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Comparative study of physical egg quality characteristics of Naked neck and Bovans chicken in diverse ages in coastal areas of Ampara district

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***Abstract*—**The chicken egg is a high-quality protein food widely consumed all over the world. Consumer acceptance is a determining factor of egg quality with respect to cleanliness, freshness, egg weight, shell quality, yolk index, albumen index, Haugh unit and chemical composition. The present study investigated the physical quality characteristics of eggs of Naked neck (village) and Bovans (commercial) chicken breeds in coastal areas of Ampara district. A total of 60 eggs, 30 from each breed were purchased for analysis. The eggs were stored at room temperature during analysis. The egg weight, egg length, egg width, shape index, shell weight, shell thickness, albumen pH, albumen height, Haugh unit, yolk height, yolk length, yolk width, yolk index and yolk color were determined. The study revealed that the egg weight, shell width, shell weight, shell thickness and yolk color were significantly different ($p<0.01$) between the eggs of Naked neck and Bovans breeds whereas egg length, shape index, albumin pH, albumen height, Haugh unit, yolk height, yolk length, yolk width and yolk index were not significantly different ($p<0.05$). The mean egg weight of Naked neck chicken was lower than Bovans chicken's eggs. The shell strength of Bovans chicken eggs is better than Naked neck chicken eggs. From the findings of the study, it is concluded that several physical external quality characteristics investigated are found to be at a higher level in Bovans chicken eggs than in Naked neck chicken eggs.

***Keywords*—**Egg quality characteristics, village chicken, commercial chicken, consumer preference

I. Introduction

Poultry plays an important role in supplying animal protein and socio-economic development in Sri Lanka, and the poultry industry is a well-established one when compared to the other animal farming sectors. Both poultry rearing systems i.e., traditional (backyard) and commercial (intensive) are widely practiced in Sri Lanka. The traditional poultry farming system contributes 15% to the national egg production and very low to meat production while commercial poultry contributes 85% - 100% to meat and egg production (Atapattu *et al*., 2016). It was reported that Sri Lankan per capita egg consumption was 120.2 in 2019 (Anon, 2019).

The foodstuff quality is an important concern for consumers and the demand for high-quality meals rises in tandem with the rise in living standards and the availability of information. This evolution is mirrored in the production of eggs for human use (Ledvinka *et al*. 2012). According to Pettersson *et al*. (2016), consumers purchase free-range eggs because they feel the chickens are "happier" and "healthier," and they believe the eggs taste better. Further, they found that free-range conditions contribute to hen welfare. Mufeeth and Thariq, (2019) found that there is a potential market for value-added native chicken products in rural and urban areas since consumers have a strong desire to add value to native chicken meat and eggs in Sri Lanka. And local chicken has distinctive adaptation traits that make it more likely than alien varieties to adapt to the local environment (Dogara *et al*., 2021). According to Abadi, (2017) from a farmer of point of view, producing exotic poultry has several advantages over domestic poultry, including a higher capacity of egg production, faster bird growth, and a better selling price for exotic chicken eggs.

It is essential to provide high-quality eggs and egg products for the egg industry to be economically viable over time. According to Rath *et al*., (2015), consumer acceptability of egg quality is governed by cleanliness, freshness, surface area, mass, volume, and coefficient of packing, as well as egg weight, shell quality, yolk index, albumen index, Haugh unit, and chemical composition. Chambers *et al*., (2017) proposed the term "egg quality" refers to a collection of characteristics that determine the use of eggs as food. As a result, egg quality can be separated into two categories: external and internal quality. External quality refers to the shell, albumin, and yolk (Kul and Seker, 2004). And also, external aspects such as cleanliness, freshness, egg weight, and shell quality are essential in terms of customer acceptability of shelled eggs (Sonaiya and Swan, 2004).

Our preliminary field assessment indicated that there is a higher level of consumer preference for village chicken eggs thus a higher market price for village chicken eggs compared to the commercial layer eggs. However, it is important to investigate the quality characteristics of locally available village chicken eggs compared to commercial layer eggs, which will be useful for consumers to base their egg purchasing behavior on a scientific principle. A previous study by Wijedasa *et al*. (2020) in Sri Lanka compared the egg quality characteristics i.e. Haugh unit, York Index, York Color, Shape Index, Shell Thickness and Egg Weight of Shaver brown and village chicken, likewise, a study by Elango and Mahendrarasa (2013) In Sri Lanka investigated egg quality characteristics of village chicken, naked neck chicken, exotic chicken and exotic local chicken in Sri Lanka. Jayasena *et al*. (2012) evaluated the traits of chicken eggs in the wholesale market in Sri Lanka. In the previous studies in Sri Lanka, the breeds of village chicken were not specified even though egg quality traits are influenced by both genetics and environmental factors (Mori *et al*., 2020). Hence, this study aimed to investigate the egg quality characteristics of the Naked neck chicken, a village chicken, and Bovans breed, a commercial breed, both are widely reared in the coastal areas of Ampara district.

