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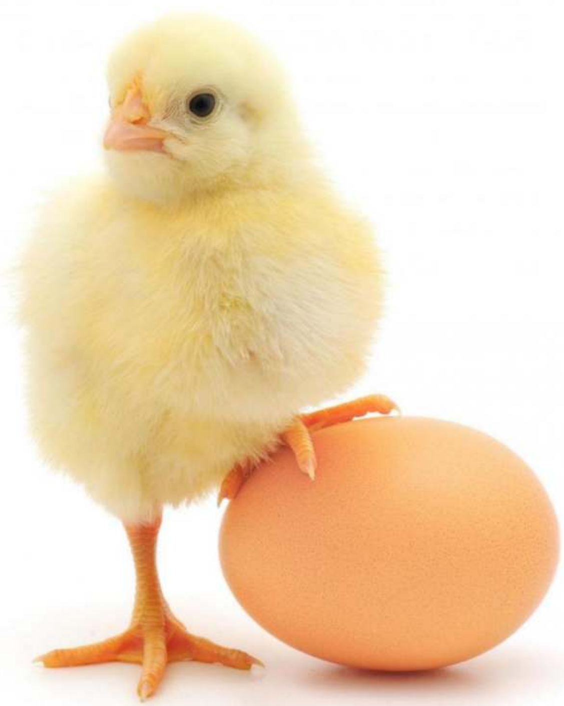

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Research Article
Storage Stability of Khaki Campbell Duck (*Anas platyrhynchos* Domesticus) Eggs at Room Temperature

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Abstract
Objective: This study compared the quality of 930 Khaki Campbell duck eggs under storage conditions at 30°C and 78% relative humidity, for 0-30 days. **Methodology:** During the 31-day storage period, 30 duck eggs/day were evaluated for the shape index, albumen index, yolk index, shell color (L*, a* and b*), specific gravity, shell breaking strength, shell thickness, Haugh unit, yolk color, pH of albumen, pH of yolk, albumen percentage, yolk percentage and shell percentage. **Results:** The storage period had no statistically significant effect on the shell strength, pH of albumen, pH of yolk, albumen percentage, yolk percentage and shell percentage ($p>0.05$). In addition, the shape index, albumen index, yolk index, shell color (L*, a* and b*), specific gravity, shell thickness, Haugh unit and yolk color were significantly affected by the storage period ($p<0.05$). The Haugh unit values decreased significantly when the storage period lengthened ($p<0.01$). **Conclusion:** These results showed that Khaki Campbell duck eggs stored for 11 days at 30°C and 78% relative humidity still maintained relatively good internal quality characteristics for human consumption.

Key words: Storage stability, Khaki Campbell duck, temperature, egg

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Eggs have been classified as nature's original functional food[1] and represent an important source of energy, proteins and other beneficial substances for the human body[2], having low calorific value, good digestibility of the components and a wide range of nutrients making eggs an important foodstuff for many regimens[3]. Moreover, eggs can add many positive attributes to food products such as: Emulsification, leavening, smoothness and flavor[4]. Ducks produce eggs of larger sizes, containing more nutrients than chickens and also contain higher proportions of protein and dry matter comparatively[5]. Lengkey *et al.*[6] reported that duck eggs are excellent for general eating and baking purposes, even though duck eggs typically have a slightly higher cholesterol content than the average chicken egg. When eggs are eaten in moderation, the difference in cholesterol between duck and chicken eggs probably is insignificant for healthy people, who get adequate exercise and eat sensibly. Egg quality traits are influenced by many factors, including maternal[7], genetic and environmental ones[8]. Both internal and external egg traits can further be significantly influenced by the length of storage period. Lengthening the storage period leads to unfavorable physiochemical changes in the egg contents[4]. Market eggs must be cooled as soon after laying as practical. The storage room should be kept at 7.2°C (45°F) at 80% relative humidity[9]. According to Soniya and Swan[10], eggs set for the first 6 days are called new eggs, those between 6 and 13 days are in between eggs and eggs after day 13 are old eggs. Quality determines the acceptability of a product to potential purchasers. The quality of eggs and the preservation of this quality during storage is a function of their physical structure and chemical composition[6]. Egg white viscosity differs in various areas of the egg. The height of the albumen is one of the principle characteristics used to judge interior egg quality. A height of 8-10 mm is considered an indicator of superior interior quality. In hens, it was demonstrated that eggs stored for more than 10 days were characterized by worse white and yolk indices and lower numbers of Haugh units compared with those examined on the day of laying[11]. Only limited information is available on egg quality traits changes in Khaki Campbell duck eggs during storage. Hence this study was carried out to analyze the quality changes of Khaki Campbell duck eggs after storage for up to 1 month.

