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Investigation of Amino Acids Content of Different Poultry Eggs Types

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Abstract

In this study, essential and non-essential amino acids in both white and yolk of organic and farm chicken, quail, duck and goose eggs were determined by High Performance Liquid Chromatography (HPLC).

Aspartic and glutamic acid were found to be higher in both yolk and white of all egg types among non-essential amino acids. The lowest amounts of non-essential amino acids in egg white and yolk was observed in goose egg, and the highest was observed in quail egg. The lowest amounts of essential amino acids in egg white and yolk were observed in goose egg, while the highest were observed in quail egg. The total amino acids amount in egg white and yolk varies in between 108.18±2.89 - 134.36±3.67 and 98.59±2.28 - 124.43±3.06 mg g-1, respectively. The total essential amino acids to total non-essential amino acids ratio in the egg samples examined varies between 75 to 86 percent, and the total essential amino acids to total amino acids ratio varies between 41 to 46 percent. From these results, it can be said that eggs are a good source of protein. Differences in amino acid content might be explained by the variety of the animal and its diet.

Keywords: Egg, Chicken, Quail, Duck, Goose, Amino acid

Introduction

A balanced diet is very important for the regular functioning of mental and physical functions and the continuation of a healthy life. Although the components needed for a balanced diet can be obtained from animal and plant sources, animal sources are preferred because they contain relatively more usable nutrients [1], [2]. Eggs are an important source of animal protein because they contain all the amino acids necessary for the human body [3]. The three main components of the egg are shell, yolk and egg white. Egg yolk contains 15-17 % protein [4], and egg white contains approximately 10.5 % protein [5]. An egg weighing an average of 60 grams contains 6 gram of egg protein Because egg is rich in essential amino acids and these 6 grams of egg protein accepted as standard for other foodstuff and scale to 100 [6]. In addition to being the building blocks of proteins, which generally constitute a significant part of the cell structure, amino acids also have different functions such as hormone production, signal transduction and homeostasis of biochemical pathways [7]. It has been reported that amino acids are important regulators of basic metabolic pathways required for repair, growth, reproduction and the immune system in the organism and increase protein accumulation [8], [9]. As a result of deficiency or inadequate levels of amino acids in the body, protein synthesis does not occur properly, causing various metabolic disorders [10]. Amino acids are classified into two groups: essential (histidine, arginine, thyronine, valine, methionine, leucine, ısoleucine, phenylalanine, tryptophan, lysine) and non-essential (aspartic acid, glutamic acid, asparagine, serine, glycine, glutamine, alanine, pyrroline, tyrosine and cysteine). Essential amino acids that cannot be synthesized in the human body must be taken regularly with food [11]. Eggs from different poultry species show unique characteristics, from size to nutritional composition [12].

This study aimed to compare the amino acid compositions according to animal species by determining the amounts of essential and non-essential amino acids in egg white and yolk of organic and farm chicken, duck, quail and goose eggs.

2. Material and Method

2.1. Material

In this study, 5 different types of eggs used; organic chicken egg (free range chicken fed from field), farm chicken egg (cage chicken), duck, quail and goose eggs supplied directly from the producers. Egg white and yolks were carefully separated and analysed.

2.2. Determination of Amino acids

Hydrolysis and derivatization of amino acids in the egg samples and HPLC methods applied to the samples were carried out according to Ali et al. [13]

2.3. Statistical analysis

All measurements were carried out in five parallels and the results are given as Mean ± Standard deviation. In statistical evaluation of the results, were performed by SPSS version 26, by using one-way ANOVA test. Differences between group means were analysed for significance using the Tukey HSD test. Statistical significance level was chosen as $p<0.05$. While the same letters shown on the same row in Table 1-4 indicate that there is no statistical difference, on the other hand different letters indicate a statistical difference.

3. Results and Discussion

Eggs are considered a cost-effective source of quality protein due to their content of essential amino acids [14], [15]. The amounts of non-essential and essential amino acids in the whites and yolks of organic and farm chicken eggs, duck, quail and goose eggs were given in Table 1-4 and Figure 1-4.

Aspartic and glutamic acids have important roles in nutritional metabolism, energy requirements, immune responses, oxidative stress, and regulation of signalling pathways [16]. Asparagine provides regulation of immune function, ammonia detoxification, regulation of sugar balance and nitrogen accumulation [17]. Serine plays a crucial function in signalling, while glycine is beneficial in mitigating the impact of oxygen-dependent free radicals [18]. Glutamine serves as a precursor in the biosynthesis of glutathione and plays an important role in antioxidant defence in the body [19]. Alanine is involved in many events in metabolism, such as balancing carbon and nitrogen flow, regulating intracellular pH, and regulating nitrogen-related metabolic events during stress [20]. Pyrroline is an important regulator of basic metabolic pathways required for repair, growth, reproduction and the immune system in organisms [21]. Tyrosine is the precursor of epinephrine, norepinephrine, DOPA and thyroid hormones, and the hydroxyl group of tyrosine also enables the synchronization of metals through oxidative and reductive reactions [22]. Cysteine plays a role in the development of anabolic and catabolic events in living organisms [23].

