

## Evaluation of some egg quality traits in relation to different prices of eggs sold by retailers at different locations in Ile-Ife, South Western Nigeria

Makinde, O. A. and Adelusi, O. N.

Department of Animal Sciences, Obafemi Awolowo University, Ile-Ife, 220005, Nigeria

Corresponding author: [olukayodemakinde@gmail.com](mailto:olukayodemakinde@gmail.com); +234-8033303438



### Abstract

*This study investigated the relationship between the amount paid for eggs and the quality of such eggs sold at the same price by different retailers in Ile-Ife, Nigeria. Two hundred and seventy (270) eggs were collected from three major egg retailers at different markets (Maintenance Market, Sabo Market, and Akarabata Market) in Ile Ife, Nigeria. Three egg trays, with 30 eggs/tray, were obtained from each retailer at three different price categories (Low, ₦900; Medium, ₦1000; and High, ₦1200). Ten eggs were randomly selected from each tray, which reflected the price category from each retailer and evaluated for egg weight, shape index, egg shell ratio, albumen index, yolk index, Haugh unit, and albumen and yolk to egg weight, in a 3 x 3 factorial arrangement of a completely randomized design experiment. Price did not significantly ( $p > 0.05$ ) affect egg quality except albumen index, Haugh unit, and egg weight. For albumen index, low-priced eggs were at par with high-priced eggs, but was better ( $p < 0.03$ ) than medium-priced eggs, which was similar ( $p > 0.05$ ) to high-priced eggs. For Haugh unit, low-priced, at par with medium-priced, was better ( $P < 0.03$ ) than high-priced eggs, which was similar ( $p > 0.05$ ) to medium-priced eggs. Egg weight was heaviest ( $p < 0.0001$ ) for high-priced eggs. Medium-priced eggs had the least tray price per unit egg weight, and therefore, best egg quality value for price. Sabo Market retailer sold eggs with the best ( $p < 0.05$ ) internal quality at medium price, and Akarabata Market retailer at high price, but retailers were not significantly different ( $p > 0.05$ ) for eggs sold at low price. In conclusion, the price paid for eggs was not commensurate with egg quality at the low and high price categories, but best value obtainable was at medium price category. The quality of eggs offered by different retailers at the same price was different. It is recommended that farms obtain egg graders to grade their eggs properly before supplying distributors and retailers, to reduce price and quality disparities.*

**Keywords:** Egg quality, Egg retailers, Egg price,

Running title: Egg price not commensurate with egg quality



## Évaluation de certains traits de qualité des œufs en relation avec différents prix des œufs vendus par les détaillants à différents endroits à Ile-Ife, dans le sud-ouest du Nigéria

### Résumé

*Cette étude a examiné la relation entre le montant payé pour les œufs et la qualité de ces œufs vendus au même prix par différents détaillants à Ile-Ife, au Nigeria. Deux cent soixante-dix (270) œufs ont été collectés auprès de trois principaux détaillants d'œufs sur différents marchés (marché de maintenance, marché de Sabo et marché d'Akarabata) à Ile Ife, au Nigéria. Trois plateaux d'œufs, avec 30 œufs/plateau, ont été obtenus auprès de chaque détaillant à trois catégories de prix différentes (Faible, ₦900 ; Moyen, ₦1000 ; et Élevé, ₦1200). Dix œufs ont été choisis au hasard dans chaque plateau, ce qui reflétait la catégorie de prix de chaque détaillant et évalué pour le poids de l'œuf, l'indice de forme, le rapport de coquille d'œuf, l'indice d'albumen, l'indice de jaune, l'unité Haugh et l'albumen et le poids du jaune par rapport à l'œuf, dans un 3 x 3 arrangement factoriel d'une expérience de conception complètement randomisée. Le prix n'a pas eu d'incidence significative ( $p > 0,05$ ) sur la qualité des œufs, à l'exception de l'indice d'albumen, de l'unité Haugh et du poids des œufs. Pour l'indice d'albumen, les œufs à bas prix étaient à égalité avec les œufs à prix élevé, mais étaient meilleurs ( $p < 0,03$ ) que les œufs à prix moyen, qui étaient similaires ( $p > 0,05$ ) aux œufs à prix élevé. Pour l'unité Haugh, le prix bas, à égalité avec le prix moyen, était meilleur ( $P < 0,03$ ) que les œufs à prix élevé, qui étaient similaires ( $p > 0,05$ ) aux œufs à prix moyen. Le poids des œufs était le plus élevé ( $p < 0,0001$ ) pour les œufs à prix élevé. Les œufs à prix moyen avaient le prix le plus bas sur le plateau par unité de poids d'œuf et, par conséquent, le meilleur rapport qualité-prix des œufs. Le détaillant du marché de Sabo vendait des œufs avec la meilleure qualité interne ( $p < 0,05$ ) à prix moyen, et le détaillant du marché d'Akarabata à un prix élevé, mais les détaillants*