MATERIALS AND METHODS

Study site: The present study was performed in November 2016 at Nakarat Farm, Nakon Panom Province, Thailand.

Measurements

Egg quality: The ducks were reared under an intensive system. A sample of 930 Khaki Campbell ducks aged 51 weeks were used in this research, using a completely randomized design. The eggs were taken randomly over 31 stages of storage time (0-31 days), with 3 replications. Each replication contained 10 eggs. The eggs were stored at 30°C and 78% relative humidity. The egg quality of 30 eggs from each group was measured based on the specific gravity, albumen percentage, yolk percentage, eggshell percentage, albumen weight, eggshell thickness, shell color, eggshell breaking strength, yolk color, pH of albumen, pH of yolk, Haugh unit, shape index, yolk index and albumen index. First, the egg weight was recorded using an electronic digital balance. The eggs were broken onto a metal plate and the height of the albumen was measured as the distance between the metal plate and the electrode placed on top of the thickest part of the broken egg. Then, the weights of albumen and egg yolk were measured using an electronic digital balance. The shells were dried at room temperature for 3 day, then at 60°C for 3 day and then reweighed. The weight of the albumen was calculated as the difference between the weight of the egg and the weight of the yolk plus shell. The values of the albumen percentage, yolk percentage and shell percentage were calculated for each individual egg using the formulae described by Lokaewmanee *et al.*[12] Shell thickness was the mean value of measurements at three locations on the egg (air cell, equator and sharp end), measured using a digital caliper and a mean value of the measurements was recorded as the shell thickness. The pH of the albumen and yolk was measured using a pH meter. The values of the shape index, albumen index, yolk index and Haugh units were calculated for each individual egg using the formulae according to Tilki and Saatci[13]. In addition, the yolk color and shell color (L*, a* and b*) were evaluated mechanically using a spectrophotometer (NF333, Nippon Denshoku Industries Co., Ltd., Tokyo, Japan). To measure the specific gravity of the egg, saline solutions were used varying in specific gravity from 1.060-1.100 in increments of 0.005.

Statistical analysis: The results were reported as Mean±SD and data on the production traits and egg quality were statistically analyzed using one-way analysis of varianc supported by the Statistical Analysis System[14]. Differences among treatment means were tested using Duncan's new multiple range test at $p<0.05$[15].

RESULTS AND DISCUSSION

The effects of different storage periods are presented in Fig. 1-16. The storage period significantly affected almost all the internal and external quality parameters investigated. The specific gravity, Haugh units, albumen index and yolk index significantly ($p<0.05$) decreased with increased storage period. The shape index, shell thickness, yolk color and shell color (L*, a* and b*) were also significantly affected by increased storage period ($p<0.05$). The shell breaking strength, albumen percentage, yolk percentage, shell percentage, albumen and yolk pH were not significantly different with increased storage period ($p>0.05$). These results were in agreement with Samli *et al.*[16], who reported a significant decrease in the specific gravity of 1.086 and 1.063 within 0 and 10 day, respectively, of storage (29°C). Dramatic deterioration was also observed in the Haugh units due to the storage period. This result was in agreement with Lapao *et al.*[17]. The Haugh units decreased from 91.4-76.3 at 5°C during 10 day of storage, whereas at 21 and 29°C storage this decline was further extended to 53.7 and 40.6, respectively. Similar results were also reported by other workers[4], where the Haugh unit values decreased significantly during cold storage (4°C and 80% RH) from values initially of 82.59 to a Haugh unit value of 67.43 at week 10. According to the USDA Agricultural Marketing Service guidelines[18], grade A determinations begin when Haugh unit values are less than 72. In the current study, the Haugh unit value was on average about 70 which is a good