II. Materials and Method

A. Egg Sample Collection

The Naked neck chicken's eggs were collected from the villages of Oluvil and Kalmunai in the Ampara district where backyard poultry rearing is practiced. The Bovans chicken eggs were collected from the commercial layer farms in Nintavur and Kalmunai in the same district. Thirty eggs (30) from Naked neck chickens of diverse ages and thirty eggs (30) from Bovans breed were purchased and the eggs were one day old. The eggs were brought to the laboratory at the Department of Biosystems Technology and stored at room temperature. For all the egg samples, egg quality parameters i.e. egg weight, specific gravity, shell weight, shell thickness, shape index, albumen pH, Haugh unit, yolk index and yolk color were obtained as follows.

The egg weight was obtained by a top-loading electronic digital balance (Nordstrom and Ousterhout, 1982). To get the eggshell weight, the contents of the eggs were removed, cleaned with the cotton tissue and then dried. Finally, the dried shell was weighed with a top-loading electronic digital balance.

The shell thickness was measured by the Vernier caliper (Klaas *et al*., 1974). Average readings were taken having the readings obtained in three different places of the eggshell. The egg length (L) and width (W) were measured with a Vernier caliper to the nearest 0.01 mm for shape index (SI) calculations and it was determined according to the following formula (Duman *et al*., 2016).

$$Shape\ Index = \frac{Egg\ weight}{Egg\ length} \times 100 \qquad (1)$$

For the albumen pH measurements, the egg albumen was manually separated into a beaker and used for the readings. A digital pH meter was used to measure the albumen pH at 25°C (Silversides and Budgell, 2004a). Albumen quality is determined by the Haugh unit and is an important parameter for egg quality analysis by the following equation (Eisen *et al*., 1962),

$$HU = 100 \times log(h + 7.6 - 1.7w^{0.37}) \qquad (2)$$

Where, HU = Haugh unit, h = observed height of the albumen in millimeters, and w = weight of egg in grams. The yolk index is calculated by dividing the albumen height by the diameter (Omri *et al*., 2019) and the formula used for the calculation is as follows;

$$Yolk\ Index = \frac{(H \times 2)}{D1 + D2} \qquad (3)$$

Whereas, H = Yolk height, D1 and D2 = Yolk diameters

The yolk color fan was used to measure the color of the egg yolk (Vuilleumier, 1969).

B. Data Analysis

The data were analyzed using SPSS version 16 and the mean, maximum, minimum and standard deviation were obtained with descriptive analysis. Means of egg quality characteristics of Naked neck and Bovans eggs were separated with an independent t-test at a $p<0.05$ significance level.

III. Results and Discussion

The study showed a significant difference ($p<0.05$) between the mean egg weights in Naked neck and Bovans chicken eggs. A higher level of mean egg weight (50.00 ±0.94g) was observed from Bovans breed where the egg weight varied from a minimum of 40g to a maximum of 60g (Table 1 & Table II). However, Wijedasa *et al*. (2020) found that the mean egg weight of commercially grown chicken (Shaver brown) was 57.83g which is higher compared to the present study. According to Monira *et al*. (2003), egg weight varies between breeds of commercially grown layers. The egg weight may vary depending on the age of the breeds (Dudusola *et al*., 2020; Wijedasa *et al*., 2020). Ismail *et al*. (2015) obtained a mean egg weight of more than 60g per egg for Bovans white layer breed under high-nutrient-density diets from 44 to 56 weeks of age. According to Wu *et al*. (2005), the overall mean egg weight for Bovans white was 60.80g per egg for ages 21 to 36 weeks and with the increase of age, egg weight increased. The results of the present study showed that the mean egg weight of Bovans chicken was the lowest compared to the previous investigations. According to Wu *et al*. (2005), the correct energy/lysine ratio increases the egg weight thus the imbalanced feed used by local poultry farmers may be the reason for the lowest mean egg weight obtained for Bovans layers at a local level in the present study. In the present study, the mean egg weight obtained for Naked neck hens was 45.87 ±0.81g. Elango and Mahendrarasa (2013) obtained an almost similar mean egg weight