*n'étaient pas significativement différents ( $p > 0,05$ ) pour les œufs vendus à bas prix. En conclusion, le prix payé pour les œufs n'était pas proportionné à la qualité des œufs dans les catégories de prix bas et élevé, mais la meilleure valeur obtenue était dans la catégorie de prix moyen. La qualité des œufs offerts par différents détaillants au même prix était différente. Il est recommandé que les fermes obtiennent des classeurs d'œufs pour classer correctement leurs œufs avant d'approvisionner les distributeurs et les détaillants, afin de réduire les disparités de prix et de qualité.*

**Mots-clés :** qualité des œufs, détaillants d'œufs, prix des œufs,

## Introduction

The external and internal qualities of an egg determine its value to consumers. Value is based on external qualities such as egg weight, eggshell thickness, density, cleanliness, shape index and internal qualities, such as yolk index, albumen index, yolk color, and Haugh unit (Stadelman and Cotterill, 1995; Ihsan, 2012; Lopez *et al.*, 2016). Internal egg quality can be influenced by factors such as age and genotype of birds (Monira *et al.*, 2003), production system (Travel and Lopes, 2010), and storage temperature and length of storage (Jin *et al.*, 2011; Ihsan, 2012). Evidently, the most important components of eggs to consumers are those under the shell (Okeudo, 2003), therefore, egg value should be directly related to the quality of these components.

Regional or country differences exist in standards for evaluating external and internal qualities of an egg, and egg quality usually depends on size (weight), internal quality, or both (Hilmi, 2019; Chukwuka *et al.*, 2011). Generally, the higher the internal quality of eggs, the higher the price. For example, USDA grades are dependent on the internal quality regardless of the size, and the highest price paid for eggs with highest internal quality grade (AA), followed by A, and B in that order (USDA, 2023; Hilmi, 2019). In other countries, value is placed on size, from small/peewee to extra-large/jumbo (Hilmi, 2003). In contrast, most African countries do not have a defined egg grading standard, and eggs are generally valued based on size comprising, large, medium, and small (Hilmi, 2019). This is true in Nigeria, where eggs are graded under an arbitrary/unstandardized system loosely based on egg size, with eggs sorted subjectively (Abanikannda and Leigh, 2012) without regard for internal quality (Chukwuka *et al.*, 2011), and eggs of different sizes/quality end up in the same tray or crate. Consequently, consumers and retailers may not be getting due value for the price paid for eggs from such grading system. The ideal situation would have the quality of eggs determining the price which eggs are sold (Rajaravindra *et al.*, 2013; USDA, 2023), however, retailers sell the eggs according to size differences sorted subjectively. Specifically, retailers in Ile-Ife offer three basic egg size grades (mostly small, mostly medium, and

mostly large) in trays with corresponding prices, comprising, low, medium, and high prices, respectively, without any relation to internal qualities. There is very scanty information in Nigeria where the link between the subjective grading of eggs by retailers and the value the consumers actually get from purchased eggs are established. Therefore, the study was conducted to determine the differences in the quality of eggs sold at the same price by some major retailers at different locations in Ile-Ife, Osun state, Nigeria.

## Materials and Methods

### Experimental location

The study was carried out at the Animal Products Laboratory, Department of Animal Sciences, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

### Sources of eggs

A total of 270 eggs were collected from three different major egg retailers in Ile-Ife at different markets (Maintenance, MM; Sabo, SM; and Akarabata markets, AM). Eggs were obtained in plastic trays/crates of 30 eggs each. Eggs were collected according to the three different prices offered per tray per retailer, comprising, low, medium, and high prices, where low price = ₦ 900/tray; medium = ₦ 1,000/tray; high = ₦ 1,200/tray. One tray per price category was randomly obtained from the stock of each retailer, to give a total of three trays per retailer, and nine trays overall. To prevent a bias due to storage, only eggs received within a week by retailers were sampled, specifically eggs not more than three days old after supplied by farms. At the laboratory, ten eggs were randomly selected from each tray per price category per retailer using the Table of Random Numbers according to Steele and Torrie (1980). Therefore, a total of 30 eggs were selected for evaluation per retailer to make 90 eggs overall on which measurements were obtained. Data on egg traits were collected the same day.

