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Assessment of protein and micronutrient quality of egg powder from three breeds chicken

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Abstract

This study examined the protein and micronutrient constituents of egg powder processed from three most common varieties of chicken such as guinea fowl (*Numida lelagris*); indigenous chicken (*Gallus gallus domesticus*) and improved commercially grown chicken (*Gallus gallus domesticus*) selected from Imo State, South-East Nigeria. Whole egg powder was processed from fresh eggs obtained from each chicken. Essential and non-essential amino acids whole eggs powder samples were determined by High Performance Liquid Chromatography (HPLC).The samples contained nine (9) essential amino acids (EAAs), histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. The results revealed that the values of EEAs were not the same among the three samples significantly ($p<0.05$). The whole egg powder of indigenous chicken (sample C) had the highest mg/100g concentrations of 16.3748 threonine, 30.0847 isoleucine, 22.6647 leucine, 3.4268 lysine and 1.1685 histidine among the three samples. On the other hand 8.5268 mg/100g and 2.0486 mg/100g of valine and phenylalanine were the highest values essential amino acids found on whole egg powder of improved commercially grown chicken (sample B). While 0.9384 and 2.0528 mg/100g of methionine and tryptophan were the highest values from whole egg powder from Guinea fowl (sample A) of the three samples. Similar pattern was found on the non-essential amino acids; the mg/100g of 7.604 serine, 2.7469 glutamate, 9.1647 arginine, 3.8099 tyrosine and 1.3206 cysteine were the highest values obtained from whole egg powder of improve commercially grown chicken among the samples. The result also indicates 39.432 mg/100g vitamin A, 35.124 mg/100g vitamin D and 9.845 mg/100g vitamin K from sample C were the highest values among the samples while highest concentration of 56.980 mg/100g vitamin E was found from sample A. The values of minerals potassium, calcium, sodium and phosphorous investigated in this work were not the same significantly. The concentration of minerals among the samples ranged from 6.082 to 8.048 mg/100g potassium, 5.056 to 8.056 mg/100g calcium, 5.347 to 8.418 mg/100g sodium and 7.093 to 8.134 mg/ 100 phosphorous were found. The indications from this study shown the potential of whole egg powder from the varieties of chicken in food and food formulation.

Keywords: Amino Acids; Guinea Fowl; Improved Commercially Grown Chicken; Egg; Indigenous Chicken

1. Introduction

Eggs are among the most nutritious and affordable sources of high-quality animal protein available to humans. They play a vital role in human nutrition due to their excellent amino acid balance, digestibility and abundance of essential vitamins and minerals (Park *et al*., 2018). However, the nutritional composition of eggs can vary depending on several factors, including breed, age, diet, and management practices of the laying hens. Among these, the breed of chicken has been identified as a key determinant influencing the amino acid profile and micronutrient content of eggs (Park *et al*., 2018). Due to its high biological value, almost all of it is used by the body and it is shown as a sample protein source

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(Park *et al*., 2018). Eggs, esteemed for their widespread global consumption, stand out as a nutritional powerhouse, boasting essential minerals, vitamins, fatty acids, amino acids, and pigments (Blanton *et al*., 2006). About 75% of the total weight of the edible portion of eggs is attributed to water, with lipids and proteins being the primary contributors to its nutrient value.

Amino acids, the building blocks of proteins, are essential for growth, tissue repair, and overall metabolic function. Eggs provide a complete set of essential amino acids (EAAs) required by humans, but differences in breed may affect their relative concentrations. As a result of deficiency or inadequate levels of amino acids in the body, protein synthesis does not occur properly, causing various metabolic disorders (Davidson, 2019). Amino acids are classified into two groups: essential amino acids (EEAs) (histidine, arginine, thyronine, valine, methionine, leucine, ısoleucine, phenylalanine, tryptophan, and lysine) and non-essential (NEAs) (aspartic acid, glutamic acid, asparagine, serine, glycine, glutamine, alanine, pyrroline, tyrosine and cysteine). Likewise, micronutrients such as iron, zinc, and vitamins A, D, and E are vital for health and immunity, and their levels in eggs may differ among chicken breeds due to genetic and physiological variations.

Comparing the amino acid composition and micronutrient profiles of eggs from different breeds can help identify the most nutritionally superior varieties. This knowledge is particularly important for nutritionists, poultry breeders, and food scientists aiming to improve egg quality through selective breeding and optimized feeding strategies. Furthermore, such information supports consumer awareness and contributes to addressing nutritional deficiencies in populations where eggs are a major protein source. This study, therefore, seeks to evaluate and compare the amino acid profile and micronutrient composition of eggs produced by different breeds of chicken. The findings will provide insights into the nutritional variability among breeds and guide future improvements in poultry production and human nutrition.