Non-essential amino acids, except tyrosine, were mostly observed in quail egg. While the least aspartic and glutamic acid, asparagine, serine and pyrroline were observed in goose egg, alanine was observed in duck egg, glycine, glutamine, tyrosine and cysteine were observed in organic chicken egg white (Table 1 and Figure 1).

Table 1. Amounts of non-essential amino acids in egg whites (mg g^{-1})

Amino acids	Organic chicken egg	Farm chicken egg	Duck egg	Quail egg	Goose egg
Aspartic Acid	13.54 ± 0.30 ^{b}	14.38 ± 0.33 ^{c}	14.74 ±0.28 ^{c}	15.36 ±0.30 ^{d}	12.57 ±0.28 ^{a}
Glutamic acid	18.23 ±0.48 ^{c}	19.52 ±0.50 ^{d}	16.13 ±0.44 ^{b}	20.58 ±0.52 ^{e}	14.40 ±0.41 ^{a}
Asparagine	3.85 ±0.12 ^{b}	5.10 ±0.17 ^{c}	3.87 ±0.12 ^{b}	5.60 ±0.19 ^{d}	3.50 ±0.10 ^{a}
Serine	3.92 ±0.13^{c}	5.15 ±0.17 ^{d}	3.88 ±0.11 ^{b}	5.70 ±0.18 ^{e}	3.44 ±0.10 ^{a}
Glycine	4.46 ±0.14 ^{a}	4.60 ±0.15 ^{a}	6.24 ±0.20 ^{c}	6.65± 0.22 ^{d}	5.38 ± 0.17 ^{b}
Glutamine	3.48 ±0.11 ^{a}	4.15 ±0.13^{b}	4.56±0.15 ^{c}	5.26 ±0.18 ^{d}	4.45 ±0.14 ^{c}
Alanine	5.63 ±0.17 ^{a}	5.88 ±0.19 ^{a}	5.54 ±0.16 ^{a}	6.62 ±0.21 ^{b}	5.61 ±0.20^{a}
Pyroline	3.00 ±0.11^{a}	2.95 ±0.10 ^{a}	2.90 ±0.10 ^{a}	3.05 ±0.11^{b}	2.89 ±0.10 ^{a}
Tyrosine	3.35 ±0.12 ^{a}	4.02 ±0.14 ^{b}	4.50 ±0.16^{c}	4.36 ±0.15 ^{c}	3.45 ±0.11 ^{a}
Cysteine	3.23 ±0.10^{a}	3.24 ±0.09 ^{a}	3.49 ±0.11 ^{b}	3.53 ±0.11 ^{b}	3.28 ±0.09 ^{a}

