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Evaluation of the amino acid profile of the yolk and albumen of guinea fowl (*Numida meleagris*) egg

Emmanuel Ilesanmi Adeyeye
Department of Chemistry, Ekiti State University Ado-Ekiti, PMB 5363, Ado-Ekiti, Nigeria.

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ABSTRACT

The amino acid composition of the yolk and albumen of the egg of guinea fowl (*Numida meleagris*) was determined on a dry weight basis. The total essential amino acid ranged from (g/100 g crude protein, cp): 48.0-46.1 or from 49.3-49.2 % respectively of the total amino acid. The amino acid scores showed lysine ranged from 1.27-1.31 (on provisional essential amino acid scoring pattern) and 1.21-1.24 (on suggested requirement of the essential amino acid of a pre-school child). The predicted protein efficiency ratio was 3.74-2.59, the essential amino acid index range was 1.44-1.38 and the calculated isoelectric point range was 5.69-5.48. The correlation coefficient (r_{xy}) was positive and significant at $r_{=0.05}$ for the amino acids, amino acid scores and the isoelectric point in the two samples.

Introduction

The guinea fowl (*Numida meleagris*) thrives under semi-intensive conditions, forages well and requires little attention. It retains many of its wild ancestor's survival characteristics: it grows, reproduces and yields well in both cool and hot conditions; it is relatively diseases free; it requires little water; it is almost as easily raised as chickens and turkeys; it is a most useful all-round farm bird[1].

Guinea fowl produces substantial numbers of eggs. In Africa, these are often sold hard-boiled in local markets. In the Soviet Union, they are produced in large commercial operations. In France, guinea fowl strains have been developed that not only grow quickly but lay as many as 190 eggs a year.

The protein in raw eggs is only 51 % bioavailable, whereas that of a cooked egg is nearer 91 % bioavailable, meaning the protein of cooked eggs is nearly twice as absorbable as the protein from raw eggs [2]. 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 chemical composition of the yolk and albumen of the guinea fowl 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 study wants to report on the amino acid profiles of the yolk and albumen of guinea fowl cooked eggs to expose their relative contributions to the egg protein as a complete food.

Materials and methods

Preparation of samples

Ten matured and fertilized eggs of guinea fowl 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 method [3] 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 [4].

Amino acid analysis

Amino acid analysis was done by ion-exchange chromatography[5] using a Technicon Sequential Multisample Amino Acid Analyzer (Technicon Instruments Corporation, New York, USA). Tryptophan was not determined due to cost.

Estimation of Isoelectric Point (pI)

The theoretical estimation of isoelectric point (pI) was determined using the equation of Olaofe and Akintayo [6] and information provided by Finar [7].

Estimation of predicted protein efficiency ratio (P-PER)

The predicted protein efficiency ratio (P-PER) was estimated by using the equation given by Alsmeyer *et al.* [8].

Estimation of dietary protein quality

The amino acid scores were calculated using two different procedures:

- Scores based on essential amino acid scoring pattern [9];
- Scores based on essential amino acid suggested pattern of requirements for pre-school child [10].

Estimation of essential amino acid index (EAAI)

The essential amino acid index (EAAI) was determined using the method of Steinke et al. [11].

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 percent (CV %). Other calculations made were the simple linear correlation coefficient (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 [12].

Tele:
E-mail addresses: eiadeyeye@yahoo.com

Results and discussion

Table I presents the amino acid (AA) of the samples. Glu and Asp were the most concentrated AA in both the yolk and the albumen with respective values (g/100 g crude protein, cp) of: 13.9-13.1 (Glu) and 9.63-9.84 (Asp). A look at Table 1 will show that AA of the yolk was slightly more concentrated (on pair wise comparisons) than the corresponding AA in the albumen in eleven or 64.7 % parameters; of the nine essential AA determined, six of them or 66.7 % were more concentrated in the yolk than the albumen on pair wise comparisons. The most concentrated essential AA (EAA) in the samples was Leu (8.07 g/100 g cp) in the yolk and 7.55 g/100 g cp in the albumen. The coefficient of variation percent (CV %) ranged between 0.85-14.0 in the AA, with Ser having the least CV % and Pro the highest CV %.

The FAO/WHO/UNU[10] 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. Tryptophan 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 phospholipids in the body. When the diet is low in protein, for instance in alcoholism and kwashiorkor, insufficient choline may be formed; this may cause accumulation of fat in the liver [13]. Phenylalanine is the precursor of some hormones and the pigment melanin in hair, eyes and tanned skin.