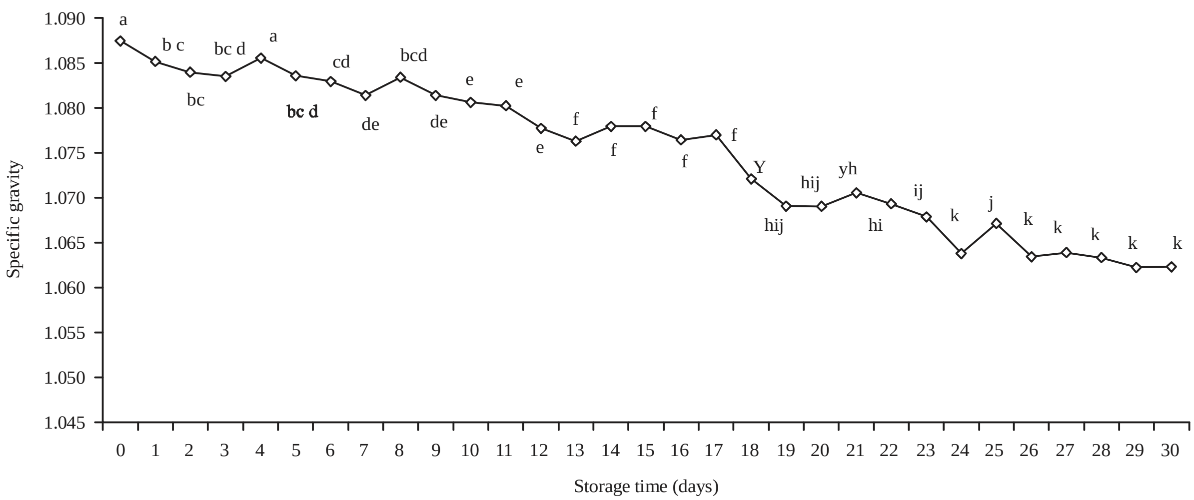

Fig. 1: Effects of different storage periods on specific gravity

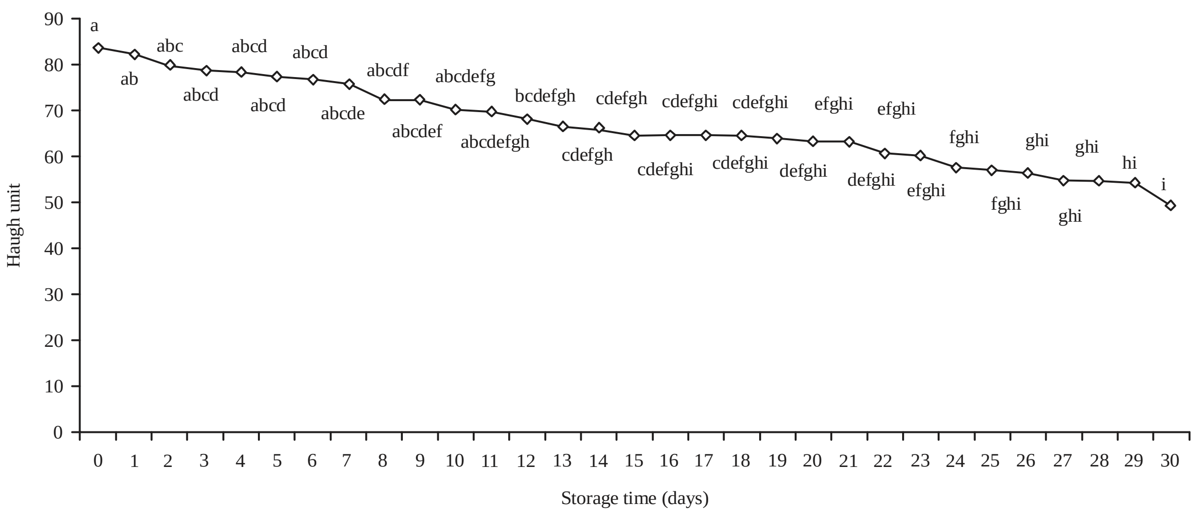

Fig. 2: Effects of different storage periods on Haugh unit