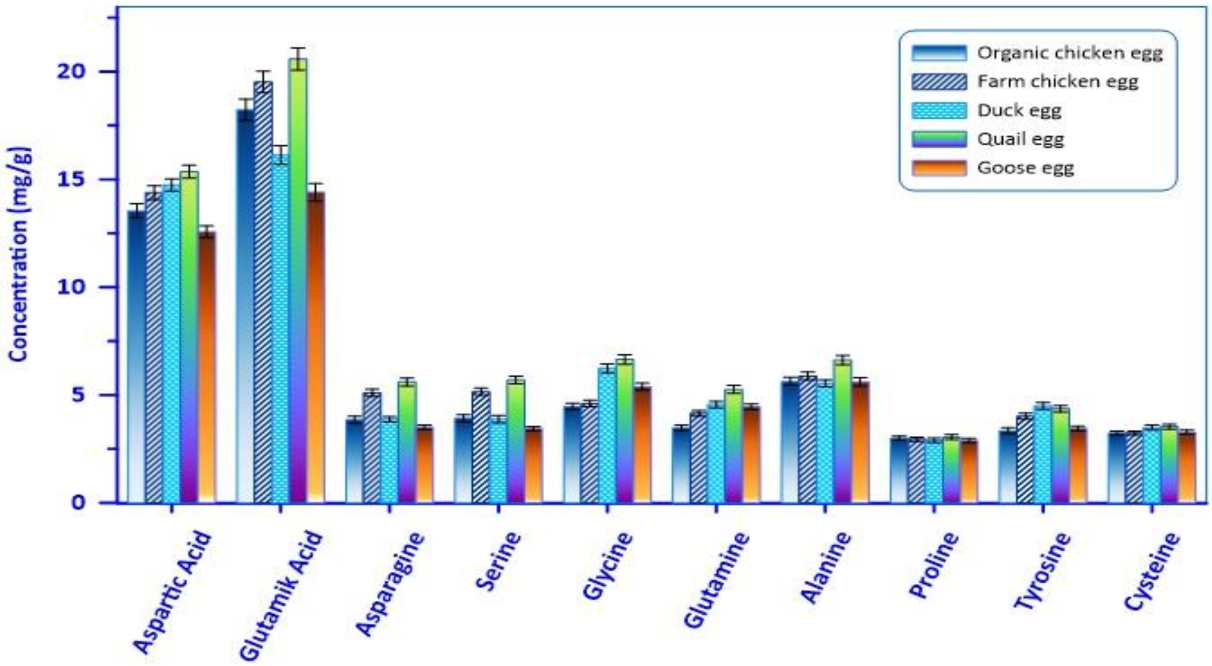

Figure 1. Nonessential amino acids in egg white

The difference between the amounts of both glutamic acid and serine in all egg samples is statistically significant (p<0.05). The difference between the amounts of both pyrroline and alanine is statistically insignificant (p>0.05) except for quail egg (Table 1). While there is no statistical difference between organic and farm chicken egg and goose eggs in terms of cysteine, the difference between duck and quail eggs is also statistically insignificant (p>0.05). The difference in glutamine between duck and goose eggs is statistically insignificant (p>0.05), on the other hand, organic chicken, farm chicken and quail eggs are significant (p<0.05) (Table 1). Quail egg is the richest in term of non-essential amino acids, except glutamic acid. The amounts of aspartic acid, asparagine, serine, glycine, glutamine and pyrroline were observed least in goose egg yolk. Glutamic acid, alanine, tyrosine and cysteine amino acids were observed least in quail, farm and organic chicken egg yolks, respectively. Aspartic acid and glutamic acid were found to be higher in both yolk and white of all eggs other than non-essential amino acids (Table 2, Figure 2).

Table 2. Amounts of non-essential amino acids in egg yolk (mg g^{-1})

Amino acids	Organic chicken egg	Farm chicken egg	Duck egg	Quail egg	Goose egg
Aspartic Acid	11.78 ± 0.24 ^{b}	12.51 ± 0.27 ^{c}	12.66 ±0.27 ^{c}	13.64 ±0.31 ^{d}	10.71 ±0.20 ^{a}
Glutamic acid	16.23 ±0.45 ^{d}	17.20 ±0.49 ^{e}	15.26 ±0.37 ^{c}	11.24 ±0.21 ^{a}	12.80 ±0.31 ^{b}
Asparagine	4.52 ±0.14 ^{a}	6.24 ±0.20 ^{c}	5.12 ±0.16 ^{b}	6.57 ±0.22 ^{d}	4.35 ±0.14 ^{a}
Serine	4.30 ±0.12 ^{b}	5.85 ±0.15 ^{d}	4.81 ±0.14 ^{c}	6.56 ±0.20 ^{e}	4.04 ±0.13 ^{a}
Glycine	4.23 ±0.12 ^{a}	4.41 ±0.15 ^{a}	4.78 ±0.16 ^{b}	5.82 ± 0.19 ^{c}	4.21 ± 0.13 ^{a}
Glutamine	3.51 ±0.09 ^{a}	4.17 ±0.11 ^{c}	4.56±0.12 ^{d}	4.86 ±0.14 ^{e}	2.82 ±0.11 ^{b}
Alanine	5.43 ±0.15 ^{b}	4.87 ±0.11 ^{a}	5.42 ±0.14^{b}	6.38 ±0.20 ^{c}	5.40 ±0.13^{b}
Pyrroline	4.47 ±0.13 ^{c}	4.50 ±0.12 ^{c}	3.14 ±0.09 ^{b}	4.77 ±0.14 ^{d}	2.95 ±0.08 ^{a}
Tyrosine	2.06 ±0.09 ^{a}	3.35 ±0.12 ^{c}	3.41 ±0.11 ^{c}	4.80 ±0.14 ^{d}	2.81 ±0.09 ^{b}
Cysteine	4.12 ±0.12 ^{a}	4.11 ±0.11 ^{a}	4.42 ±0.13 ^{b}	4.48 ±0.14 ^{b}	4.16±0.11 ^{a}