Table II presents parameters on the quality of the protein of the samples. The EAA ranged between 48.0-46.1 g/100 g cp with a variation of 2.86 %. The total sulphur AA (TSAA) of the samples was 4.03 g/100 g cp (yolk) and 3.73 g/100 g cp (albumen). The values of 4.03-3.73 g/100 g cp are close to the value of 5.8 g/100 g cp recommended for infants [10]. The aromatic AA (ArAA) range suggested for infant protein (6.8-11.8 g/100 g cp) [10] is very favourably comparable with the present report of 12.2-11.8 g/100 g. The percentage ratio of EAA to the total AA (TAA) in the samples ranged between 49.3 % and 49.2 %. These values are well above the 39 % considered adequate for ideal protein food for infants, 26 % for children and 11 % for adults [10].

The percentage of total neutral AA (TNAA) ranged from 58.3 down to 57.2, indicating that these formed the bulk of the AA; total acidic AA (TAAA) ranged from 24.2-24.5 which is far lower than % TNAA, whilst the percentage range in total basic AA (TBAA) is 17.5 (yolk) and 18.3 (albumen) which made them the third largest group among the parameters. The predicted protein efficiency ratio (P-PER) is 3.74 (yolk) and 3.17 (albumen) meaning that the yolk may be much easily bioavailable than the albumen by as much as 15.2 %. The Leu/Ile ratio is low in both samples with values of 1.60 (yolk) and 1.54 (albumen) with a CV % of 2.70, hence no concentration antagonism might be experienced in the guinea fowl egg yolk and albumen when used as the only protein source in food. The essential amino acid index (EAAI) ranged from 1.44-1.38. 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 [14]. The EAAI of defatted soybean is 1.26 [14]. In the results of the isoelectric point (pI), there was a shift from 5.69 (yolk) down to 5.48 (albumen). This type of shift was also observed in the brain (4.64) down to 4.32 (eyes) of guinea fowl [15]. The calculation of pI from the AA would assist in the production of the protein isolate of an organic product.

The % Cys in TSAA is low with a range value of 32.3-33.2 like most animal AA values [16] and unlike most plant AA values [15]. Cys can spare with Met in improving protein quality and has positive effects on mineral absorption, particularly zinc [17].

Table III shows the essential AA scores (EAAS) based on the provisional amino acid scoring pattern [9]. EAAS less than 1.0 in the yolk is Thr (0.99) and it is Val (0.92) in the albumen thereby serving as the limiting AA (LAA) in the corresponding samples. Normally the EAA most often acting in a limiting capacity are Met +Cys, Lys, Thr and Try in that order. Try was not determined, Thr would be limiting in yolk (0.99). Thr would be limiting in yolk (0.99). To make corrections for the LAA in the samples if they serve as sole sources of protein food therefore, it would be 100/99 x protein of yolk or 1.01 x protein of yolk and 100/92 or 1.09 x protein of albumen. The Table IV shows the EAAS based on suggested requirement of the EAA of a pre-school child [10]. All the EAAS were greater than 1.00. Whilst Ile had the highest score in Table 4 (1.80-1.75), Phe + Tyr had the highest score (1.54-1.46) in Table III.

The following values would show the position of the quality of the guinea fowl 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) [10]; from the present results based on these standards, we have: 45.9 g cp (with His) and 43.0 (no His) in yolk; 44.0 g cp (with His) and 40.9 (no His) in albumen; Try was not determined. The yolk would satisfy the requirements of all age groups but less for the albumen.

Table V gives a brief summary of the AA profile in the samples. Column under factor B means shows that the values there are very close with a range of 47.1-48.5. 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 all the Tables I-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 0.07 (Table I), -0.32 (Table II, pI only), 0.01 (Table III) and 0.23 (Table IV).

The coefficient of alienation was low in Table I (13.9 %), Table II (28.1 %), slightly low in Table III (45.8 %) and slightly high in Table IV (51.8 %). The index of forecasting efficiency (IFE) was high in Table I (86.1 %), Table II (71.9 %), slightly low in Table III (54.2 %) and low in Table IV (48.2 %). Low IFE versus high C_A makes prediction of relationship difficult. The C_A produces an index of lack of relationship whilst the IFE gives the reduction in errors of prediction or relationship. The C_A and IFE values showed that a good relationship existed between the yolk and albumen AA in *Numida meleagris* eggs particularly with the results in Tables I, II and III.

Conclusions

This study showed that the amino acid in the yolk of the egg of *Numida meleagris* is better than its albumen in TAA, TEAA, TSAA, TArAA, P-PER, Leu/Ile ratio and EAAI. Removal of yolk before consumption of the egg will therefore reduce the availability/function of the parameters enunciated. 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.