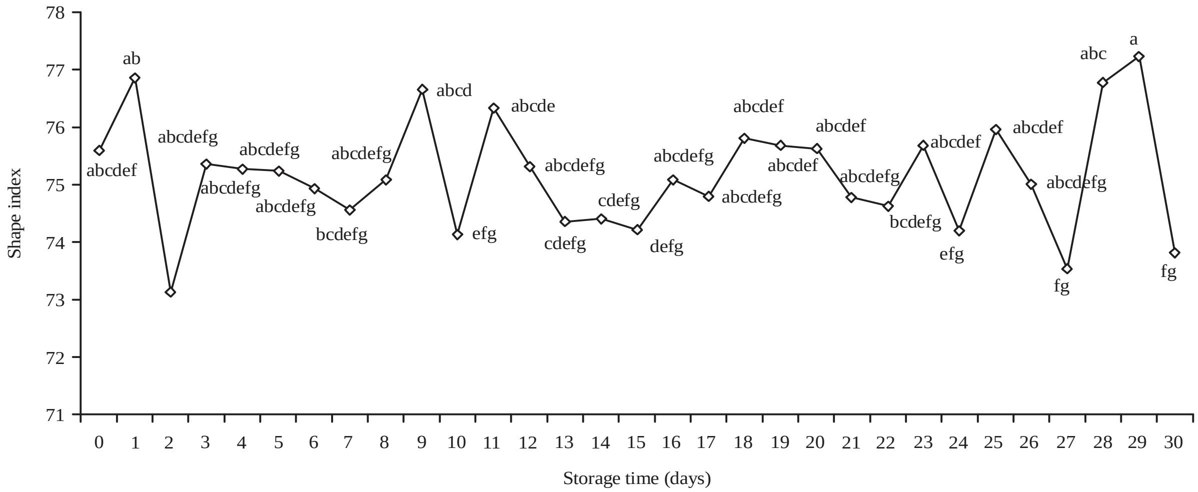

Fig. 3: Effects of different storage periods on shape index

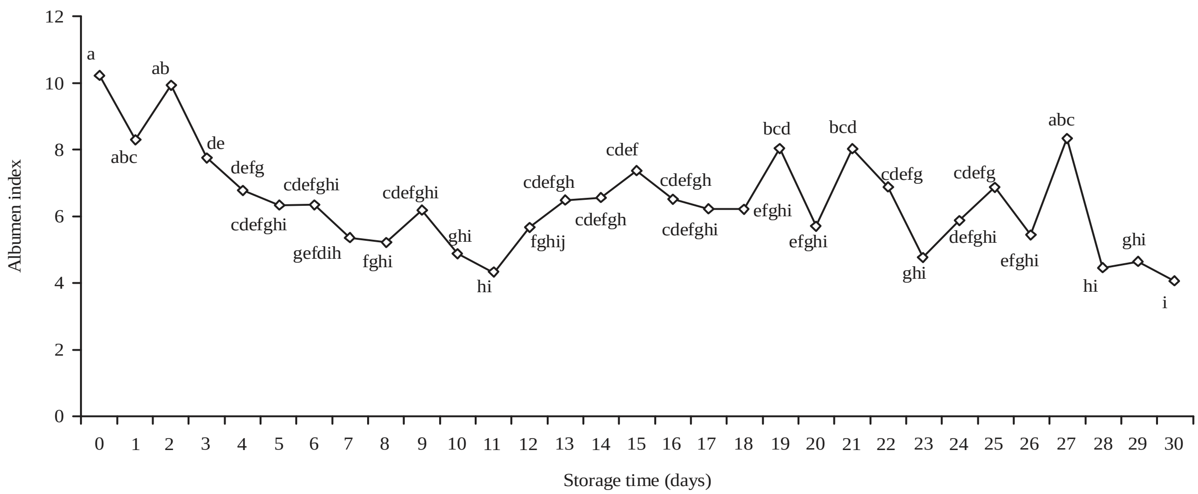

Fig. 4: Effects of different storage periods on albumen index