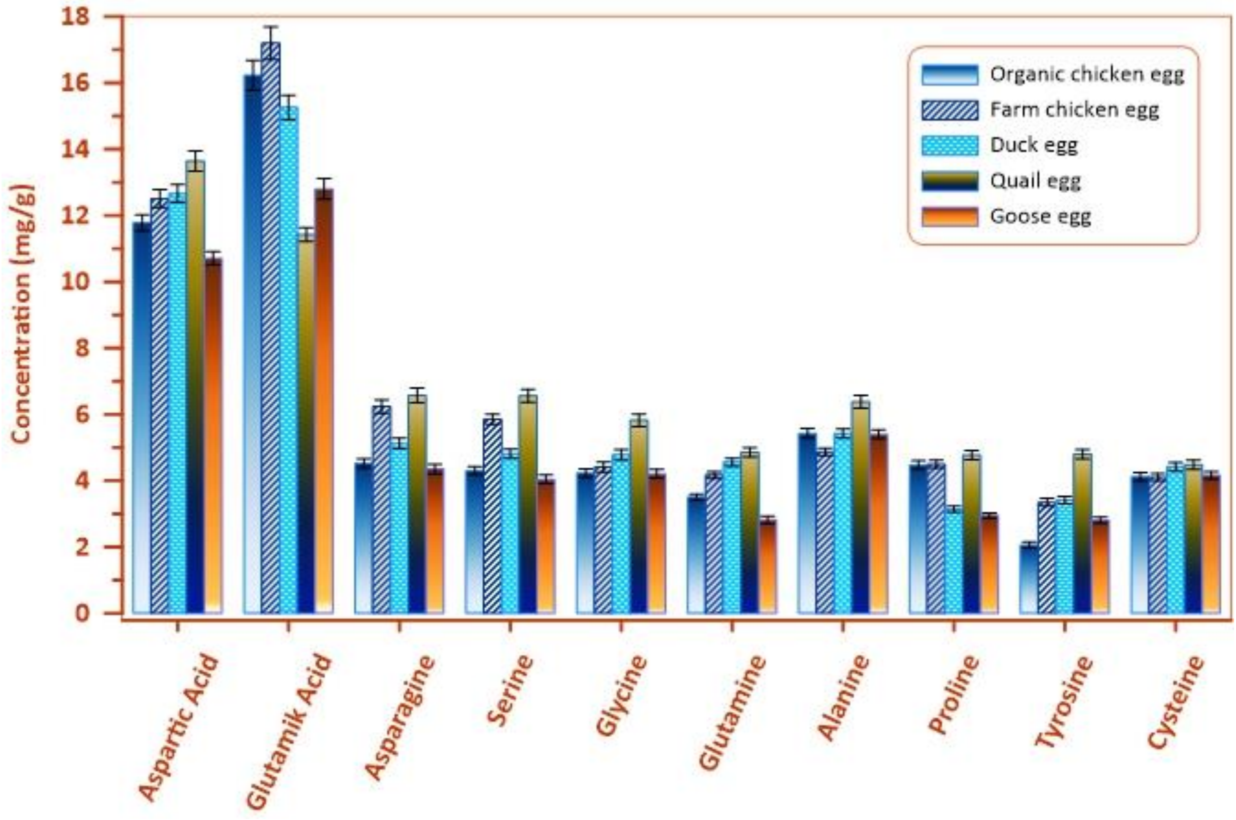

Figure 2. Non -essential amino acids in egg yolk

There is statistically significant difference between egg yolks in terms of serine, glutamic acid and glutamine ($p<0.05$). The difference between organic chicken, duck and goose egg yolks in terms of alanine is statistically insignificant ($p>0.05$). There is no statistical difference between quail and duck egg and farm and organic chicken and goose eggs in terms of cysteine ($p>0.05$) (Table 2).

Dajnowska et al. [24], found that non-essential amino acids in chicken egg white between 3.28 - 13.71 mg g^{-1} and the essential amino acids between 2.28 - 8.65 mg g^{-1}. In the same study, they reported that the amounts of non-essential amino acids in egg yolk were between 4.19-19.30 mg g^{-1} and essential amino acids were between 4.02 - 13.87 mg g^{-1}. The amounts of essential and non-essential amino acids in the whites of organic and farm chicken eggs were higher than findings of Dajnowska et al. [24], on the other hand, the amounts of essential and non-essential amino acids in the yolks of lower than their results. Zhao et al. [25] found the amount of alanine, arginine, asparagine, cysteine, glutamine, glycine and pyrroline in duck egg white as 2.47, 1.24, 7.92, 0.90, 12.93, 9.05 and 3.40 g (100 g) $^{-1}$, respectively. In addition, the amounts of histidine, isoleucine, leucine, lysine, methionine, phenylalanine, serine, threonine, tyrosine and valine were found to be 4.82, 8.64, 6.78, 5.73, 9.0, 10.51, 7.60, 4.46, 8.28 and 6.36 (100 g in egg white) $^{-1}$, respectively. The amounts of essential and non-essential amino acids in duck egg white were found to be lower than findings of Zhao et al. [25]

Table 3. Amounts of essential amino acids in egg white (mg g^{-1})