(43.43±1.9g) for Naked neck eggs. However, the mean egg weight obtained in the present study was significantly lower compared to the value obtained by Wijedasa *et al*. (2020) which is 54.44±3.70g for Sri Lankan village chicken. The differences in the egg weight of Naked neck chicken in the present study compared to previous studies may be due to differences in breed, age and body weight of hens (Monira *et al*., 2003; Wu *et al*., 2005; Wijedasa *et al*., 2020). In the backyard chicken farming system at the household level, age records are not maintained. According to Jayasena *et al*. (2012) extra-large and large eggs are prominent in the wholesale egg market in Sri Lanka with a mean weight of 65.24 ± 4.65g and 57.03 ± 1.96g respectively indicating the bigger demand for larger size eggs in marketing. In the present study, eggs from both Naked neck and Bovans chickens were lower in weight.

The Haugh unit (HU) is an indication of albumen quality and the other freshness values of eggs (Eisen *et al*., 1962; Moula *et al*., 2013). Higher values of the HU indicate the freshness of eggs (Menezes *et al*., 2012). In the present study, Naked neck chicken eggs were found with higher mean Haugh units of 82.48 ±1.16 than Bovans' eggs which is with a mean value of 79.87 ±0.91 (Table 1 & Table II), however, the difference was not significant ($p<0.05$). According to Wijedasa *et al*. (2020), the HU value of a freshly laid egg ranges from 72-110 and the HU value of a fresh egg is 79 (Eke *et al*., 2013). The HU value of Naked neck chicken eggs ranges from 75.14 to 96.30 indicating that they are within the range of freshness whereas for Bovans chicken eggs it varies from 67.52 to 88.48 (Table 1) which may indicate the Naked neck chickens' eggs were better in freshness

The shape index for Naked chicken eggs varied from 61.28 to 98.10 with a mean of 77.16 ±1.27 whereas it varied from 71.64 to 80.95 for Bovans chickens' eggs with a mean of 77.11 ±0.43 (Table 1). However, the difference in shape index between the two breed's eggs was not significant ($p<0.05$). Eggs are classified based on shape index (SI) namely as sharp egg (SI < 72), normal (standard) egg (SI = 72–76), or round egg (SI > 76) (Sarica and Erensayin, 2009). The results show that the eggs from Bovans were under the normal (standard) class whereas the eggs from Naked neck chickens were diverse in shape though the mean value is within the range of the normal class. According to Wijedasa *et al*. (2020), the shape index of village chicken eggs was 74% based on their study of Sri Lankan village chickens whereas Elango and Mahendrarasa (2013) obtained a relatively low shape index value of 67.21% for Sri Lankan village chicken eggs. The diverse shape of eggs in Naked neck chickens in the present study may be due to the genetic basis of the birds, the age of the bird, the season of the bird rearing and the bird's diet (Nikolova and Kocevski, 2006). Duman *et al*. (2016) found significant correlations between egg shape index and egg weight, specific gravity, egg surface area, albumen index and Haugh unit. Further, Duman *et al*. (2016) concluded that the shape index affects certain egg quality characteristics, hence, it is important to use it in future breeding programs. If the SI values are higher, a force for the rupturing of the egg is needed in higher amounts under low compression speeds (Altuntaş and Şekeroğlu, 2008). The results indicate that the eggs of Bovans chickens were in better shape from standard to normal compared to Naked neck chicken eggs.

The yolk color of Naked neck chickens' eggs was significantly different ($p<0.01$) compared to the York color of Bovans chicken eggs (Table 1 and Table II) and the York color value ranged from 5 to 11 with the mean of 8.53 ±0.29 for Naked chickens' eggs whereas it ranged from 1 to 5 with the mean of 3.63 ±0.27 for Bovans' eggs. The results in the present study are in agreement with the findings of Wijedasa *et al*. (2020) in which the yolk color was 7.30±0.02 for domestic chicken eggs. According to Desalew *et al*. (2015) eggs from the chicken of the village production system have egg yolk with deep yellow color compared to the eggs from the intensive poultry farming system. According to Wijedasa *et al*. (2020), domestic hens under a backyard farming system could obtain enough plant pigments (Xanthophyll, Carotenoids, and Cryptoxanthin, etc.) causing increased yolk color. Yolk color is the most important parameter determining the demand for an egg. The dark orange color of local egg yolks, due to the intake of green grass, has higher functional values in the hotel industry than the pale color of egg yolks. Thus the eggs from Naked neck chickens may be found with better market value compared to Bovans' eggs.

