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The amino acid profiles of the yolk and albumen of domestic duck (*Anas platyrhynchos*) egg consumed in Nigeria

Emmanuel Ilesanmi Adeyeye[1], Wasiu Babatunde Adebayo[1] and Opeyemi Olusegun Ayejuyo[2]
[+]Department of Chemistry, Ekiti State University, Ado-Ekiti, PMB 5363, Ado-Ekiti, Nigeria.
[++]Department of Chemistry, University of Lagos, PMB 56, Akoka, Yaba Lagos, Nigeria.

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ABSTRACT

The amino acid composition of the yolk and albumen of the egg of domestic duck was determined on a dry weight basis. The total essential amino acid ranged from (g/100 g crude protein, cp): 40.9-41.3 or from 43.5-47.8 % respectively of the total amino acid. The amino acid scores showed lysine ranged from 1.26 -1.27 (on provisional essential amino acid scoring pattern) and 1.19-1.21 (on suggested requirement of the essential amino acid of a pre-school child). The predicted protein efficiency ratio was 2.33-2.52, the essential amino acid index range was 1.31-1.32 and the calculated isoelectric point range was 4.90-5.53. The Leu/Ile ratio range was 1.80-1.38. The correlation coefficient (r_{xy}) was positive and significant at $r_{=0.05}$ for the amino acids, amino acid scores (on suggested requirement of the essential amino acid of a pre-school child) and the isoelectric point in the two samples. Domestic duck yolk and albumen amino acids were compared with yolk and albumen of domestic guinea fowl and domestic chicken eggs.

Introduction

From ancient times domestic ducks have served as a source of food and income for people in many parts of the world. Ducks are a source of meat, eggs and down-feathers (for making bedding and warm jackets). Ducks are able to subsist and grow to maturity on relatively simple diets, based on locally available feedstuffs. Duck meat and duck eggs are good dietary sources of high quality protein, energy and several vitamins and minerals. When properly included as part of a well-balanced daily diet, duck meat and eggs can supply a substantial portion of the nutrients required by humans. Ducks may be raised in small or large flocks. A small flock of ducks may be kept by a household as a supplemental source of food or income. A small flock of ducks can be established at low cost.

Domestic ducks fall into the following major genetic classifications[1].

(1) Common ducks. Most domestic ducks fall into this group. Common ducks are believed to have originated from the Mallard (Anas platyrhynchos). Some of the better known breeds of common ducks include the Pekin, Asylesbury, Rouen, Call, Indian Runner, Khaki Campbell, Cayuga, Albio, Maya and Tsaiya. Common ducks can interbreed and produce fertile offspring. Eggs from common ducks require about 28 days to hatch.

(2) Muscovy ducks. The Muscovy (Cairina moschata) is distinctly different genetically from common ducks. This breed is believed to have originated in South America, although ancient records of this or a similar breed have been found in Egypt. There are both coloured and white feathered varieties of Muscovies. The Sudani is a breed of Muscovy found in Egypt. Unlike common ducks, the head and face of Muscovies is covered with caruncles (a fleshy growth that resembles wattles). Another prominent feature of Muscovy ducks is the large difference in body size between the drake and the duck, the male weighing 30-50 % more than the female. Muscovies tolerate hot weather much better than common ducks. Muscovy eggs require about 35 days to hatch. While Muscovies can be crossed with common ducks, their offsprings are sterile.

(3) Sterile Hybrid Ducks. When Muscovies and common ducks are allowed to mate naturally, the fertility rate is usually very low. It is a common practice today to use artificial insemination to increase the fertility. Whatever the method of mating, the offspring are sterile and cannot be used for breeding. These hybrids are usually raised for their meat, or in some cases, for their liver (foie gras), which is a delicacy sold in famous restaurants. These sterile hybrids are called mule (Muscovy male x common female) or hinny (common male x Muscovy female) ducks. In some cases special names are assigned to hybrids by commercial breeders. For example, once hybrid produced by crossing Muscovy males with Pekin females is called "Moulard". Such names may identify the commercial breeder and the particular strain of Muscovy and common duck used to produce the hybrid. In Taiwan, the hybrid produced by crossing a White Muscovy male with a Kaiya (Pekin x Tsaiya) female is called simply, the "Mule Duck". Mule Ducks are popular among the people of Taiwan because of their taste and high proportion of lean meat.