Amino acids	Organic chicken egg	Farm chicken eggs	Duck egg	Quail egg	Goose egg
Histidine	1.84 ±0.04 ^{b}	1.98 ±0.05 ^{c}	2.28 ±0.06 ^{d}	2.42 ±0.09 ^{d}	1.74 ±0.04 ^{a}
Arginine	3.68 ±0.10 ^{b}	3.80 ±0.11 ^{b}	4.06 ±0.12 ^{c}	3.23 ±0.10 ^{a}	3.28 ±0.11 ^{a}
Thyronine	3.27 ±0.11 ^{b}	3.57 ±0.12 ^{c}	3.71 ±0.13 ^{c}	4.76 ±0.14 ^{d}	3.05 ±0.09 ^{a}
Valine	6.65 ±0.17 ^{d}	6.46 ±0.15 ^{d}	5.82 ±0.12 ^{b}	6.09 ± 0.13 ^{c}	5.39 ±0.11 ^{a}
Methionine	5.12 ±0.11 ^{a}	5.39 ±0.12 ^{b}	5.78 ±0.16 ^{c}	4.98 ±0.10 ^{a}	5.42 ±0.13 ^{b}
Leucine	11.43 ±0.29 ^{d}	10.63 ±0.27 ^{c}	9.14 ±0.23 ^{b}	10.48 ±0.26 ^{c}	8.15 ±0.21 ^{a}
Isoleucine	6.03 ±0.14 ^{b}	5.66 ±0.12 ^{a}	6.14 ±0.15 ^{b}	6.55 ±0.17 ^{c}	6.00 ±0.14 ^{b}
Phenylalanine	6.90 ±0.16 ^{a}	7.58 ±0.19 ^{b}	7.26 ±0.18 ^{b}	8.76 ±0.24 ^{c}	7.25 ±0.17 ^{b}
Tryptophan	2.96 ±0.04 ^{d}	3.17 ±0.06 ^{e}	2.74 ±0.04 ^{c}	2.53 ±0.03 ^{b}	2.45 ±0.03 ^{a}
Lysine	6.15 ±0.14 ^{a}	7.18 ±0.20 ^{c}	6.84 ±0.18 ^{c}	7.85 ±0.24 ^{d}	6.48 ±0.16 ^{b}

Table 4. Amounts of essential amino acids in egg yolk (mg g^{-1})

Amino acids	Organic chicken egg	Farm chicken egg	Duck egg	Quail egg	Goose egg
Histidine	1.68 ±0.03 ^{b}	1.74 ±0.05 ^{b}	2.15 ±0.06 ^{c}	2.30 ±0.08 ^{d}	1.55 ±0.03 ^{a}
Arginine	2.96 ±0.08 ^{b}	3.16 ±0.09 ^{c}	3.33 ±0.10 ^{c}	2.86 ±0.08 ^{b}	2.70 ±0.07 ^{a}
Thyronine	2.60 ±0.06 ^{a}	2.65 ±0.08 ^{a}	2.85 ±0.09 ^{b}	3.70 ±0.11 ^{c}	2.54 ±0.05 ^{a}
Valine	6.96 ±0.19 ^{c}	6.88 ±0.17 ^{c}	4.71 ±0.10 ^{a}	5.22 ± 0.12 ^{b}	4.53 ±0.10 ^{a}
Methionine	4.34 ±0.08 ^{b}	4.38 ±0.09 ^{b}	4.40 ±0.10 ^{b}	3.95 ±0.09 ^{a}	4.48 ±0.08 ^{b}
Leucine	9.25 ±0.22 ^{c}	9.15 ±0.20 ^{c}	7.96 ±0.17 ^{b}	9.32 ±0.19 ^{c}	7.05 ±0.14 ^{a}
Isoleucine	5.83 ±0.12 ^{b}	5.08 ±0.10 ^{a}	5.75 ±0.11 ^{b}	6.92 ±0.14 ^{c}	4.97 ±0.09 ^{a}
Phenylalanine	5.88 ±0.10 ^{a}	6.49 ±0.13 ^{b}	6.03 ±0.12 ^{a}	7.80 ±0.14 ^{c}	6.41 ±0.12 ^{b}
Tryptophan	3.38 ±0.05 ^{c}	3.47 ±0.06 ^{d}	3.24 ±0.04 ^{b}	3.34 ±0.04 ^{c}	2.91 ±0.03 ^{a}
Lysine	6.90±0.14 ^{a}	8.00 ±0.15 ^{d}	7.68 ±0.14 ^{c}	8.90 ±0.18 ^{e}	7.20±0.14 ^{b}