2. Materials and Methods

2.1. Sample collection

Fresh whole eggs from guinea fowl (*Numida meleagris*) improved commercially grown chicken (layers-ISA Brown) (*Gallus gallus domesticus*) and indigenous locally grown chicken (*Gallus gallus domesticus*) were collected at Obichere farm from Obibiezena, Owerri North Local Government Area, Imo State, Nigeria.

2.2. Preparation of Egg powder

The procedure described by Zubairu *et al*., (2025) and Ndife *et al.,* (2010) were modified for the production of whole egg powder samples. Twenty (20) fresh whole eggs were collected from each breed of chicken studied in this work. The eggs were aseptically washed with clean water and annually de-shelled carefully to separate shell from white egg and yolk. White egg and yolk was whisked manually and further homogenized with the aid of laboratory warring blender (model: Model, JB-205). A dehydrator (drum dryer) was set at 60 ^{o}C temperature and the homogenized albumen-yolk was applied to a tiny non-stick layer component of the dehydrator. The drying process takes between 15 to 17 hours until a brittle egg was achieved during this period. The brittle egg particles was scraped off the tiny non-stick plate and further grinded into a fine particle using laboratory warring blender (model: Model, JB-205). The dehydrated whole egg powder samples were packaged in an air-tight Ziploc polyethylene bags and labeled accordingly for further use.

2.3. Determination of Amino acid profile of the eggs

Amino acids content of whole egg powder samples was measured as hydrolysate using an amino acid analyzer (Sykam-S7130) based on high performance liquid chromatographic technique. Sample hydrolysis was prepared following the method of Spackman et al., (2006).

2.4. Determination of minerals contents

Minerals were analyzed by dry-ashing 1g each of each of the processed sample at 550°C in a muffle furnace. The ash obtained was dissolved in 10% HCl, filtered through an acid-washed filter paper and made up to standard volume with deionised water. Sodium and potassium contents was determined by flame photometry (AOAC, 2015) while calcium and phosphorous were determined using Varian AA240 Atomic Absorption Spectrophotometer according to the method Onwuka (2005).

2.5. Determination of vitamins

2.5.1. Beta-carotene (precursor of vitamin A)

Beta-carotene was determined using the method of AOAC (2015). Five grams of a sample was weighed into a separating funnel (250 ml). Two milliliter (2ml) of NaCl solution was introduced into it and shaken vigorously, followed by 10 ml of ethanol, then 20 ml of methane. The mixture was shaken vigorously for 5 minutes and allowed to stand for 30 minutes after which the lower layer was run off. The absorbance of the top layer was determined at a wavelength of 460 mm using a spectrophotometer.

$$\text{Beta-Carotene} = \frac{Absorbance}{Specific\ extinction\ coefficient \times path\ length\ cell} \quad \ldots\ldots\ldots \text{(Eqn 1.0)}$$

Where:
Molar extinction efficient (∑) = $15x10^{-4}$
Specific extinction efficient = ∑ x molar mass of beta-carotene
Molar mass of beta-carotene = 536.88g/mol
Path length of cell = 1cm

Vitamin D

2.5.2. Determination of Vitamin E

Vitamin E was determined according to AOAC (2010). Two grams (2g) of sample was mixed with 10 ml of absolute alcohol (ethanol) and 20 ml of molar ethanol sulphruric acid solution was added to it. The container was wrapped in aluminum foil to avoid direct light effect on the contents, it was boiled under reflux for 45 minutes and allowed to cool before 50ml of separating funnel (also wrapped in foil) and an additional 50ml of distilled water was used to wash out the container into the funnel. A 150mls of diethyl ether was added to it, mixed well and allowed to separate. The (other layer) extract was collected and evaporated to dryness in a desiccators over sodium sulphate (anhydrous). The residue (vitamin E extract) was re-dissolved in 10ml of absolute ethanol and used for the analysis. A 1ml aliquot of the extract was dispersed into a test tube meanwhile, a standard of Vitamin E was prepared and diluted to a desired concentration. A 1ml of the solution (Vitamin E) and 1ml of ethanol was dispersed into separate tubes to serve as standard and reagent bank respectively. A 5ml of ethanol was added to each tube followed by 1ml of concentrated HNO_3 added drop wise with great caution. The tubes were boiled at 90^0C in a water bath for 3 minutes cooled in running water and their absorbance measured in a spectrophotometer at 470nm wavelengths. The reagent blank was used to calibrate the instrument at zero. The vitamin E content was calculated using the formula below and expressed as mg/100g:

$$\text{Vitamin E content} = \frac{Au \times As \times C \times F}{(F{=}100 \times Vf \times D)/W \times Va}$$