Poultry eggs are eaten in most areas of the world with fewer social taboos associated with them than with pigs and cattles. In Asia ducks are sole source of livelihood of a considerable number of people who may own large flock for meat and egg production. Of the world duck population of 52.8 million, 90 % is found in Asia[2].

However, in Nigeria, more emphasis is laid on domestic fowl to the neglect of other classes of poultry. As a result domestic fowl dominated the poultry industry. Of the 150 million poultry population, 120 million (80 %) were indigenous. Domestic fowl constituted 91 % of this while guinea fowl, duck,

Tele:
E-mail addresses: adeyeyeilesanmi2012@gmail.com

turkey and others were 4 %, 3 % and 2 % respectively. The population of ducks in Nigeria has been put at 1.21 million as against 133.5 million local/exotic chicken. The Federal Livestock Department Annual Report in 1988 reported that 69 % of total meat and 12 % of total eggs from 218.8 poultry were supplied by domestic fowl in 1987[2].

Despite abundant water, pasture land and the fact that 10 % of Nigerian households keep ducks[3], consumption of its meat and especially eggs, was low. In fact, a survey[2] showed that ducks were neither raised for egg production nor consumption. Thus duck eggs were seldom eaten or sold. The reason obtained by the survey, basically on taboo, partially explains why duck eggs have not found favour with consumers.

Adenowo et al.[2] had worked on the freshly laid eggs of local duck (LD), local turkey (LT), guinea fowl (GF) and local chicken (LC) measuring the following parameters: egg weight, per cent composition of yolk, albumen, moisture, crude protein, lipid, carbohydrate (by difference) and ash. From the results, ducks egg had higher values for egg weight, % yolk, % lipid and % ash than other species (67.5 g Vs 65.0 g, 42.0 g and 34.5 g; 50.7 Vs 32.9 and 33.0; 13.4 Vs 11.9, 11.7 and 11.5; and 1.24 Vs 0.89; 1.23 and 1.23 for LD, LT, GF and LC respectively); but tallis with GF for % crude protein (12.8 and 12.8). It has the lowest value for % moisture content (71.4 Vs 73.2, 72.5 and 78.8 respectively). The result also showed that duck eggs, unlike other species had lower % albumen than % yolk (50.7 and 38.2 Vs 32.7 and 50.3 for GF and 33.0 and 57.1 for chicken). Though protein level is highest in turkey (13.3 %), it was followed closely by that of duck egg and guinea egg (12.8 % and 12.8 %), chicken egg having the least value (12.3 %). This shows that duck egg compete favourably with other choice eggs in protein content. That the ash content of duck egg was highest showed that duck egg is a good source of minerals[2].

Adeyeye[4] carried out the comparative study on the characteristics of egg shells of some bird species. He reported as follows, total egg weight in (g): francolin 25.2 (23.5-27.1), duck 74.9 (62.3-76.8), turkey 70.9 (62.3-79.5); edible egg (g): francolin 19.9 (18.3-21.6), duck 64.6 (54.0-67.3), turkey 62.7 (54.0-71.4); shell weight (g): francolin 5.23 (4.18-5.68), duck 9.40 (8.35-9.54), turkey 8.20 (8.13-8.35).

The protein in raw eggs is only 51 % bioavailable, whereas that of cooked egg is nearer 91 % bioavailable, meaning the protein of cooked eggs is nearly twice as absorbable as the protein from raw eggs[5]. As an ingredient, egg yolks are an important emulsifier in the kitchen, and the proteins in egg white allow it to form foams and aerated dishes.

There are no reports on the amino acid composition of the yolk and albumen of the domestic duck eggs. There is also a debate on whether to discard the yolk in the consumption of egg to reduce it's suspected promotion of coronary heart diseases. This experiment was conducted to assess the amino acid composition of local duck eggs yolk and albumen and compare the results with published works on the yolk and albumen of local guinea fowl and local chicken eggs.

Materials and methods

Preparation of samples

Ten matured and fertilized eggs of domestic duck were purchased from Ado-Ekiti, Nigeria, market. The eggs were cooked in the laboratory, shells removed, yolk and albumen separated and also oven dried separately. The dried samples were pulverised, sieved and kept in freezer in McCartney bottles pending analysis.