### Data collection

Egg length and width were measured with a *Vernier calliper* to the nearest 0.01 mm. The eggs were weighed

individually, as well as shell, albumen, and yolk, using a digital scale (Model PR224/E, Ohaus Corporation, USA) with an accuracy of 0.0001 g. The combined albumen and yolk weights was determined after the eggshell was carefully broken, contents poured onto a clean glass plate, and before weighing in a Petri dish, albumen, and yolk width and height were measured using a *Vernier calliper*. These measurements, taken at an average ambient temperature of 29.5°C, were used to calculate some external and internal traits of eggs. External traits were, shape index (SI), shell ratio (SR) or percentage shell, and egg weight. Internal traits comprised albumen and yolk indices (AI and YI), Haugh unit (HU), and proportion of albumen and yolk weight to egg weight (AY/E).

Shape index (%) was determined from egg width (W) and length (L) according to Rayan *et al.*, (2010) as:

$$SI = (W/L) \times 100.$$

Shell quality was measured as shell ratio (SR) from shell weight (SW) and egg weight (EW) as:

SR = (SW/EW) x 100 (Niraj *et al.*, 2014); to remove bias that may occur due to differing egg sizes (Brandao *et al.*, 2014).

Albumen index was determined from albumen height (AH, mm) and width (AW, mm) as:

$$AI = AH/AW \text{ (Hasan and Aylin, 2009)}$$

Yolk index was determined from albumen length (YH, mm) and width (YW, mm) as:

$$YI = YH/YW \text{ (Oluyemi and Roberts, 2000)}$$

Haugh unit score was determined from albumen height (H) and egg weight (g) as:

$$HU = 100 \log (H + 7.6 - 1.7W^{0.37}) \text{ (Monira et al., 2003)}$$

AY/E = Albumen and Yolk weight/Egg weight (Niraj *et al.*, 2014), which gives egg contents per unit egg weight.

### **Statistical analysis**

The experiment was set up to compare selected external and internal quality traits of eggs among three retailers and according to different price categories. Therefore, the experiment was in a 3 x 3 factorial design arrangement for three retailers (MM, SM, and AM) and three price levels (Low, Medium, and High). Data collected were subjected to the factorial Analysis of Variance (ANOVA) using SAS (2002) software at the significance level of 0.05. Significant differences

between means were separated using Duncan's multiple range test of the same software.

### **Results and Discussion**

Table 1 shows the overall factorial relationship between the retailer, price, corresponding egg quality, and their interaction. Table 2 further clarifies these relationships. Considering the external egg quality traits, price did not significantly ( $p > 0.05$ ) affect the shape index (SI) and shell ratio (SR) indicating that customers obtained the same value for both traits regardless of price paid. This was not so for egg weight (EW) where expectedly, price paid was highly significantly ( $p < .0001$ ) influenced by the weight of the egg and the heaviest egg attracted the highest price (Tables 1 and 2). Hilmi (2019) reported this practice by retailers that eggs are valued for size in developing countries, and specifically in Nigeria (Chukwuka *et al.*, 2011). However, in standard practice, eggs are graded for internal quality first, before being sorted by weight, meaning that, weight is not the determinant for grade or internal quality (Hilmi, 2019; USDA, 2023). Further assessment of the effect of price regarding whether consumers obtain commensurate value for internal egg quality from the price paid for eggs (Table 2), showed that eggs sold at different prices were of the same value in YI and AY/E, but not for AI ( $p < 0.0320$ ), and HU ( $p < 0.0201$ ), which are the typical indicators of internal egg quality. In fact, AI correlates positively and significantly to HU (Oluyemi and Roberts, 2000; Sarica and Erensayin, 2009), which is the universal standard for albumen quality, and by extension, one of the most important factors for evaluating internal egg quality (Stadelman and Cotterill, 1995; USDA, 2023; Rajaravindra *et al.*, 2013). In Table 2, low-priced eggs were higher ( $p < 0.0320$ ) in AI than medium-priced eggs, but similar ( $p > 0.05$ ) to eggs sold at high price, which were, in turn, of the same value ( $p > 0.05$ ) as medium-priced eggs. A similar pattern was observed for HU, except that for this, eggs sold at low price were higher ( $p < 0.0201$ ) in value than high-priced eggs, but similar ( $p > 0.05$ ) to eggs sold at medium price, which were, in turn, of the same value ( $p > 0.05$ ) as high-priced eggs. Furthermore, since the high price category with the heaviest eggs ( $p < .0001$ ) did not have the best internal egg quality, in terms of HU, but the low price category with the smallest eggs, it can be inferred that the price paid by consumers is not commensurate with the egg quality obtained. This seemingly indicates that eggs with better quality than obtainable at the highest price are sold at the cheapest price, thereby reinforcing the observation that egg size does not determine the value of internal egg quality (Hilmi, 2019; USDA, 2023).