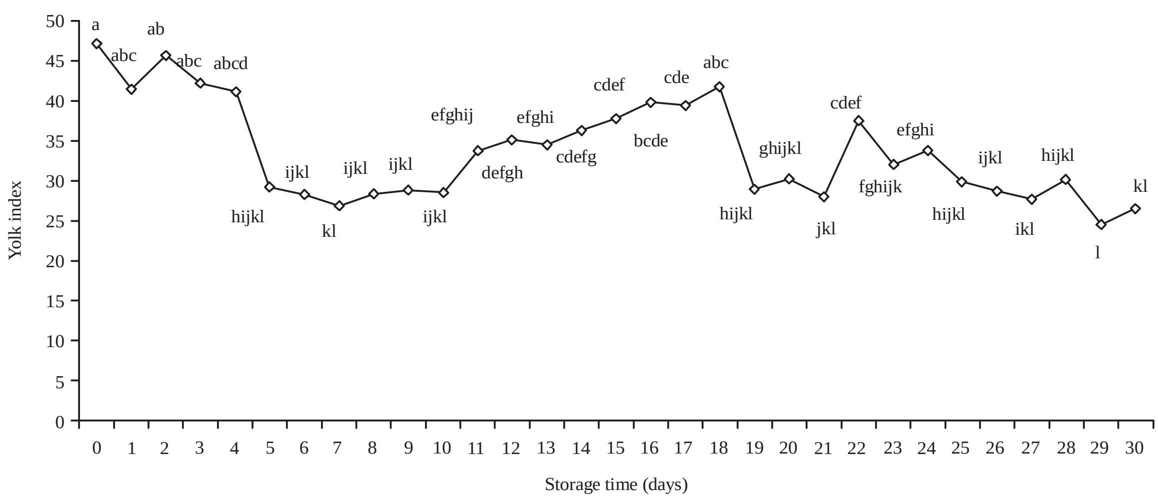

Fig. 5: Effects of different storage periods on yolk index

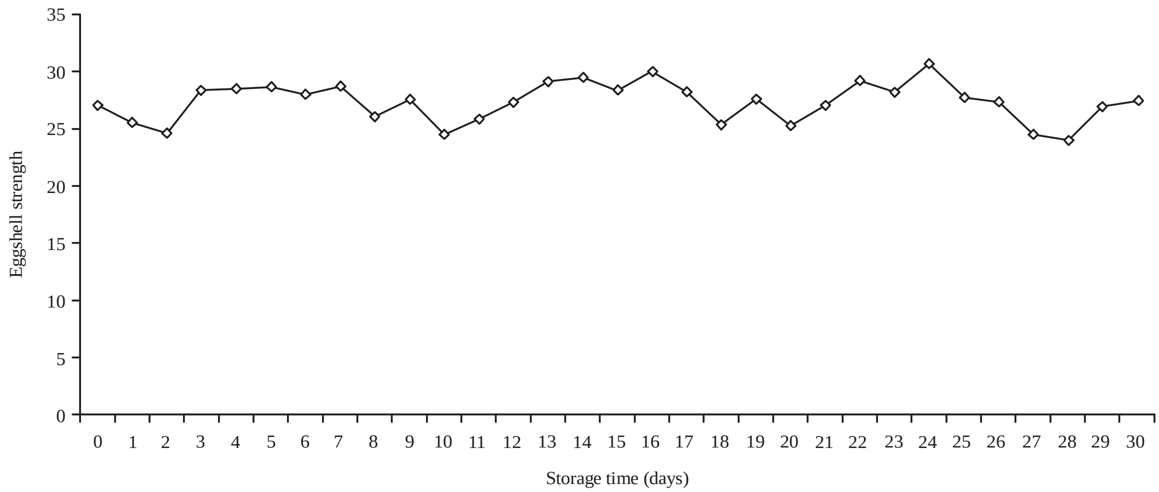

Fig. 6: Effects of different storage periods on eggshell strength