Crude protein determination and fat extraction

The micro-Kjeldahl[6] method was followed to determine the fat-free crude protein. The fat was extracted with a chloroform/methanol (2:1 v/v) mixture using Soxhlet extraction apparatus[7]. The extraction lasted for 15 h.

Determination of amino acid profile

The amino acid profile in the known sample was determined using methods described by Spackman et al.[8] The known sample was dried to constant weight, defatted, hydrolysed, evaporated in a rotary evaporator and loaded into the Technicon Sequential Multi-sample Amino Acid Analyzer (TSM) (Technicon Instruments Corporation, New York, USA). Method of analysis was by ion-exchange chromatography.

Hydrolysis of the sample

A known weight (35 mg) of the defatted sample was weighed into glass ampoule. 7 ml of 6 MHCl was added and oxygen was expelled by passing nitrogen into the ampoule. (This is to avoid possible oxidation of some amino acids during hydrolysis.) The glass ampoule was then sealed with Bunsen burner flame and put in an oven present at 105 $^oC \pm 5$ ^oC for 22 h. The ampoule was allowed to cool before broken opened at the tip and the content was filtered to remove the humins. The filtrate was then evaporated to dryness at 40 ^oC under vacuum in a rotary evaporator. The residue was dissolved with 5 ml of acetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer.

Loading of the Hydrolysate into the TSM analyser

The amount loaded was between 5 to 10 microlitre. This was dispensed into the cartridge of the analyser. The TSM analyser is designed to separate and analyse free acidic, neutral and basic amino acids of the hydrolysate. The period of analysis lasted for 76 min.

Amino acid analysis information

(a) Domestic duck yolk

Weight of sample hydrolysed = 0.1761 g

(g/100 g protein) = NH x NH/2 x S_{std} x C

Where S_{std} = NE_{std} x Mol. Weight x µA A_{std}

Dilution = 5

C = Dilution x 16/Sample Wt (g) x N% x 10 x Vol. loaded÷ NH x W(nleu)

%N (Fat Free) = 11.36

Volume Loaded: basic = 10 µl

Acidic/Neutral = 5 µl

C_{basic} = 0.001038703

C_{acidic}/neutral = 0.002077406

(b) Domestic duck albumen

Weight of sample hydrolysed = 0.1848 g

Concentration (g/100 g protein) = NH x NH/2 x S_{std} x C

Where S_{std} = NE_{std} x Mol. Weight x µA A_{std}

Dilution = 5

C = Dilution x 16/Sample Wt (g) x N% x 10 x Vol. loaded÷ NH x W(nleu)

% N (Fat Free) = 10.82

Volume Loaded: basic = 10 µl

Acidic/Neutral = 5µl

Cbasic = 0.001039202

$C_{acidic/neutral}$ = 0.002078404

Method of calculating amino acid value from the chromatogram peaks

The net height of each peak produced by the chart recorder of TSM (each representing an amino acid) was measured. The half-height of the peak on the chart was found and the width of the peak on the half-height was accurately measured and recorded. Approximate area of each peak was then obtained by multiplying the height with the width at half-height. The norleucine equivalent (NE) for each amino acid in the standard mixture was calculated using the formula:

NE = Area of norleucine peak/Area of each amino acid.

A constant S was calculated for each amino acid in the standard mixture:

S_{std} = NE_{std} x mol. weight x μMAA_{std}

Finally the amount of each amino acid present in the sample was calculated in g/16N or g/100 g protein using the following formula:

Concentration (g/100 g protein) = NH x W@NH/2 x S_{std} x C

Where: C = Dilution x 16/ Sample wt (g) x N % x 10 vol. loaded ÷ NH x W (nleu)

Where: NH = Net height

W = Width @ half height

Nleu = Norleucine.

Tryptophan was not determined because of cost.

Estimation of Isoelectric Point (pI)

The theoretical estimation of isoelectric point (pI) was determined using the equation of Olaofe and Akintayo[9] and information provided by Finar[10] using the equation:

$$I\,Pm = \sum_{i=l}^{n} IPiXi$$

where IPm is the isoelectric point of the mixture of amino acids, IPi is the isoelectric point of the i^{th} amino acid in the mixture and Xi is the mass or mole fraction of the i^{th} acid in the mixture.