**Table 1: Combined effects of retailers and price on egg quality traits**

Traits	Retailer (R)			SM			AM			SEM	P value			
	Price (P)	Low	Medium	High	Low	Medium	High	Low	Medium		High	P	R	R x P
SI, %		73.38	75.85	75.01	76.81	80.13	77.53	76.60	72.53	77.64	0.447	NS	**	**
SR		0.11	0.12	0.12	0.12	0.13	0.12	0.13	0.12	0.12	0.001	NS	NS	NS
AI		14.58	13.18	13.15	16.58	15.66	15.05	15.17	13.45	17.16	0.251	*	***	**
YI		33.92	33.92	36.35	38.80	48.52	39.90	39.97	37.77	45.06	0.795	NS	***	**
HU		102.47	98.03	91.83	104.21	104.25	99.21	107.37	102.19	109.33	0.824	*	***	***
AY/E, %		85.29	89.14	85.60	86.30	86.57	87.57	86.28	87.17	86.74	0.302	NS	NS	NS
EW, g		53.70	61.20	70.50	53.90	61.90	66.70	56.90	62.40	67.60	0.671	***	NS	**

P Value: \*, \*\* and \*\*\* for  $P < 0.05$ ,  $P < 0.01$  and  $P < 0.001$ , respectively. SEM = Standard error of the mean. NS = Not significant ( $P > 0.05$ )  
 MM= Maintenance market; SM= Sabo market; AM= Akarabata market; Low price = ₦ 900/tray; Medium = ₦ 1000/tray; High = ₦ 1,200/tray; \$1 = ₦ 360; SI= Shape index; SR= Shell ratio; AI= Albumen index; YI= Yolk index; HU= Haugh unit; AY/E= Albumen and Yolk weight to Egg weight ratio; EW= Egg weight.

**Table 2: Main effects of retailers, price, and interaction on egg quality traits**

Parameters	Retailer (R)			Price (P)			SEM	P Value		
	MM	SM	AM	LOW	MEDIUM	HIGH		P	R	R X P
SI, %	74.80 <sup>b</sup>	78.16 <sup>a</sup>	75.58 <sup>b</sup>	75.60	76.17	76.73	0.4467	0.5171	0.0023	0.0071
SR	0.115	0.120	0.120	0.117	0.120	0.118	0.0011	0.5258	0.0662	0.0620
AI	13.64 <sup>b</sup>	15.76 <sup>a</sup>	15.26 <sup>a</sup>	15.44 <sup>a</sup>	14.10 <sup>b</sup>	15.12 <sup>ab</sup>	0.2506	0.0320	0.0003	0.0061
YI	34.73 <sup>b</sup>	42.41 <sup>a</sup>	40.93 <sup>a</sup>	37.56	40.07	40.44	0.7954	0.1615	<.0001	0.0019
HU	97.45 <sup>c</sup>	102.60 <sup>b</sup>	106.30 <sup>a</sup>	104.68 <sup>a</sup>	101.50 <sup>ab</sup>	100.13 <sup>b</sup>	0.8239	0.0201	<.0001	0.0035
AY/E, %	86.68	86.73	86.81	83.96	87.63	86.64	0.3016	0.0697	0.9816	0.1110
EW, g	61.80	60.83	62.30	54.83 <sup>c</sup>	61.83 <sup>b</sup>	68.27 <sup>a</sup>	0.6710	<.0001	0.1708	0.0179
Tray price (₦)/EW				16.41	16.17	17.50				

<sup>abc</sup> Means with different superscripts are significantly different at  $p < 0.05$ . SEM = Standard error of the mean.  
 MM= Maintenance market; SM= Sabo market; AM= Akarabata market; Low price = ₦ 900/30 eggs/tray; Medium = ₦ 1000/tray; High = ₦ 1,200/tray; \$1 = ₦ 360; SI= Shape index; SR= Shell ratio; AI= Albumen index; YI= Yolk index; HU= Haugh unit; AY/E= Albumen and Yolk to Egg weight ratio; EW= Egg weight.