Where:
F = experimental factor
D = dilution factor
Au = absorbance of the unknown (sample)
As = absorbance of standard vitamin E
Vf = total extract volume
Va = volume of extract analyzed
C = conc. of standard vitamin E
W = weight of residue

2.5.3. Determination of Vitamin K content

The spectrophotometric procedure described by Paul and Pearson (2005) was used for the determination of vitamin K. Ten grams (10 g) of the sample was refluxed for 3 h with 100 ml of ethanol and filtered. The residue was extracted in the dark with 100 ml of petroleum ether (40-60 ^{o}C) using soxhlet apparatus for 48 h at 70 ^{o}C. The ethanol and ether extracts were evaporated to dryness in vacuum under nitrogen. The residue was re-dissolved in 100 ml of ether and 10 ml aliquot was mixed with equal volume of cold half saturated Barium hydroxide with 50 ml of water and then 5 ml of 1:1 ethanol: water solution. The washings were extracted with 10 ml of ether and all the combined ether extracts were dried over anhydrous sodium sulphate and evaporated in vacuum under nitrogen. The residue was taken up to 2 ml of 1:1 ethanol: water solution. A 1 ml of 0.04% 2, 4-Dinitropheylhydrazin in 1:3 HCl was added. The mixture was heated in a boiling water bath for 45 min and cooled. Two milliliters (2 ml) of 8% NaOH and 1 ml of amyl alcohol were added

and heated in a boiling water bath for 2 min and cooled. The mixture was made up to 10 ml with ethanol and absorbance taken at 620 nm (model 752, Jenway, England) against water. Vitamin K concentrations were calculated from the standard vitamin K calibration curve and values expressed as mg/100g.

$$Y=0.946x$$

Therefore, $X=\frac{y}{0.946}$
Where Y = absorbance reading of the sample
X= concentration of vitamin K in the sample

3. Results and Discussion

3.1. Amino acid profile of whole egg powder from different breeds of chicken

Protein quality is determined by their amino acids composition, quantity and scores of essential amino acids present, and ratio essential amino acids to non-essential amino acids (Galla *et al*., 2012). The amino acid profile of whole egg powder samples from different breeds of chicken is presented in Table 1. The egg powder samples contained varied concentrations of all nine (9) essential amino acids (EAA) namely histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

The whole egg powder of indigenous chicken (sample C) had the highest mg/100g concentrations of 16.3748 threonine, 30.0847 isoleucine, 22.6647 leucine, 3.4268 lysine and 1.1685 histidine among the three samples. The values of these amino acids differed significantly ($p<0.05$) among the samples and as well as Food and Agriculture/World Health Organization recommended daily allowance (RDA). This result aligned with the findings of Ismail et al., (2013) and Adeyeye (2013) who reported higher concentration of essential amino acids in village hen. However this could be attributed to the fact that local chicken often free-range consume a wider variety of natural foods, including, insects, worms, and snails- high in protein and amino acids (Attia *et al*., 2020). In addition, they eat seeds grains, green plants, weeds, kitchen scraps or organic waste. This diverse, protein-rich natural diets increase the quality of egg protein and may lead to higher essential amino acid levels. On the other hand 8.5268 mg/100g and 2.0486 mg/100g of valine and phenylalanine were the highest values essential amino acids found on whole egg powder of improved commercially grown chicken (sample B). While 0.9384 and 2.0528 mg/100g of methionine and tryptophan were the highest values from whole egg powder from Guinea fowl (sample A) of the three samples. Similar pattern was found on the non-essential amino acids; the mg/100g of 7.604 serine, 2.7469 glutamate, 9.1647 arginine, 3.8099 tyrosine and 1.3206 cysteine were the highest values obtained from whole egg powder of improve commercially grown chicken among the samples. Some values obtained in this study were lower while some were higher compared to that earlier reported by Onyenweaku *et al* (2022) that guinea fowl eggs have a higher concentration of essential amino acids (EAA) and total amino acids (TAA) compared to local chicken eggs.