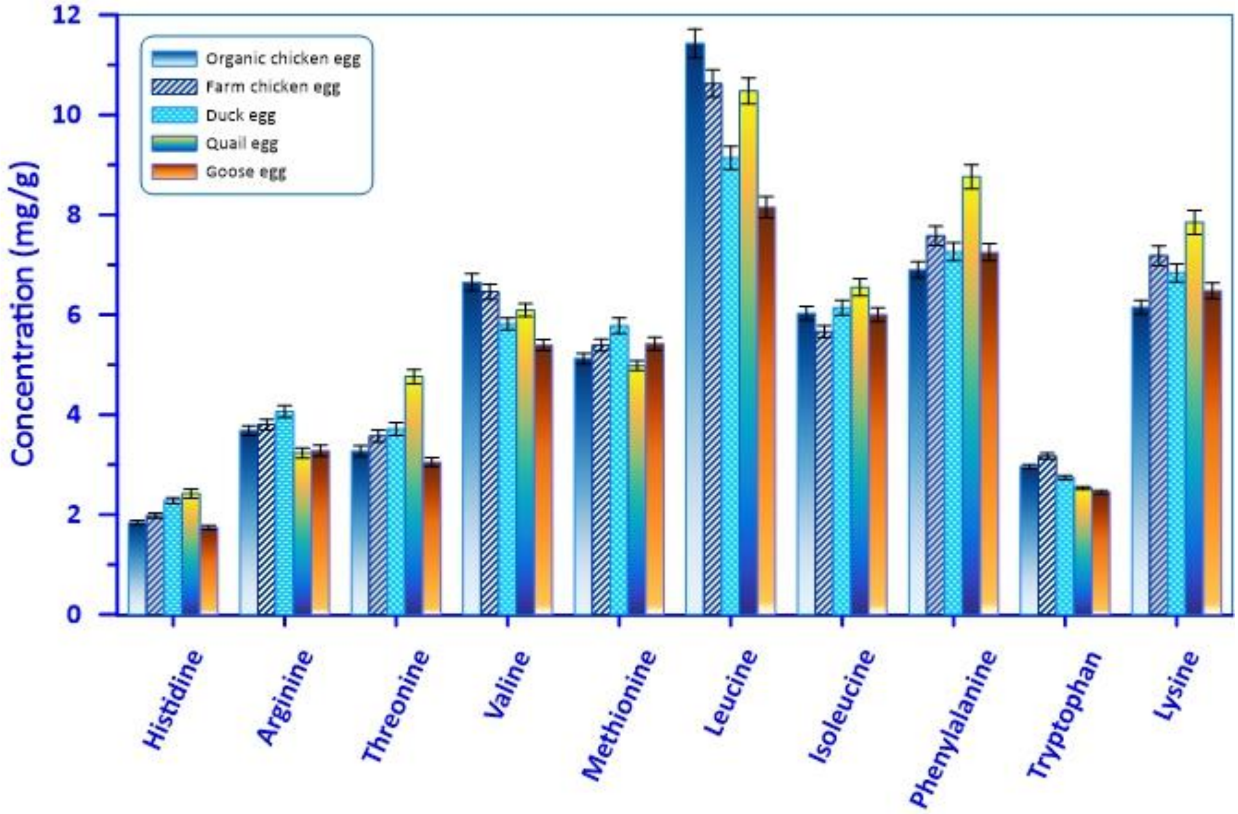

Figure 3. Essential amino acids in egg white

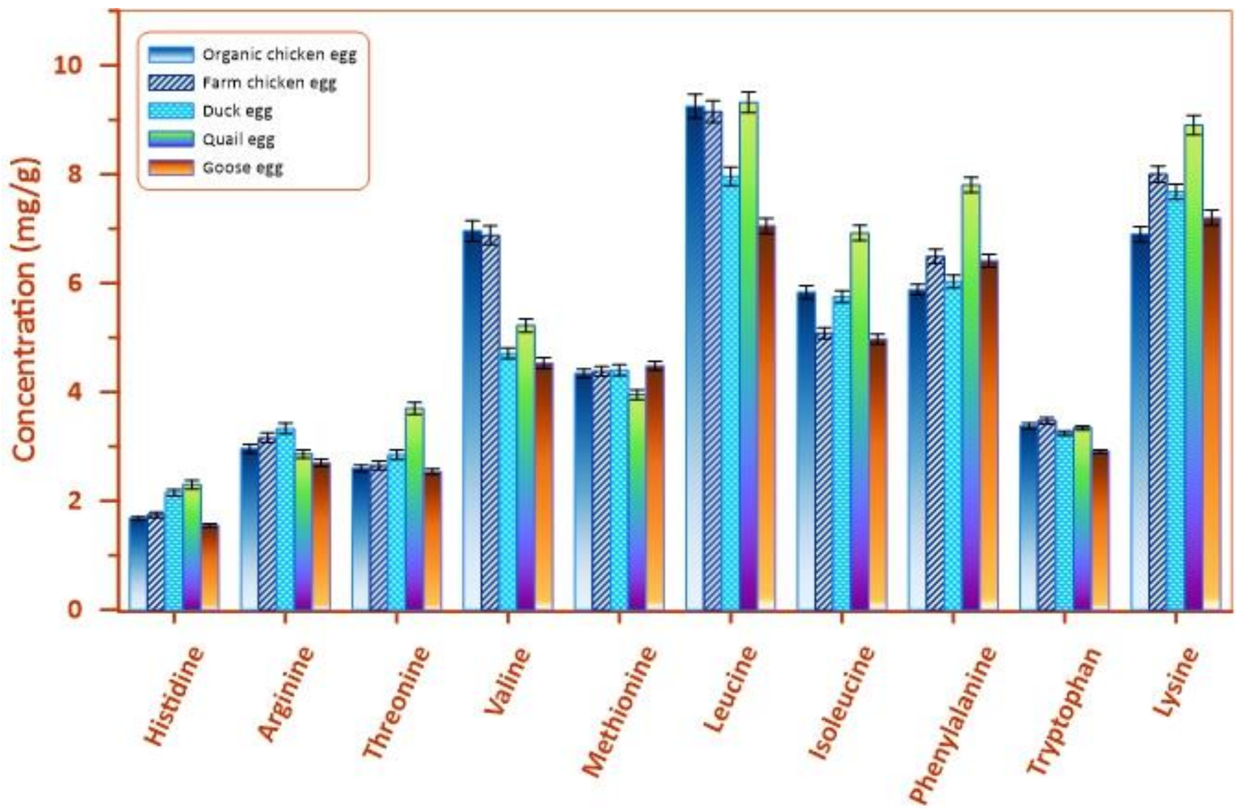

Figure 4. Essential amino acids in egg yolk

Histidine ensures protein methylation, maintenance of hemoglobin structure and function, and the formation of histamine, which has many roles in metabolism [26]. Arginine, which has an important role in nitrogen metabolism, is a source of nitrogen for the cell. Arginine, which is needed during physiological and biochemical processes in the cell and during growth and development periods, also serves as a precursor for the biosynthesis of polyamines and nitric oxide [27]. Threonine is the basic part of proteins such as collagen and elastin, has a very important role in fat metabolism and the immune system, and also helps in the synthesis of glycine and serine [28]. Tryptophan, has a role in a number of key biological processes, particularly the function of neurons, the immune system, and the state of homeostasis of the gut [29]. Leucine is an essential branched-chain amino acid that plays a crucial role in protein synthesis and muscle recovery. It also facilitates the regulation of blood sugar levels, accelerates wound healing and increases growth hormone production. Isoleucine plays an important role in muscle metabolism and is mostly concentrated in muscle tissue. It is also very important for immunological function, hemoglobin synthesis and energy management [30]. Alanine ensures intracellular and intercellular reactions and transfers, safe passage of nitrogen, and regulation of the glucose-alanine cycle. It is also involved in many events such as regulating intracellular pH and reducing and regulating nitrogen-related metabolic events during stress [23], [31]. Phenylalanine plays an important role in catabolic events required for defense mechanisms requiring carbon and nitrogen. It also serves as a building block for a wide variety of secondary compounds such as flavonoids, phenylpropanoids, anthocyanins and lignin, which are found in the structural component of cell walls [32]. Methionine plays an important role in metabolic and physiological processes in the development of living cells, cell growth and adaptation to stress [33]. Lysine plays a crucial part in protein synthesis, the production of hormones and enzymes, and the absorption of calcium. It is also crucial for energy generation, immunological function, and the synthesis of collagen and elastin [30].