The mean eggshell thickness was significantly different between Naked neck chicken and Bovans breed ($p<0.050$) whereas the highest mean shell thickness of 0.34mm was found with Bovans chicken eggs (Table II). According to Kumar *et al*. (2014), eggshell thickness of Bovans white egg was 0.39±0.03mm which is a little higher than the values obtained in the present study for Bovans and Naked neck chicken eggs. Sun *et al*. (2019) obtained an eggshell thickness of 0.343 ± 0.024 mm for the White Leghorn layer, almost similar to the values obtained in the present study for both types of chicken. However, Wijedasa *et al*. (2020) found that eggshell thickness of a village chicken egg was 0.09±0.01mm which is much lower than values obtained in the present and previous studies and also this mean value seems to be unrealistic. Ketta and Tůmová (2018), concluded that when an eggshell becomes thicker, eggshell strength increases. Hence, eggshell thickness is an important quality parameter in handling eggs with no or minimal damage since it has a positive correlation with breaking strength (Sun *et al*., 2012). Further, Sun *et al*. (2012) found that the mean eggshell thicknesses with membrane were 0.369 ± 0.021mm and without membrane, it was 0.356 ± 0.022 mm. The present study may indicate that the eggshell thickness of both Naked Neck hens and Bovans is almost similar to the average shell thickness.

According to Table 1, the mean yolk index value was 0.36 ±0.01 in both Naked neck and Bovans chicken. Yakubu *et al*. (2008) found that the mean yolk index value of the Naked neck chicken in Nigeria was 50.60. According to Rath *et al*. (2015), the yolk index for White Leghorn was 40.24±0.10.

Table I: Egg quality parameters of domestic and commercial breeds

Egg Quality Parameters	Naked neck (Village) Breed			Bovans (Commercial) Breeds		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
External Parameters						
Weight (g)	45.87 ±0.81	38	57	50.00 ±0.94	40	60
Egg length (mm)	51.81 ±0.75	41.08	63.18	53.08 ±0.35	49.56	56.68
Egg width (mm)	39.75 ±0.26	36.96	42.62	40.90 ±0.22	38.36	43.10
Shape Index	77.16 ±1.27	61.28	98.10	77.11 ±0.43	71.64	80.95
Shell weight (g)	4.74 ±0.17	3.37	6.74	5.42 ±0.15	4.02	7.14
Shell thickness (mm)	0.30 ±0.01	0.22	0.39	0.34 ±0.01	0.30	0.39
Internal Parameters						
Albumin pH	8.77 ±0.03	8.22	9.05	8.72 ±0.03	8.42	9.02
Albumin height (mm)	6.13 ±0.19	4.70	8.42	5.95 ±0.12	4.82	7.30
Hough Unit	82.48 ±1.16	75.14	96.30	79.87 ±0.91	67.52	88.48
Yolk height (mm)	14.07 ±0.42	7.28	17.40	13.88 ±0.41	10.24	16.62
Yolk length (mm)	39.92 ±0.41	36.40	45.16	38.94 ±0.33	35.78	44.46
Yolk width (mm)	38.70 ±0.37	35.30	43.40	38.05 ±0.28	34.28	40.70
Yolk Index	0.36 ±0.01	0.19	0.47	0.36 ±0.01	0.26	0.45
Yolk Color	8.53 ±0.29	5	11	3.63 ±0.27	1	5

The data were given as Means ± Standard Deviation (SD) of 30 samples.

Table II: Independent Samples Test for egg quality parameters

Variables	T value	P value
Weight in the air (g)	-3.33	0.002
Egg Length (mm)	-1.52	0.134
Egg Width (mm)	-3.36	0.001
Shape Index	0.03	0.974
Shell Weight (g)	-2.98	0.004
Shell Thickness (mm)	-4.36	0.000
Albumin pH	1.23	0.225
Albumin Height (mm)	0.81	0.420
Hough Unit	1.77	0.082
Yolk Height (mm)	0.33	0.746
Yolk Length (mm)	1.86	0.068
Yolk Width (mm)	1.45	0.153
Yolk Index	-0.24	0.812
Yolk Color	12.19	0.000

Means with P <0.05 are significantly different.

