd El-Hack et al., 2019). Quail egg consumption may therefore be a rich and vital way of obtaining vitamin A for vitamin A deficient subjects.

The significantly high carotenoid content reported for turkey eggs in this present work is in agreement with the report of Hammershøj et al. (2010). Although, the observed variation within the analysed types of avian eggs may be as a result of the genetic makeup of the birds as well as variation in the composition of the birds' diets. The physical colour of the yolk of turkey egg justifies the high carotenoid content observed in this study. Carotenoids are important in the body for pigmentation. In fact, the yellow, orange, and red colours are typically associated with birds. Carotenoids possess a great antioxidant potential that can alleviate the harmful effect caused by oxidative stress through their radical scavenging ability (Nabi et al., 2022). They may also affect visual functions when accumulated in the retina's muscular regions. Carotenoids are natural products of plants and animals, but birds are not able to synthesize these compounds hence have to be supplied in their diets (Maoka, 2020).

## CONCLUSION

Eggs indeed provide a prodigious supply of nutrients needed for adequate maintenance of optimal health and should therefore be harnessed in alleviating inadequate food and/or nutrient supply affecting different landscapes on earth, especially underdeveloped and developing nations. The study also revealed each egg having its own uniqueness over others in terms of nutrient composition although quail and local chicken eggs seemed to be more rounded in terms of nutrient, mineral, and vitamin compositions. Despite the high nutritional contents in eggs, on a general note, consumption must be guided because of potential problems (the high content of fat). There is an obvious disparity in the popularity of eggs in terms of the choice of consumption and this is relative to locations. On average, the most commonly consumed egg globally is the chicken egg not because it is the most nutritious but due to factors like the rate of production (they lay over 300 eggs annually) as well as the ease of rearing the birds. The variation in the production capacity of birds may put a restraint on the availability of some other types of eggs. It is therefore recommended that the government, non-governmental organisations, private business firms as well as individuals be encouraged to go into large-scale diversified poultry farming for egg production.

## ACKNOWLEDGMENT

The authors acknowledge the technical expertise of the laboratory unit, Biochemistry Department, Federal University of Technology Minna, Niger State.

## CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to the research, authorship, and publication of this article.

## ETHICAL COMPLIANCE

The authors have followed ethical standards in conducting the research and preparing the manuscript.

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*Received July 27, 2022*
*Accepted after revisions April 2, 2023*