The highest amounts of histidine, thyronine, isoleucine, phenylalanine and lysine were observed in egg white of quail egg, arginine and methionine in duck egg white, valine and leucine in organic chicken egg white, and tryptophan in farm chicken egg white. Among the essential amino acids, the lowest levels of histidine, thyronine, valine, leucine, and tryptophan were observed in goose egg white, while arginine and methionine were observed in quail egg white, phenylalanine and lysine in organic chicken egg white, and isoleucine in farm chicken egg white (Table 3, Figure 3). There is a statistically significant difference in all egg whites in terms of tryptophan ($p<0.05$). While there was no significant difference between farm chicken egg and duck egg in terms of lysine and threonine amounts ($p>0.05$), the difference between other egg types were significant ($p<0.05$). The difference between organic chicken egg, duck egg and goose egg in terms of isoleucine was statistically insignificant ($p>0.05$) in egg whites. It can be said that the amount of leucine in both the white and yolk of eggs of all types was higher than other essential amino acids (Figure 3-4). The highest amounts of histidine, thyronine, leucine, isoleucine, phenylalanine and lysine in egg yolk were observed in quail egg, on the other hand valine and tryptophan in organic chicken egg, arginine in duck egg, and methionine in goose egg were found. The least histidine, arginine, thyronine, valine, leucine, isoleucine, tryptophan and lysine in egg yolk were observed in goose egg, and phenylalanine was observed in organic chicken egg (Table 4 and Figure 4). The difference in egg yolks in terms of lysine is statistically significant ($p<0.05$). Quail egg yolk is statistically different from other eggs in terms of the amount of methionine ($p<0.05$). The difference between organic and farm chicken egg and quail egg in terms of leucine in egg yolk is statistically insignificant ($p>0.05$) (Table 4).

Ali and Abdul El-Aziz [34], determined the amounts of aspartic acid, serine, glutamic acid, glycine, pyroline, histidine, arginine, thyronine, valine, methionine, tryptophan, isoleucine, leucine, phenylalanine and lysine in quail egg, respectively 9.49, 5.47, 14.29, 4.08, 2.13, 2.29, 5.14, 4.07, 4.60, 2.73, 0.80, 4.92, 8.95, 6.34 and 6.81 g (100 g protein) $^{-1}$.

Sun et al. [12], found the non-essential amino acids in the egg white of chicken, duck, goose and quail eggs to be between 0.350-1.285, 0.349-1.308, 0.286-1.148, 0.403-1.328 g (100 g white) $^{-1}$, respectively. In the same study, they reported that the essential amino acids were between 0.224 - 0.916, 0.206 - 0.849, 0.178 - 0.752, 0.268 - 0.993 g (100 g white) $^{-1}$, respectively. The amounts of both essential and non-essential amino acids in the whites of organic and farm chicken, duck, goose and quail eggs were found to be higher than the findings of Sun et al. [12].