**Table 3: Differences between retailers at respective egg prices for egg quality traits**

Traits Price	Retailer			SEM	P Value
	MM	SM	AM		
<i>SI, %</i>					
Low	73.38	76.81	76.60	0.689	0.0701
Medium	75.85 <sup>b</sup>	80.13 <sup>a</sup>	72.53 <sup>b</sup>	1.003	0.0043
High	75.01	77.53	77.64	0.577	0.1068
<i>AI</i>					
Low	14.58	16.58	15.17	0.365	0.0662
Medium	13.18 <sup>b</sup>	15.66 <sup>a</sup>	13.45 <sup>b</sup>	0.344	0.0025
High	13.15 <sup>b</sup>	15.05 <sup>ab</sup>	17.16 <sup>a</sup>	0.540	0.0059
<i>YI</i>					
Low	33.92	38.80	39.97	1.320	0.1394
Medium	33.92 <sup>b</sup>	48.52 <sup>a</sup>	37.77 <sup>b</sup>	1.599	<.0001
High	36.35 <sup>b</sup>	39.90 <sup>b</sup>	45.06 <sup>a</sup>	1.164	0.0050
<i>HU</i>					
Low	102.47	104.21	107.37	1.218	0.2581
Medium	98.03 <sup>b</sup>	104.25 <sup>a</sup>	102.19 <sup>a</sup>	0.884	0.0089
High	91.83 <sup>c</sup>	99.21 <sup>b</sup>	109.33 <sup>a</sup>	1.898	0.0001
<i>EW</i>					
Low	53.70	53.90	56.90	0.591	0.4060
Medium	61.20	61.90	62.40	0.581	0.7134
High	70.50 <sup>a</sup>	66.70 <sup>b</sup>	67.60 <sup>b</sup>	0.587	0.0162

<sup>abc</sup>Means on rows with different superscripts are significantly different at  $p < 0.05$ . SEM = Standard error of the mean.

SI= Shape index; AI= Albumen index; YI= Yolk Index; HU=Haugh Unit; EW= Egg Weight; MM= Maintenance market; SM=Sabo market; AM=Akarabata; Low price = ₦ 900/tray; Medium = ₦ 1000/tray; High = ₦ 1,200/tray; \$1 = ₦ 360.

However, since the unit egg contents (AY/E) was the same for all price and egg weight categories (Table 2), a consideration of the price per unit weight of eggs should yield the most economical price category per egg quality. Price per unit weight or contents of eggs for different prices (Table 2), gives ₦ 16.41, ₦ 16.17, and ₦ 17.50 for low- (54.83 g), medium- (61.83 g), and high-priced eggs (68.27 g), respectively. It can be opined, therefore, that the medium-priced eggs were the most economical price category for egg quality because they were the cheapest in price per quality, as they were significantly heavier than low-priced eggs, but not significantly different in the key internal egg quality standard of HU. Therefore, it can be inferred that medium-priced eggs gave the most commensurate egg quality value for price.