Estimation of predicted-protein efficiency ratio (P-PER)

The predicted protein efficiency ratio (P-PER) was estimated using one of the equations developed by Alsmeyer et al.[11], that is:

P-PER = -0.468 + 0.454 (Leu) -0.105 (Tyr)

Estimation of dietary protein quality

The amino acid scores were calculated using two different methods:

- Calculating the essential amino acid scores using the following formula[12]:

Amino acid score = Amount of amino acid per test protein [mg/g]/Amount of amino acid per protein in reference pattern [mg/g].

- Calculations based on the pre-school child (2-5 years) suggested essential amino acid requirements[13].

Estimation of essential amino acid index (EAAI)

The essential amino acid index was calculated by using the ratio of test protein to the reference protein for each eight essential amino acids plus histidine according to Steinke et al.[14]:

$$\text{Essential amino acid index} = \sqrt[9]{\frac{\text{mg lysine in 1 g test protein}}{\text{mg lysine in 1 g reference protein}} \times \text{etc. for all 8 essential amino acids + His}}$$

Leucine/ isoleucine ratio

The leucine/isoleucine ratios, their differences and their percentage differences were also calculated.

Statistical analysis

The statistical analysis carried out included the determination of the grand mean, standard deviation (SD) and the coefficients of variation per cent (CV %). Other calculations made were the simple linear correlation (r_{xy}), coefficient of determination (r_{xy}^2), coefficient of alienation (or index of lack of relationship) (C_A) and index of forecasting efficiency (IFE) and subjected to Table standards to test for significance difference, the level of probability was set at $r_{=0.05}$ at n-2 degrees of freedom[15].

Results and discussion

Table I presents the amino acid (AA) profiles of the samples. Glu and Asp were the most abundant AA in both the yolk and the albumen with respective values (g/100 g crude protein, cp) of : 13.4-12.6 (Glu) and 10.12-10.09 (Asp). A look at Table I will show that AA in the albumen was slightly more concentrated (on pair wise comparisons) than the corresponding AA in the yolk in twelve or 70.6 % parameters; of the nine essential AA determined, seven of them or 77.8 % were more concentrated in the albumen than the yolk on pair wise comparisons. The most concentrated essential AA (EAA) in the samples was Lys (7.01 g/100 g cp) in the yolk and Arg (7.80 g/100 g cp) in the albumen. The coefficient of variation per cent (CV %) ranged between 0.21-22.4 in the AA, with Asp having the least CV % and Ile the highest CV %.

Table I. Amino acid composition (g/100 g crude protein) of yolk and albumen of duck egg (dry weight)

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys[a]	7.01	6.91	6.96	0.07	1.02
His[a]	2.50	2.59	2.55	0.06	2.50
Arg[a]	5.77	7.80	6.79	1.44	21.2
Asp	10.1	10.1	10.1	0.02	0.21
Thr[a]	3.84	3.51	3.68	0.23	6.35
Ser	4.00	4.78	4.39	0.55	12.6
Glu	13.4	12.6	13.0	0.51	3.92
Pro	4.23	5.29	4.76	0.75	15.7
Gly	4.17	5.50	4.84	0.94	19.5
Ala	4.62	5.31	4.97	0.49	9.83
Met[a]	2.29	2.36	2.33	0.05	2.13
Cys	1.24	1.30	1.27	0.04	3.34
Val[a]	4.71	5.03	4.87	0.23	4.65
Ile[a]	3.87	5.32	4.60	1.03	22.4
Leu[a]	6.95	7.33	7.14	0.27	3.76
Phe[a]	4.38	4.88	4.63	0.35	7.64
Tyr	3.37	3.21	3.29	0.11	3.44
Try[a]	-	-	-	-	-
Protein fat free	71.0	67.6	69.3	2.39	3.44

[a]Essential amino acid; -not determined, mean value is grand mean of the amino acids

Table II. EAA, non-EAA, acidic, neutral, sulphur and aromatic acid contents (g/100 crude protein) of yolk and albumen of guinea fowl egg (dry weight)