Adeyeye et al. [35], reported that the essential amino acids in the egg white and yolk of duck egg varied between 2.36-6.91 and 2.29-7.01 g (100 g crude protein) $^{-1}$, respectively, and the non-essential amino acids varied between 1.30-12.6 and 1.24-13.4 g (100 g crude protein) $^{-1}$. Nimalaratne et al. [36], reported that non-essential amino acids in the egg yolk of corn-fed chickens were between 345.6-1171.9 and essential amino acids were between 44.1-1584.3 µg (g dry weight) $^{-1}$. It appears that the amounts of both essential and non-essential amino acids in the yolks of both organic and farm chicken eggs are higher than the findings of Nimalaratne et al. [36].

Adeyeye [37], reported that the amount of non-essential amino acids in duck egg was between 1.27 - 13.1 and essential amino acids 2.24 - 6.65 g (100 g crude protein) $^{-1}$.Total essential amino acid (TEA), total non-essential amino acid (TNEA), total amino acid amounts (TA) and TEA/TNEA, TEA/TA ratios in both egg white and yolk of egg samples are given in Table 5.

Table 5. TEA, TNEA, TAA (mg g^{-1}) with ratio of TEA/TNEA and TE/TA

	TEA	TNEA	TA	TEA/ TNEA	TEA/T A
Organic chicken egg white	54.03±1.30	62.69 ±1.78	116.72±3.08	86	46
Organic chicken egg yolk	49.78±1.07	60.65±1.65	110.43±2.72	82	45
Farm chicken egg white	55.42±1.39	68.99±1.97	124.41±3.36	80	45
Farm chicken egg yolk	51.00±1.12	67.21±1.83	118.21±2.95	76	43
Duck egg white	53.77±1.37	65.85±1.89	119.62±3.26	82	45
Duck egg yolk	48.10±1.03	63.58±1.69	111.68±2.72	75	43
Quail egg white	57.65±1.50	76.71±2.17	134.36±3,67	75	43
Quail egg yolk	54.31±1.17	69.12±1.89	124.43±3.06	79	44
Goose egg white	49.21±1.19	58.97±1.70	108.18±2.89	83	41
Goose egg yolk	44.34±0.85	54.25±1.43	98.59±2.28	82	45

The amount of TEA in egg whites and yolks varied between 49.21±1.19 - 57.65±1.50 and 44.34±0.85 - 54.31±1.17 mg g^{-1}, respectively, and the lowest amounts were observed in goose egg. While the amount of TNEA in egg whites varied between 58.97±1,70 - 76.71±2,17 mg (g white) $^{-1}$, the highest amount was observed in quail egg. While the total amount of TNEA in egg yolks varied between 54.25±1,43 - 69.12±1,89 mg (g yolk) $^{-1}$, the lowest amount was observed in goose egg (Table 5). The lowest amount of TA was observed in goose egg yolk, while the highest value was observed in quail egg white.

It was reported that the amount of TNEA in the egg white and yolk of duck egg was 53.0 and 45.1 g (100g crude protein) $^{-1}$, and the amount of TEA was 40.9, 41.3 4 g (100g crude protein)$^{-1}$, respectively. In addition, they found that the amount of TA and TNEA in duck egg as 82.4, 42.9 g100 (g crude protein) $^{-1}$, respectively [38].

Since essential amino acids cannot be synthesized in metabolism, they must be obtained from external sources. Amino acid composition is the most important factor in defining food protein quality [38]. According to the Food and Agriculture Organization (FAO/WHO) and the World Health Organization, the TEA/TA ratio in a good protein source should be over 40 %, and the TEA/TNEA acid ratio is over 60 % [39].

Obtained results indicate that the TEA/TA ratio in egg whites varied between 41- 46 percent, and it varied between 43 – 45 percent in egg yolks depending on the variety of egg type. It was observed that the TEA/TNEA ratios in egg whites and yolks varied between 75 – 86 and 75 – 82 percent, respectively. From these results, it can be said that all eggs are a good source of protein and that organic chicken egg are better than others types of egg studied in this work.

4. Conclusion and Suggestions

Aspartic acid and glutamic acid were found to be higher in both yolks and whites of all eggs than other non-essential amino acids. It can be said that the amount of leucine in both the white and yolk of eggs was higher than other essential amino acids. While both white and yolk of quail egg were richest in TNEA, it has been determined that white and yolk of goose egg were poorer than other egg types. While the highest TEA was observed in quail egg white, the lowest was observed in goose egg yolk. The TEA/TEA ratio in the egg samples examined varied between 75 to 86 percent, and the TEA/TA ratio varied between 41 to 46 percent. From these results, it can be said that eggs were a good source of protein. Differences

Contributions

All the authors have contributed equally.

Conflict of Interest Statement

Authors declare that they have no known conflict of interest.

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