Duman *et al*. (2016) found that yolk index values of ATAK-S strain of laying hens at the age of 33 weeks old were 43.5, 44.0 and 43.1 for standard, sharp and round eggs respectively and the values were not significant between different shapes of eggs. The yolk index in the present study for eggs from both breeds was comparatively lower when compared to the previous studies. However, Rajkumar *et al*. (2009) found that the yolk index value was 37.74 in Naked neck chicken eggs in India which is almost similar to the yolk index value obtained in the present study, further they found that the yolk index value decreased with age. Yakubu *et al*. (2009) found that the yolk index was not significantly different between Naked neck and normal feathered chicken eggs whereas Rajkumar *et al*. (2009) found that the yolk index was significantly different between Naked neck and normal feathered chicken eggs in their study carried out in India. The findings by Yakubu *et al*. (2009) and Rajkumar *et al*. (2009) and in the present study with regard to the breed effects on yolk index may indicate that the non-genetic factors i.e. the nutrition, environment, storage conditions, stress level, behavioral activities of hens and age affect the yolk index values. In general, the limitation of the present study is a non-specification of the age of breeds and a smaller sample size. However, the findings of this study are significant with regard to the breeds specified in this study under local conditions. It is suggested that a controlled experiment may be undertaken to investigate the genetic effects of chicken breeds on egg quality characteristics.

IV. Conclusion and Recommendation

The study found that egg weight, egg width, shell weight, shell thickness and the yolk color between the Naked neck chicken eggs and Bovans eggs were significantly different. The mean weight of Naked neck and Bovans chicken eggs was found to be lower compared to the eggs normally found in wholesale market. Bovans chicken eggs are found with better shell strength since the eggs are found with higher shell thickness than Naked neck chicken eggs. The eggs from Naked neck chicken may find better market value compared to Bovans' eggs because of the deep yellow color egg yolk. The shape index, Haugh unit and yolk index were not significantly different indicating that these egg quality characteristics are almost similar in eggs of both chicken breeds. Based on the findings of the study, it is concluded that several egg quality characteristics are found at a better level in Bovans (commercial grown) eggs than in Naked chicken (village) eggs. Further, it is suggested to conduct a controlled experiment to investigate the egg quality characteristics of different breeds.

References

Abadi, T. (2017). Perception of farmers on exotic chicken breeds and its management condition in North western zone. S*hire-Maytsebri Agricultural Research Center, 86*(3), 168–179.

Altuntaş, E., Şekeroğlu, A. (2008). Effect of egg shape index on mechanical properties of chicken eggs. *Journal of Food Engineering, 85*(4), 606–612. https://doi.org/10.1016/j.jfoodeng.2007.08.022

Anon. (2019). Department of Animal Production and Health, S. L. (2019). Livestock Statistical Bulletin. 1–46.

Atapattu, N., Abeywickrama, L., Gunawardana, W. (2016). Contribution of Backyard Chicken Egg Production to Fulfill Household Nutrient Requirement: A Study in Southern Sri Lanka. *International Journal of Livestock Research, 6*(7), 7. https://doi.org/10.5455/ijlr.20160619063921

Chambers, J. R., Zaheer, K., Akhtar, H., Abdel-Aal, E.-S. M. (2017). Egg Innovations and Strategies for Improvements Chicken Eggs ORIGIN OF THE EGG PRODUCING CHICKEN. In Egg Innovation and Strategies for Improvement. *Elsevier Inc*. https://doi.org/10.1016/B978-0-12-800879-9/00001-9

Desalew, T., Wondmeneh, E., Mekonnen, G., Tadelle, D. (2015). Comparative study on some egg quality traits of exotic chickens in different production systems in East Shewa, Ethiopia. *African Journal of Agricultural Research, 10*(9), 1016–1021. https://doi.org/10.5897/ajar2014.9373

Dogara, M. U., Kalla, D. J. U., Mancha, Y. P., Shuaibu, A. (2021). Evaluation of egg production and egg quality traits of Noiler chickens. *Nigerian Journal of Animal Science, 23*(2), 100-113.