Amino acid	Yolk	Albumen	Mean	SD	CV %
Total amino acid (TAA)	86.4	93.9	90.1	5.25	5.82
Total non-essential amino acid (TNEAA)	45.1	53.0	49.1	5.58	11.4
Total EAA (TEAA)					
-with His	41.3	40.9	41.1	0.33	0.81
-no His	38.8	38.3	38.5	0.40	1.03
% TNEAA	52.2	56.5	54.3	3.03	5.57
% Total EAA					
-with His	47.8	43.5	45.7	3.03	6.63
-no His	44.9	40.8	42.8	2.93	6.85
Total neutral amino acid (TNAA)	47.7	53.8	50.7	4.35	8.57
% TNAA	55.2	57.3	56.3	1.55	2.76
Total acidic amino acid (TAAA)	23.5	22.7	23.1	0.53	2.30
% TAAA	27.2	24.2	25.7	2.08	8.11
Total basic amino acid (TBAA)	15.3	17.3	16.3	1.43	8.77
% TBAA	17.7	18.4	18.1	0.53	2.96
Total sulphur amino acid (TSAA)	3.53	3.66	3.60	0.09	2.56
% TSAA	4.08	3.90	3.99	0.13	3.27
% Cys in TSAA	35.1	35.5	35.3	0.28	0.80
Total aromatic amino acid (TArAA)	10.3	10.7	10.5	0.30	2.91
% TArAA	11.9	11.4	11.6	0.34	2.92
P-PER[a]	2.33	2.52	2.43	0.13	5.54
Leu/Ile ratio	1.80	1.38	1.59	0.30	18.7
Leu-Ile (difference)	3.08	2.01	2.55	0.79	29.7
% Leu-Ile (difference)	44.3	27.4	35.9	12.0	33.3
EAAI[b]	1.31	1.32	1.32	0.01	0.64
Isoelectric point (pI)	4.90	5.53	5.22	0.44	8.43

[a]Predicted-protein efficiency ratio; [b]Essential amino acid index.

The FAO/WHO/UNU[13] EAA standards for pre-school children (2-5 years) were (g/100 g protein): Leu (6.6), Phe +Tyr (6.3), Thr (3.4), Try (1.1), Val (3.5), Ile (2.8), Lys (5.8), Met + Cys (2.5), His (1.9) and total (33.9 with His) and 32.0 (no His). Based on this information, both samples would provide (individually) more than enough of the EAA for the pre-school children. Tryptohan was not determined. Histidine is a semi-essential AA particularly useful for histamine present in small quantities in cells. Arginine is also good for children and it is high in the samples. Isoleucine is an EAA for both old and young. Methionine is needed for the synthesis of choline which in turn forms lecithin and other pohospholipids in the body. When the diet is low in protein, for instance in alcoholism and kwashiorkor, insufficient choline may be formed[16]. Phenylalanine is the precursor of some hormones and the pigment melanin in hair, eyes and tanned skin.

Table III. Amino acid scores of the duck egg yolk and albumen based on provisional amino acid scoring pattern

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys	1.27	1.26	1.27	0.01	1.06
Thr	0.96	0.88	0.92	0.06	6.31
Met + Cys (TSAA)	1.01	1.05	1.03	0.03	2.55
Val	0.94	1.01	0.97	0.05	4.65
Ile	0.97	1.33	1.15	0.26	22.3
Leu	0.99	1.05	1.02	0.04	3.74
Phe + Tyr	1.29	1.35	1.32	0.04	2.95
Try	-	-	na	na	na
Total	1.01	1.07	1.04	0.04	3.73

not determined; na – not available.