In terms of non-essential amino acids (NEAA) of the whole egg powder samples, glycine was not dictated in the sample C processed from indigenous chicken egg while sample A (from guinea fowl) and sample B (commercially improved chicken breed) were 11.15237 and 11.86604 g/100g protein respectively. Serine and proline were highest in sample C (indigenous chicken) whole egg powder and their values ranged from 1.79434 to 7.60039 g/100g protein 15.74579 to 30.86587 g/100g protein for serine and proline respectively. The concentration of aspartate was highest in guinea fowl egg while glutamate was highest in indigenous chicken eggs. Their values ranged from 0.973883 g/100g protein to 1.9382 g/100g protein, and 2.35171g/100g protein to 2.74691 g/100g protein for aspartate and glutamate respectively. The concentrations of arginine, tyrosine and cysteine were observed to be highest in indigenous chicken egg and significant difference existed among the samples in terms of these amino acids. The results on amino acids profile of the whole egg powder in this study suggested that the quality of egg protein is quiet influenced by the chicken feed quantity, quality and frequency of feeding irrespective of the environment. Despite the significant difference ($p<0.05$) on the concentration of amino acids observed on the whole egg powder samples, still higher than those from plant protein sources such as soybean, beef and wheat protein.

3.2. Vitamin content of whole egg powder from different breeds of chicken

The vitamin contents of whole egg powder from different breeds of chicken are presented in Table 2. The result showed that sample C (whole egg powder from indigenous chicken) had the highest 39.432 mg/100g of vitamin A, 35.124 mg/100g of vitamin D and 9.845 mg/100g of vitamin K among other samples. In the view sample A from guinea fowl had the least concentration of 18.459, 25.30 and 8.231 mg/100g of vitamin A, D and K respectively. This finding did not agreed with that earlier reported by Ezejesi *et al* (2022). Vitamin D content was seen to be higher in local chicken egg

when compared with commercial chicken egg and guinea fowl egg. The value differed significantly ($p < 0.05$). The value 56.980 mg/100g of vitamin E content was highest in guinea fowl egg (sample A) and the least value of 52.422 mg/100g was found in sample B. Furthermore, the value of 56.980 mg/100g of vitamin E was the highest amount found in sample A of guinea fowl source followed by 54.382 mg/100g of sample C (sample from improved commercially grown chicken) and the least vitamin E content of 52.422 mg/100g was in whole egg powder sample B from commercially improved breed chicken. The significant difference observed on the vitamins content of whole egg powder could be attributed to the breeds and as well as nature of the nutrient in the feeds supplied to the chicken. Despite the difference on the concentration of vitamins studied in this work the values were high which the powder a potential source of micronutrient in food and food formulation.

3.3. Mineral contents of whole egg powder from different breeds of chicken

The mineral contents of whole gg powder samples from different breeds of chicken are shown in Table 3. The concentrations of mineral content of whole egg powder samples were not the same significantly ($p<0.05$); this finding corroborate the report of Essayas et al., (2003) who also discovered significant difference on the concentrations of micronutrients content different egg powder samples. The potassium content of the eggs ranged from 6.082mg/100 to 8.048mg/100g with the indigenous chicken egg having the highest value of 8.042mg/100g.

Table 1 Amino acid profile of egg powder from three selected species of chicken

Amino acids (mg/100g)	**Samples**			**RDA, mg/kg Day**
	A	B	C	(FAO/WHO, 2007)
Glycine	11.15237[a]	11.86604[a]	ND	-
Alanine	14.60451[b]	15.66460[a]	6.74451[c]	-
Serine	1.84277[b]	1.79434[b]	7.60039[a]	-
Proline	16.00301[b]	15.74579[b]	30.86587[a]	-
Valine	7.64917[b]	8.52680[a]	4.33865[c]	26 (1820 mg/day
Threonine	14.06571[b]	13.59456 [c]	16.37483[a]	15 (1050 mg/day)
Isoleucine	18.77535[c]	22.66472[b]	30.08472[a]	20 (1400 mg/day)
Leucine	2.01382[b]	1.59647[c]	22.66472[a]	39 (2730 mg/day)
Aspartate	1.93822[a]	1.55145[b]	0.973887[c]	-
Lysine	1.04562[c]	1.84156[b]	3.42689[a]	30 (2100 mg/day)
Methionine	0.938450[a]	0.801761[a]	0.908718[a]	10.4 (728 mg/day)
Glutamate	2.35171[b]	2.10961[c]	2.74691[a]	-
Phenylalanine	1.47733[c]	2.04864[a]	1.51518[b]	-
Histidine	0.53812[c]	0.886003[b]	1.16858[a]	10 (700 mg/day)
Arginine	9.00561[b]	7.44988[c]	9.16476[a]	-
Tyrosine	0.751941[b]	0.639793[c]	3.80994[a]	-
Tryptophan	2.05284[a]	1.84195[b]	1.76542[c]	4 (280 mg/day
Cysteine	0.57553[c]	0.761577[b]	1.32066[a]	-