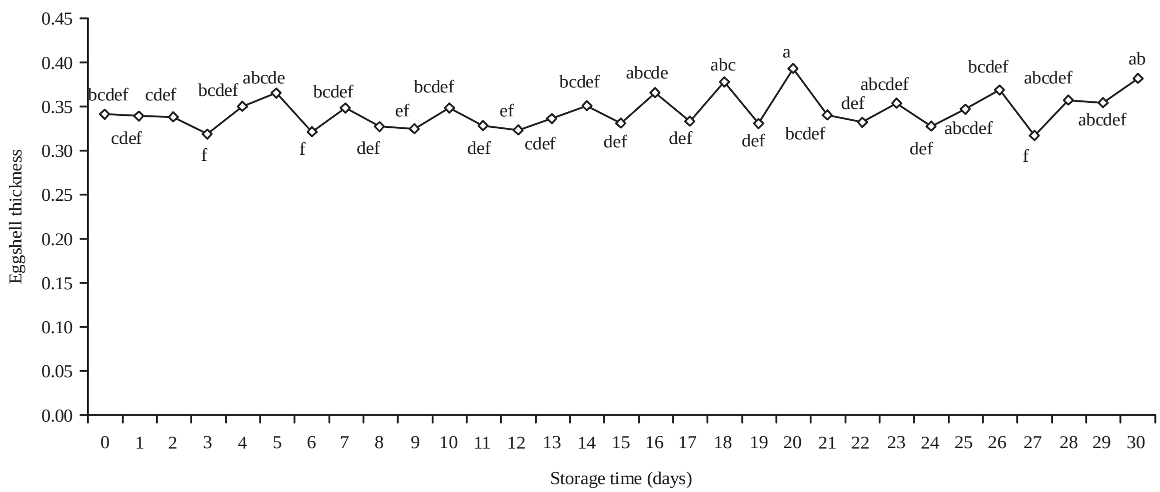

Fig. 7: Effects of different storage periods on eggshell thickness

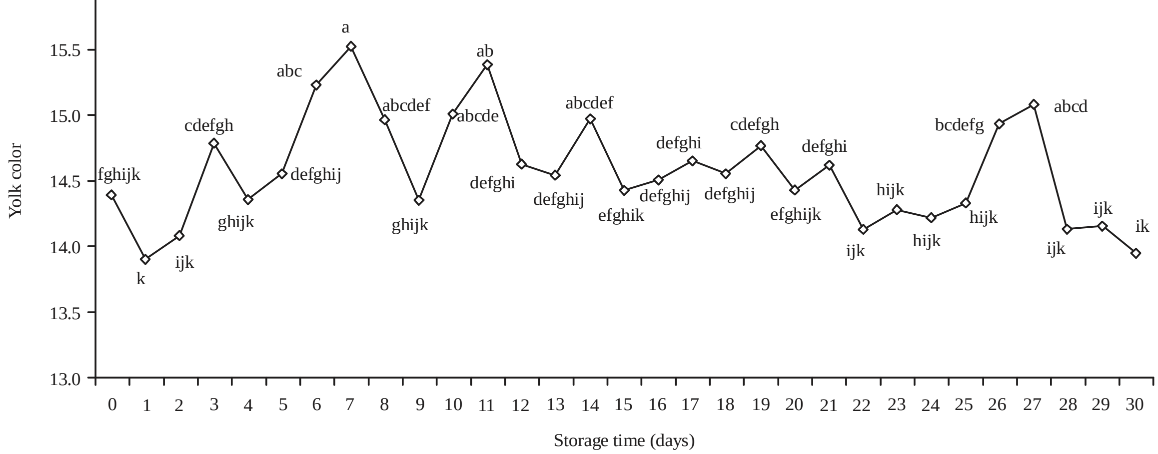

Fig. 8: Effects of different storage periods on yolk color