Table II contains parameters on the quality of the protein of the samples. The EAA ranged between 40.9-41.3 g/100 g cp with a CV % of 0.81. The total sulphur AA (TSAA) of the samples was 3.53 g/100 g cp (yolk) and 3.66 g/100 g cp (albumen). The values of 3.53-3.66 g cp are close to the value of 5.8 g/100 g cp recommended for infants[13]. The aromatic AA (ArAA) range suggested for infant protein (6.8-11.8 g/100 g cp)[13] is very favourably comparable with the present report of 11.4-11.9 g/100 g. The percentage ratio of EAA to the total AA (TAA) in the samples ranged between 43.5 % and 47.8 %. These values are well above the 39 % considered adequate for ideal protein food for infants, 26 % for children and 11 % for adults[13]. The percentage of total neutral AA (TNAA) ranged from 55.2-57.3, indicating that these formed the bulk of the AA; total acidic AA (TAAA) ranged from 22.7-23.5 which is far lower than % TNAA, whilst the percentage range in total basic AA (TBAA) is 17.7 (yolk) and 18.4 (albumen) which made them the third largest group among the parameters. The predicted protein efficiency ratio (P-PER) is 2.33 (yolk) and 2.52 (albumen) meaning that the albumen may be much easily bioavailable than the albumen by as much as 7.54 %. The Leu/Ile ratio was low in both samples with values of 1.80 (yolk) and 1.38 (albumen) with a CV % of 18.7, hence no concentration antagonism might be experienced in the domestic duck egg yolk and albumen when used as the only prtotein source in food. The essential amino acid index (EAAI) ranged from 1.31-1.32. EAAI is useful as a rapid tool to evaluate food formulations for protein quality, although it does not account for differences in protein quality due to various processing methods or certain chemical reactions[17]. The EAAI of defatted soybean is 1.26[17]. In the results of the isoelectric point (pI), there was a shift from 4.90 (yolk) to 5.53 (albumen), this type of shift (in the reverse order) was also observed in the brain (4.64) down to 4.32 (eyes) of guinea fowl[18]. The calculation of pI from the AA would assist in the production of the protein isolate of an organic product.

Table IV. Amino acid scores of the duck egg yolk and albumen on the suggested requirement of the essential amino acid of a pre-school child

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys	1.21	1.19	1.20	0.01	1.06
His	1.32	1.36	1.34	0.03	2.48
Thr	1.10	1.00	1.05	0.07	6.33
Val	1.35	1.44	1.35	0.01	0.89
Met + Cys (TSAA)	1.41	1.46	1.26	0.04	2.98
Ile	1.38	1.90	1.64	0.37	22.3
Leu	1.05	1.11	1.08	0.04	3.79
Phe + Tyr	1.23	1.28	1.26	0.04	2.98
Try	-	-	na	na	na
Total	1.22	1.29	1.26	0.05	3.82

The % Cys in TSAA is low with a range of 35.1-35.5 like most animal AA values[19] and unlike most plant AA values[18]. Cys can spare with Met in improving protein quality and has positive effects on mineral absorption, particularly zinc[20].

Table V. Summary of the amino acid profiles into factors A and B

	Samples (Factor A)		Factor B means
	Yolk	Albumen	
Amino acid composition (Factor B)			
Total essential amino acid	41.3	40.9	41.1
Total non-essential amino acid	45.1	53.0	49.1
Factor A means	43.2	46.9	45.1

Table VI. Summary of the statistical analysis of the data in Tables I, II, III and IV

From Table	r_{xy}	r_{xy}^2	R_{xy}	C_A %	IFE %	$\bar{X}$ (SD)	$\bar{Y}$ (SD)	Remarks
I	0.9768	0.95	0.89	21.4	78.6	5.41 (3.25)	5.82(3.03)	*
II (pI only)	0.9643	0.93	-4.76	26.5	73.5	28.8 (14.1)	32.5 (14.1)	*
III	0.6632	0.44	0.29	74.8	25.2	1.06 (0.14)	1.12 (0.17)	NS
IV	0.8233	0.68	-0.81	56.8	43.2	1.25 (0.12)	1.34 (0.26)	*

*Results significant at $r_{=0.05}$ at n-2 degrees of freedom; NS – result not significant at $r_{=0.05}$ at n-2 degrees of freedom.

Table III shows the essential AA scores (EAAS) based on the provisional amino acid scoring pattern[12]. EAAS less than 1.0 in the yolk are Thr (0.96), Val (0.94), Ile (0.97) and Leu (0.99) and it is only Thr (0.88) in the albumen. Normally the EAA most often acting in a limiting capacity are Met + Cys, Lys, Thr and Try in that order. Try was not determined. The above information showed that Thr would be the limiting AA (LAA) in both samples. To make corrections for the LAA in the samples if they serve as sole sources of protein food therefore, it would be 100/96 x protein of yolk or 1.04 x protein of yolk and 100/88 or 1.14 x protein of albumen. The Table IV shows the EAAS based on suggested requirement of the EAA of a pre-school child[13]. All the EAAS were greater than 1.00. Whilst Met + Cys (TSAA) had the highest score (1.41) in the yolk, Ile had the highest score (1.90) in albumen. Also, whilst Phe + Tyr had the highest score in Table III (1.29-1.35), Ile had the highest score (1.38-1.90) in Table IV.