Consideration of retailers, from the perspective of whether there are differences in the quality of eggs sold at the same price by them, shows, in the first instance, that there were significant differences ( $p < 0.01$ ) in SI (Tables 1 and 2), as well as the price at which differences occurred (Table 3). Table 2 shows that retailer SM sold eggs with the highest SI ( $p < 0.01$ ) overall, and that most of such eggs were sold at medium price ( $p < 0.01$ ) as indicated in Table 3. Shape index classification for eggs are namely, sharp (long) egg (SI < 72), normal (standard) egg (SI = 72–76) or round egg (SI > 76) (Duman *et al.*, 2016). Rajaravindra *et al.* (2013) indicated that uniformity of eggs increases as SI increases, implying, SM sold significantly more uniform and rounder eggs, at medium price, than MM or AM, who sold more normal shaped eggs (78.16 vs. 74.8 or 75.58, respectively; Table 2). SI has been found, in some studies, to be significantly and positively correlated with AI (Alkan *et al.*, 2013), YI (Begli *et al.*, 2010; Sarica *et al.*, 2012), and HU (Duman *et al.*, 2016), probably indicating that eggs sold by SM at medium price may have higher value than those by MM or AM, and this can actually be observed in Table 3. Highly significant differences also occurred between retailers and corresponding price with regard to internal egg quality traits of AI ( $p < 0.001$ ), YI and HU ( $p < 0.0001$ ) but not egg contents per unit egg weight (AY/E) ( $p > 0.05$ ) (Table 2). It can be observed that SM had the highest value for AI ( $p < 0.0003$ ), and YI ( $p < 0.0001$ ), but not significantly different from AM, and MM the least. This probably further suggests that SM sold egg with quality superior to the other retailers. Nevertheless, AM was superior ( $p < 0.0001$ ) in HU, followed by SM and MM, in that order (Table 2).

Examination of egg prices at which the differences occurred between retailers, in Table 3, shows that SM

was superior to others, at medium price, in AI ( $p < 0.0025$ ), and YI ( $p < 0.0001$ ) but similar to AM, and both superior to MM ( $p < 0.0089$ ) in HU at the same price. It can thus be inferred that SM sold eggs with best value at medium price. At high price, AM sold eggs with the best value because of superiority in YI ( $p < 0.005$ ) and HU ( $P < 0.0001$ ) only, but was similar ( $p > 0.05$ ) to SM for AI, for which MM was inferior ( $p < 0.0059$ ) to both. However, MM was superior ( $p < 0.0162$ ) to SM and AM, only in egg weight at high price. There was no significant difference ( $p > 0.05$ ) in egg quality among retailers for eggs sold at low price. These results indicated that the egg retailers do not sell the same quality of eggs at the same price at medium and high prices. These differences could be due to the different sources or farms where the eggs were obtained from, probably based on feeding and management practices, different handling procedures or storage methods practised by the farms and each retailer.

### Conclusion

The results of this study showed that the amount of money that consumers pay is not commensurate with the quality of eggs bought in trays of 30 eggs each, from some major egg retailers in Ile-Ife, Osun State, Nigeria. The eggs sold at medium price seem to offer the best value for money. In addition, there were differences between the egg retailers in the quality of eggs sold in trays at the same price. It was recommended that further studies may be needed to develop simple and reliable methods locally, for proper grading of eggs based on internal quality.

### References

- Abanikannda, O. T. F. and Leigh, A. O. 2012.** Grading of table eggs as a marketing strategy for smallholder Nigerian farmers. *International Journal of Livestock Production*. 3: 43-46
- Begli, H. E., Zerehdaran, S., Hassani, S., Abbasi M. A. and Khan Ahmadi A. R. 2010.** Heritability, genetic and phenotypic correlations of egg quality traits in Iranian native fowl. *British Poultry Science* 51: 740-744.
- Brandão, M., Santos, F., Machado, L., Verinaud, M., Oliveira, J., Soares, N., Nascimento, E. and Pereira, V. 2014.** The effect of eggshell apex abnormalities on table egg quality during storage in 2 seasons of the year. *Poultry Science* 93 (10) 2657-2662.
- Chukwuka, O. K., Okoli, I. C., Okuedo, N. J., Udebibie, A. B. I., Ogbuewu, I. P., Aladi, N. O., Iheshiulor, O. O. M. and Omede, A. A. 2011.** Egg quality defects in poultry management and food