Dudusola, I., Bashiru, H. A., Adeleke, O. E. (2020). Effect of laying age and plumage colour on internal and external quality characteristics of noiler chicken eggs. *Slovak Journal of Animal Science, 53*(04), 192-198.

Duman, M., Şekeroğlu, A., Yıldırım, A., Eleroğlu, H., Camcı. (2016). Zusammenhang zwischen Formindex des eies und eiqualitätsmerkmalen. European Poultry Science, 80(February). https://doi.org/10.1399/eps.2016.117

Eisen, E. J., Bohren, B. B., McKean, H. E. (1962). The Haugh Unit as a Measure of Egg Albumen Quality. *Poultry Science, 41*(5), 1461–1468. https://doi.org/10.3382/ps.0411461

Eke, M. O., Olaitan, N. I., Ochefu, J. H. (2013). Effect of Storage Conditions on the Quality Attributes of Shell (Table) Eggs. *Nigerian Food Journal, 31*(2), 18–24. https://doi.org/10.1016/s0189-7241(15)30072-2

Elango, S., Mahendrarasa, R. (2013). Comparative analysis of the egg quality traits in different chicken genotypes in the dry zone of Sri Lanka (pp. 86-91). Proceedings of the 3rd International Symposium, South Eastern University of Sri Lanka, Oluvil, Sri Lanka.

Gerber, N. (2005). Factors affecting egg quality in the commercial laying hen: a review. Poultry Industry Association of New Zealand, 1–28.

Ismail, F. S. A., Abo El-Maaty, H. M. A., Rabie, M. H., Aswad, A. Q. (2015). Productive performance of bovans white laying hens fed high nutrient density diets under Egyptian summer conditions. *Asian Journal of Animal and Veterinary Advances, 10*(12), 865–874. https://doi.org/10.3923/ajava.2015.865.874

Jayasena, D. D., Cyril, H. W., Jo, C. (2012). Evaluation of Egg Quality Traits in the Wholesale Market in Sri Lanka during the Storage Period. *Journal of Animal Science and Technology, 54*(3), 209–217. https://doi.org/10.5187/jast.2012.54.3.209

Klaas, E. E., Ohlendorf, H. M., Heath, R. G. (1974). Avian eggshell thickness: variability and sampling. *The Wilson Bulletin, 86*(2), 156–164.

Kul, S., Sekar, I. (2004). Phenotypic Correlations Between Some External and Internal Egg Quality Traits in the Japanese Quail (Coturnix coturnix japonica). *International Journal of Poultry Science,3*,6 February. https://doi.org/10.3923/ijps.400.405

Kumar, N., Belay, Z. N., Asfaw, Y. T., Kebede, E. (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*(2), 71–75. https://doi.org/10.9790/2380-07227175

Ledvinka, Z., Zita, L. , Klesalová, L. (2012). Egg quality and some factors influencing it: A Review. *Scientia agriculturae bohemica, 43*, 2012 (1): 46–52.

Manjula, P., Gajaweera, C. J., Lee, S. H., Lee, J. (2018). A Brief Review on Poultry Sector and Genetic Resources in Sri Lanka. *Journal of Animal Breeding and Genomics, 2*(3). https://doi.org/10.12972/jabng.20180032

Menezes, P. C. De, Lima, E. R. De, Medeiros, J. P. De. (2012). Revista Brasileira de Zootecnia Egg quality of laying hens in different conditions of storage , ages and housing densities. July 2010, 2064–2069.

Monira, K. N., Salahuddin, M., Miah, G. (2003). Effect of breed and holding period on egg quality characteristics of chicken. *International Journal of Poultry Science, 2*(4), 261-263. https://doi.org/10.3923/ijps.2003.261.263

Mori, H., Takaya, M., Nishimura, K., Goto, T. (2020). Breed and feed affect amino acid contents of egg yolk and eggshell color in chickens. *Poultry Science, 99*(1), 172–178. https://doi.org/10.3382/ps/pez557

Moula, N., Ait-Kaki, A., Leroy, P., Antoine-Moussiaux, N. (2013). Quality Assessment of marketed eggs in Bassekabylie (Algeria). *Revista Brasileira de Ciencia Avicola, 15*(4), 395–399. https://doi.org/10.1590/S1516-635X2013000400015

Mufeeth, M. M., Thariq, M. G. M. (2019). Evaluation of consumer preference for value addition to native chicken meat and egg. *SEUSL Journal of Marketing, 4*(1), 2019.