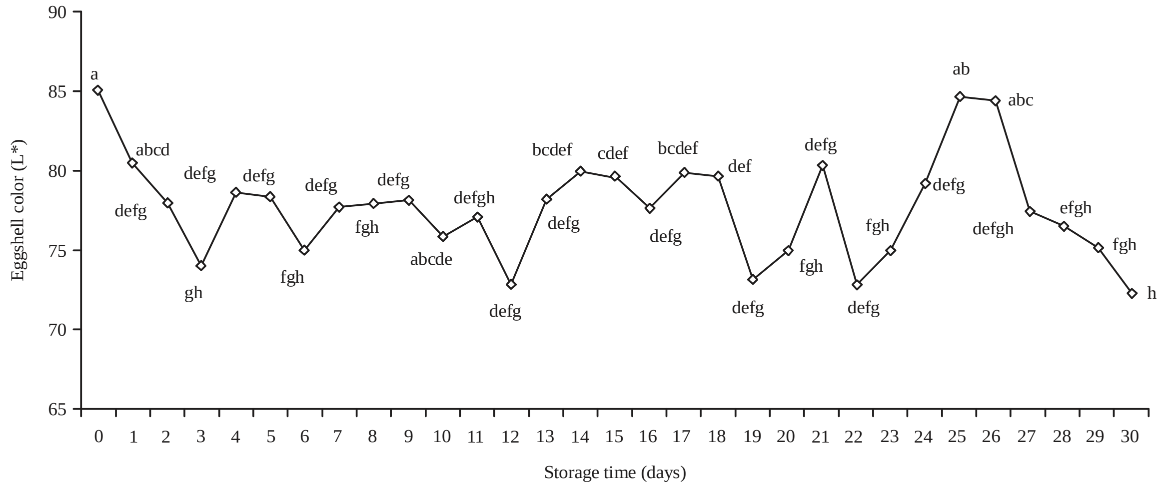

Fig. 9: Effects of different storage periods on eggshell color (L*)

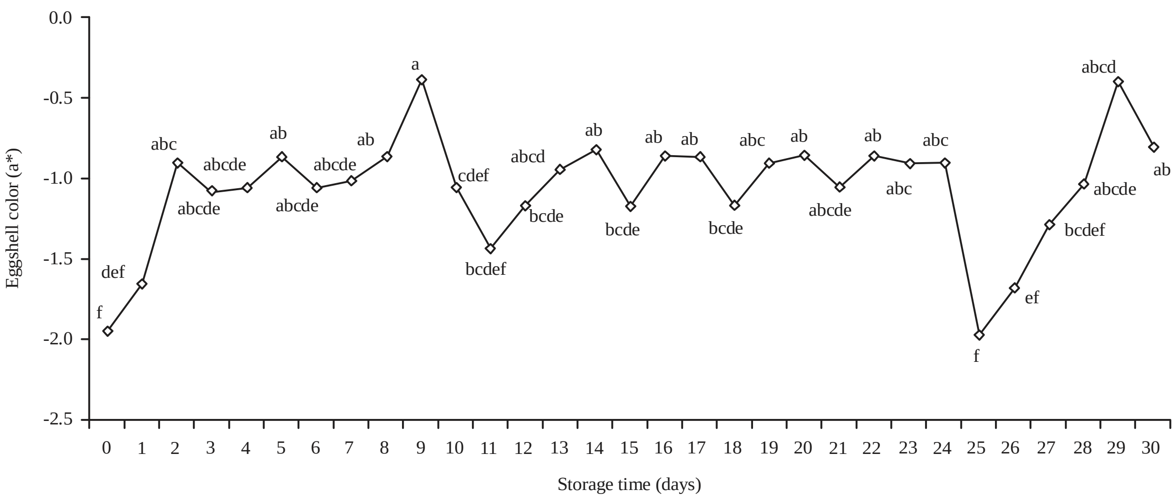

Fig. 10: Effects of different storage periods on eggshell color (a*)