Value are means $\pm$ standard deviations. Values along the same row with different superscript are significantly different ($p<0.05$). RDA-Recommended Daily Allowance.; Key: Sample A: Guinea Fowl egg powder (*Numida meleagris*); Sample B: Commercial (Improved) Chicken egg powder (*Gallus gallus domesticus*); Sample C: Indigenous Chicken egg powder (*Gallus gallus domesticus*)

The result revealed that eggs from indigenous chicken breed had highest concentration (8.048) of potassium, while 6.082 mg/100g was the least potassium found in sample C of the whole egg powder from commercially improved chicken breed. Despite the significant difference of the concentration of potassium in this work; the result aligned with report of Kopdorah *et al.,* (2023) on the mineral composition of chicken, duck, guinea fowl and turkey obtained from Yobe State. Similarly, calcium content 8.056 mg/100g of the whole egg powder of indigenous chicken is significantly

($p<0.05$) higher than 5.056 and 8.042 mg/ 100 of whole egg powder samples from guinea fowl and commercially improved chicken. However, the value of 8.418 mg/100g sodium and 8.134 mg/100g phosphorous found on whole egg powder from guinea fowl were relatively higher than 5.347 to 8.222 mg/100g sodium and 7.093 to 7.267 mg/100g phosphorous of whole egg powder from other breed of chicken studied in this work. The variation of the mineral composition observed in the egg powder of the various chicken (birds) could be attributed to type feed, poultry-raising system adopted, and the genetic characteristics of the chicken.

Table 2 Vitamin contents of egg powder of three selected chicken

Property (mg/100g)	Sample A	Sample B	Sample C
Vitamin A	$18.459^{C} \pm 0.12$	$18.809^{b} \pm 0.04$	$39.432^{a} \pm 0.03$
Vitamin D	$25.300^{C} \pm 0.09$	$29.359^{b} \pm 0.11$	$35.124^{a} \pm 0.12$
Vitamin E	$56.980^{a} \pm 0.15$	$52.422^{c} \pm 0.04$	$54.382^{b} \pm 0.12$
Vitamin K	$8.231^{b} \pm 0.03$	$7.874^{C} \pm 0.06$	$9.845^{a} \pm 0.02$

Value are means ± standard deviations. Values along the same row with different superscript are significantly different ($p<0.05$). Key: Sample A: Guinea Fowl egg powder (*Numida meleagris*); Sample B: Commercial (Improved) Chicken egg powder (*Gallus gallus domesticus*); Sample C: Indigenous Chicken egg powder (*Gallus gallus domesticus*)

Table 3 Mineral contents of eggs from different breeds of chicken (mg/100g)

Parameters (mg/100g)	Sample A	Sample B	Sample C
Potassium	$7.073^{b} \pm 0.12$	$6.082^{c} \pm 0.07$	$8.048^{a} \pm 0.02$
Calcium	$5.056^{C} \pm 0.20$	$8.042^{b} \pm 0.02$	$8.056^{a} \pm 0.05$
Sodium	$8.418^{a} \pm 0.06$	$8.222^{b} \pm 0.05$	$5.347^{C} \pm 0.12$
Phosphorus	$8.134^{a} \pm 0.01$	$7.267^{b} \pm 0.18$	$7.093^{C} \pm 0.06$

Value are means ± standard deviations. Values along the same row with different superscript are significantly different ($p<0.05$).; Key: Sample A: Guinea Fowl egg powder (*Numida meleagris*); Sample B: Commercial (Improved) Chicken egg powder (*Gallus gallus domesticus*); Sample C: Indigenous Chicken egg powder (*Gallus gallus domesticus*)

4. Conclusion

The study demonstrates that genetic differences significantly influence egg nutritional quality. Variations were observed in essential amino acids such as lysine, methionine, and leucine, as well as in key micronutrients including potassium, phosphorus, and vitamins. These differences highlight the importance of breed selection in optimizing egg nutrition and quality. The findings demonstrate that certain breeds may produce eggs with superior amino acid balance and higher micronutrient levels, making them more suitable for addressing protein-energy malnutrition and micronutrient deficiencies. Consequently, poultry producers and nutrition policymakers can utilize this information to promote specific chicken breeds with enhanced nutritional benefits. In conclusion, understanding the amino acid and micronutrient composition of eggs from different breeds not only contributes to improving poultry breeding and management strategies but also supports efforts to enhance human health and nutrition through better food choices.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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