Nikolova, N., Kocevski, D. (2006). Forming egg shape index as influenced by ambient temperature and age ofhens. *Biotechnology in Animal Husbandry, 22*(1-2), 119-125. https://doi.org/10.2298/BAH0602119N (11) (PDF) Comparison of Egg Quality Characteristics of Different Poultry Species.

NORDSTROM, J. O., OUSTERHOUT, L. E. (1982). Estimation of Shell Weight and Shell Thickness from Egg Specific Gravity and Egg Weight. *Poultry Science, 61*(10), 1991–1995. https://doi.org/10.3382/ps.0611991

Omri, B., Amraoui, M., Tarek, A., Lucarini, M., Durazzo, A., Cicero, N., Santini, A., Kamoun, M. (2019). Arthrospira platensis (Spirulina) supplementation on laying hens' performance: Eggs physical, chemical, and sensorial qualities. *Foods, 8*(9). https://doi.org/10.3390/foods8090386.

Pettersson, I.C., Weeks, C.A., Wilson, L.R.M. and Nicol, C.J. (2016), Consumer perceptions of free-range laying hen welfare, *British Food Journal, Vol. 118* No. 8, pp. 1999-2013. https://doi.org/10.1108/BFJ-02-2016-0065.

Rajkumar, U., Sharma, R. P., Rajaravind, K. S., Niranjan, M., Reddy, B. L. N., Bhattachar, T. K., Chatterjee, R. N. (2009). Effect of Genotype and Age on Egg Quality Traits in Naked Neck Chicken under Tropical Climate from India. *International Journal of Poultry Science, 8*(12), 1151–1155. https://doi.org/10.3923/ijps.2009.1151.1155

Rath, P. K., Mishra, P. K., Mallick, B. K., Behura, N. C. (2015). Evaluation of different egg quality traits and interpretation of their mode of inheritance in White Leghorns. *Veterinary World, 8*(4), 449–452. https://doi.org/10.14202/vetworld.2015.449-452

Sarica, M., C. Erensayin, 2009: Poultry Products. In: TURKOGLU M., M. S ARICA: Poultry Science 2009. Bey-Ofset,Ankara, Turkey, ISBN (Not available), 89-138. (11) (PDF) Relation between egg shape index and egg quality characteristics.

Silva, P., Dematawewa, M. and Chandrasiri, N.(2010). Farm animal genetic resources. pp. 1-46. In: Silva, P. (Ed) Indigenous Animal Genetic Resources in Sri Lanka – Status, Potentialand Opportunities. UNEP-GEF-ILRI FAnGR Asia Project Publication. Sri Lanka. (11) (PDF) Comparative study on morphological and morphometric features of villagechickeninSriLanka.

Silversides, F. G., Budgell, K. (2004). The relationships among measures of egg albumen height, pH, and whipping volume. *Poultry Science, 83*(10), 1619–1623. https://doi.org/10.1093/ps/83.10.1619.

Sonaiya, E.B., Swan, S.E.J/ (2004). Small scale poultry production , Technical Guide Manual. FAO, Rome,Italy. FAO.

Sun, C., Liu, J., Yang, N., Xu, G. (2019). Egg quality and egg albumen property of domestic chicken, duck, goose, Turkey, quail, and pigeon. *Poultry Science, 98*(10), 4516–4521. https://doi.org/10.3382/ps/pez259

Vuilleumier, J. P. (1969). The 'Roche Yolk Colour Fan'—An Instrument for Measuring Yolk Colour. *Poultry Science, 48*(3), 767–779. https://doi.org/10.3382/ps.0480767

Wijedasa, W. M. R. M., Wickramasinghe, Y. H. S. T., Vidanarachchi, J. K., Himali, S. M. C. (2020). Comparison of Egg Quality Characteristics of Different Poultry Species. *Journal of Agricultural Science, 12*(11), 331. https://doi.org/10.5539/jas.v12n11p331

Yakubu, A., Ogah, D. M., Barde, R. E. (2008). Productivity and egg quality characteristics of free range naked neck and normal feathered Nigerian indigenous chickens. *International Journal of Poultry Science, 7*(6), 579–585. https://doi.org/10.3923/ijps.2008.579.585

Wu, G., Bryant, M. M., Voitle, R. A., Roland, D. A. (2005). Effect of Dietary Energy on Performance and Egg Composition of Bovans White and Dekalb White Hens During Phase I. 1610–1615.