The following values would show the position of the quality of domestic duck egg yolk and albumen protein: the EAA requirements across board are (values with His) (g/100 g protein): infant (46.0), pre-school (2-5 years) (33.9), school child (10-12 years) (24.1) and adult (12.7) and without His: infant (43.4), pre-school (32.0), school child (22.2) and adult (11.1)[13]; from the present results based on these standards, we have: 41.3 g cp (with His) and 38.8 (no His) in yolk; 40.9 g cp (with His) and 38.3 (no His) in albumen; Try was not determined. Non of the samples could satisfy the requirements of infants in 100 % level but would satisfy other age groups.

Table VII. Amino acid composition (g/100 g cp) of yolk and albumen of duck, guinea fowl and chicken (dry weight) compared

Amino acid	Yolk			Albumen		
	Domestic duck	Chicken	Guinea fowl	Domestic duck	Chicken	Guinea fowl
Lys	7.01	7.28	7.01	6.91	6.91	7.20
His	2.50	3.25	2.90	2.59	3.00	3.09
Arg	5.77	7.55	7.12	7.80	6.62	6.87
Asp	10.1	10.5	9.63	10.1	9.94	9.84
Thr	3.84	4.20	3.95	3.51	4.45	4.15
Ser	4.00	3.65	4.94	4.78	4.35	5.00
Glu	13.4	14.5	13.9	12.6	14.1	13.1
Pro	4.23	4.86	5.60	5.29	4.89	4.89
Gly	4.17	5.52	5.60	5.50	5.08	4.86
Ala	4.62	5.00	4.70	5.31	5.20	5.08
Met	2.29	2.86	2.73	2.36	2.39	2.49
Cys	1.24	1.37	1.30	1.30	1.30	1.24
Val	4.71	5.38	5.61	5.03	4.95	4.60
Ile	3.87	4.91	5.03	5.32	4.21	4.91
Leu	6.95	7.85	8.07	7.33	7.93	7.55
Phe	4.38	5.22	5.56	4.88	5.05	5.22
Tyr	3.37	3.69	3.69	3.21	4.17	3.53
Try	-	-	-	-	-	-
Protein(fat free)	71.0	75.3	81.1	67.6	75.6	77.1

Table V gives a brief summary of the AA profile in the samples. Column under Factor B means show that the values there were very close with a range of 40.9-41.3. However, Table VI depicts the summary of the statistical analysis of results in Tables I, II (pI only), III and IV. The simple linear correlation coefficient (r_{xy}) values showed high positive and significant results for Tables I, II and IV but r_{xy} values being highest in I and II at $r_{=0.05}$ and n-2 degrees of freedom. The regression coefficient (R_{xy}) showed that for every unit increase in the yolk AA parameter, the increase was 0.89 (Table I), -4.76 (Table II, pI only), 0.29 (Table III) and – 0.81 (Table IV). The r_{xy} value from Table III results was not significant. The coefficient of alienation was low in Table I (21.4 %), Table II (26.5 %) but high in Table III (74.8 %) and slightly high in Table IV (56.8 %). The index of forecasting efficiency (IFE) was high in Table I (78.6 %), Table II (73.5 %), low in Table III (25.2 %) and Table IV (43.2 %). Low IFE versus high C_A makes prediction of relationship difficult. The C_A produces an index of lack of relationship whilst IFE gives the reduction in errors of prediction of relationship. The C_A and IFE values showed that a good relationship existed between the yolk and albumen AA of Anas platyrhynchos eggs particularly with the results in Tables I, II and IV.

Conclusions

This study showed that the amino acid in the albumen of the egg of Anas platyrhynchos is better than its yolk in TAA, TSAA, TArAA, P-PER, Leu/Ile ratio, TBAA and EAAI. Removal of yolk before consumption of the egg will therefore reduce the availability/function of TEAA, also to be lost would be all phospholipids (including those needed for brain development), all essential fatty acids and all forms of sterols. The bird is free-range and its yolk cholesterol would not be high enough to promote incidence of coronary heart disease.

For clear comparison between the amino acid profiles of the yolk and albumen of domestic duck, chicken (hen)[21] and guinea fowl eggs[22], Table VII depicts their comparison on one to one parameter bases.

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