- safety. *Asian Journal of Agricultural Research*, 5(1): 1-16
- Duman, M., Şekeroğlu, A., Yıldırım, A., Eleroğlu, H. and Camcı, Ö. 2016.** Relation between egg shape index and egg quality characteristics. *European Poultry Science* 80: 1-9
- Hasan, A. and Aylin, A. O. 2009.** Effect of Storage Time, Temperature and Hen Age on Egg Quality in Free-Range Layer Hens. *Journal of Animal and Veterinary Advances*, 8(10): 1953-1958.
- Hilmi, M. 2019.** Egg Marketing - A Guide for the Production and Sale of Eggs. Chapter 2 - Marketing quality eggs. *Hilmi agricultural services bulletin* 150 Rome ISSN 1010-1365  
<http://www.Hilmi.org/3/Y4628E/y4628e04.htm#bm04>
- Ihsan, T. T. 2012.** Effects of storage temperature and length on egg quality parameters of laying hen. *Journal of Animal Scientist*, 1(2):32-36.  
[http://ijscience.com/Journal\\_of\\_Animal\\_Scientist/pdf-files/Issue-2/32-36.pdf](http://ijscience.com/Journal_of_Animal_Scientist/pdf-files/Issue-2/32-36.pdf)
- Jin, Y. H., Lee, K. T., Lee, W. I. and Han, Y. K. 2011.** Effects of storage temperature and time on the quality parameters of eggs from laying hens at peak production. *Asian-Australasian Journal of Animal Sciences*. 24(2): 279-284.  
DOI: <https://doi.org/10.5713/ajas.2011.10210>
- López, E. S., Serrano, A. B., Saavedra F. F, Linares, C. P. and Cervantes, L. J. 2016.** Temperature and shelving period effect on albumin height and color of supermarket eggs sold in north-west Mexico. *Acta Universitaria*, 26 (4), 12-18. doi: 10.15174/au.2016.909
- Monira, K. N., Salahuddin, M. and Miah, G. 2003.** Effect of breed and holding period on egg quality characteristics of chicken. *International Journal of Poultry Science* 2: 261-263.  
DOI:10.3923/ijps.2003.261.263
- Niraj, K., Zinabu, N. B., Yohanes, T. A. and Etsay, K. 2014.** Evaluation of egg quality traits of Rhode Island Red and Bovans white under intensive management in Mekelle Ethiopia. *IOSR Journal of Agriculture and Veterinary Science* 7:71-75. <http://www.iosrjournals.org/iosr-javs/papers/vol7-issue2/Version-2/K07227175.pdf>
- Okeudo, N. J., Onwuchekwa, C. I. and Okoli, I. C. 2003.** Effect of oil treatment and length of storage on the internal quality, organoleptic attributes and microbial profile of chicken eggs. *Tropical Animal Production Investigations* 6:63-70.
- Oluyemi, J. A., and Roberts, F.A. 2000.** *Poultry Production in Warm Wet Climates*. Page 158-160.
- Published by Spectrum Books Limited, Spectrum House Ibadan, Nigeria.
- Rajaravindra, K. S., Rajkumar, U., Rekha, K., Niranjan, M., Reddy, B. L. N. and Chatterjee, R. N. 2013.** Evaluation of egg quality traits in a synthetic coloured broiler female line. *Journal of Applied Animal Research*. 43: 10-14.
- Rayan, G. N., Galal, A., Fathi, M. M. and El-Attar, A. H. 2010.** Impact of Layer Breeder Flock Age and Strain on Mechanical and Ultrastructural Properties of Eggshell in Chicken. *International Journal of Poultry Science* 9:139-147.  
DOI: 10.3923/ijps.2010.139.147
- Sarica, M. and Erensayin C. 2009.** Poultry Products. In: M. Turkoglu, M. Sarica (Eds.), *Poultry Science*, Bey-Ofset, Ankara, Turkey. pp. 89-138.
- Sarica, M., Onder, H. and Yamak, U. S. 2012.** Determining the most effective variables for egg quality traits of five hen genotypes. *International Journal of Agriculture and Biology* 14:235-240.
- SAS. 2002.** The SAS system for Windows. Version 9.0. SAS Institute Inc. Cary, NC, USA
- Stadelman, W. J. and Cotterill, O. J. 1995.** *Egg Science and Technology*. 4th Edition. Food Products Press. New York. pp. 29-40.
- Steel, R. G. D. and Torrie, J. H. 1980.** *Principles and procedures of statistics*. A biometrical approach, 2nd Edition, McGraw-Hill Book Company, New York.
- Travel, A., Nys, Y. and Lopes, E. 2010.** Productivity and environmental factors affecting egg quality. *INRA Productions Animales* 23:155-166.
- USDA. 2023.** United States Department of Agriculture. Agriculture Marketing Service. *Egg-Grading Manual*. U.S. Standards, Grades, and Weight Classes for Shell Eggs. Section VI : 27-30.  
<https://www.ams.usda.gov/grades-standards/shell-egg-grades-and-standards>

Date received: 27th April, 2022

Date accepted: 7<sup>th</sup> April, 2023