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

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys[a]	7.01	7.20	7.11	0.13	1.89
His[a]	2.90	3.09	3.00	0.13	4.49
Arg[a]	7.12	6.87	7.01	0.16	2.32
Asp	9.63	9.84	9.74	0.15	1.53
Thr[a]	3.95	4.15	4.05	0.14	3.49
Ser	4.94	5.00	4.97	0.04	0.85
Glu	13.9	13.1	13.5	0.57	4.19
Pro	5.60	4.86	5.23	0.52	10.0
Gly	5.60	4.89	5.25	0.50	9.57
Ala	4.70	5.08	4.89	0.27	5.49
Met[a]	2.73	2.49	2.61	0.17	6.50
Cys	1.30	1.24	1.27	0.04	3.34
Val[a]	5.61	4.60	5.11	0.71	14.0
Ile[a]	5.03	4.91	4.97	0.08	1.71
Leu[a]	8.07	7.55	7.81	0.37	4.71
Phe[a]	5.56	5.22	5.39	0.24	4.46
Tyr	3.69	3.53	3.61	0.11	3.13
Try[a]	-	-	-	-	-
Protein fat free	81.1	77.1	79.1	2.83	3.58

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

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

Amino acid	Yolk	Albumen	Mean	SD	CV %
Total amino acids (TAA)	97.4	93.6	95.5	2.69	2.81
Total non-essential amino acid (TNEAA)	49.4	47.5	48.5	1.34	2.77
Total EAA					
-with His	48.0	46.1	47.1	1.34	2.86
-no His	45.1	43.0	44.1	1.48	3.37
%TNEAA	50.7	50.7	50.7	0.00	-
% Total EAA					
-with His	49.3	49.2	49.3	0.07	0.14
-no His	46.3	45.9	46.1	0.28	0.61
Total neutral amino acid(TNAA)	56.8	53.5	55.2	2.33	4.23
%TNAA	58.3	57.2	57.8	0.78	1.35
Total acidic amino acid (TAAA)	23.6	22.9	23.3	0.49	2.13
% TAAA	24.2	24.5	24.4	0.21	0.87
Total basic amino acid (TBAA)	17.0	17.2	17.1	0.14	0.83
% TBAA	17.5	18.3	17.9	0.57	3.16
Total sulphur amino acid (TSAA)	4.03	3.73	3.88	0.21	5.47
% TSAA	4.14	3.98	4.06	0.11	2.79
% Cys in TSAA	32.3	33.2	32.8	0.64	1.94
Total aromatic amino acid (TArAA)	12.2	11.8	12.0	0.28	2.36
% TArAA	12.5	12.6	12.6	0.07	0.56
P-PER[a]	3.74	2.59	3.17	0.81	25.7
Leu/Ile ratio	1.60	1.54	1.57	0.04	2.70
Leu-Ile (difference)	3.04	2.64	2.84	0.28	9.96
% Leu-Ile (difference)	37.7	35.0	36.4	1.91	5.25
EAAI[b]	1.44	1.38	1.41	0.04	3.01
Isoelectric point (pI)	5.69	5.48	5.59	0.15	2.66

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

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

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys	1.27	1.31	1.29	0.03	2.19
Thr	0.99	1.04	1.02	0.04	3.48
Met + Cys	1.15	1.07	1.11	0.06	5.10
Val	1.12	0.92	1.02	0.14	13.9
Ile	1.26	1.23	1.25	0.02	1.70
Leu	1.15	1.08	1.12	0.05	4.44
Phe +Tyr	1.54	1.46	1.50	0.06	3.77
Try	-	-	na	na	na
Total	1.23	1.17	1.20	0.04	5.54

-not determined; na-not available

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

Amino acid	Yolk	Albumen	Mean	SD	CV %
Lys	1.21	1.24	1.23	0.02	1.73
His	1.53	1.63	1.58	0.07	4.48
Thr	1.16	1.22	1.19	0.04	3.57
Val	1.60	1.31	1.46	0.21	14.1
Met + Cys	1.61	1.49	1.55	0.08	5.47
Ile	1.80	1.75	1.78	0.04	1.99
Leu	1.23	1.14	1.19	0.06	5.35
Phe + Tyr	1.47	1.39	1.43	0.06	3.96
Try	-	-	na	na	na
Total	1.31	1.25	1.28	0.04	3.31

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

	Samples (Factor A)		
	Yolk	Albumen	Factor B means
Amino acid composition (Factor B)			
Total essential amino acid	48.0	46.1	47.1
Total non-essential amino acid	49.4	47.5	48.5
Factor A means	48.7	46.8	47.8

Table VI. Summary of the statistical analysis of the data in Tables 1, 2, 3 and 4

From Table	r_{xy}	r_{xy}^2	R_{xy}	C_A %	IFE %	Remark
1	0.9903	0.98	0.07	13.9	86.1	*
2 (pI only)	0.9905	0.92	-0.32	28.1	71.9	*
3	0.8891	0.46	0.01	45.8	54.2	*
4	0.8553	0.73	0.23	51.8	48.2	*

*Result significant at $r_{=0.05}$ at n-2 degrees of freedom