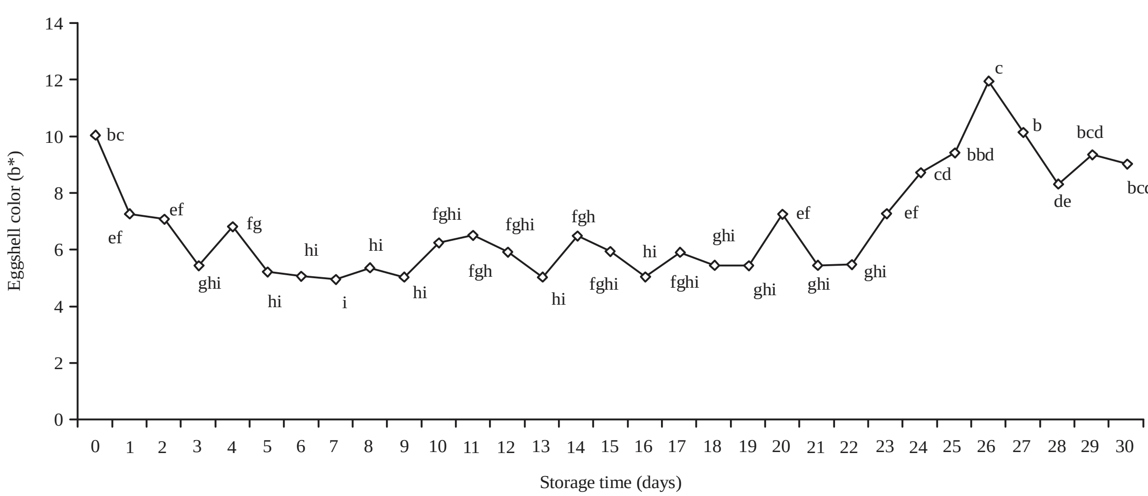

Fig. 11: Effects of different storage periods on eggshell color (b*)

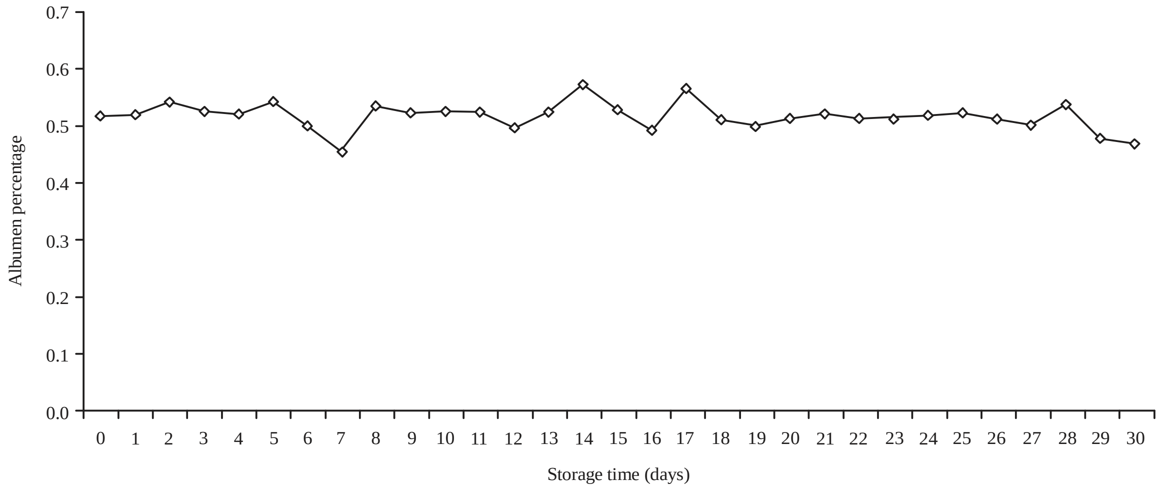

Fig. 12: Effects of different storage periods on albumen percentage

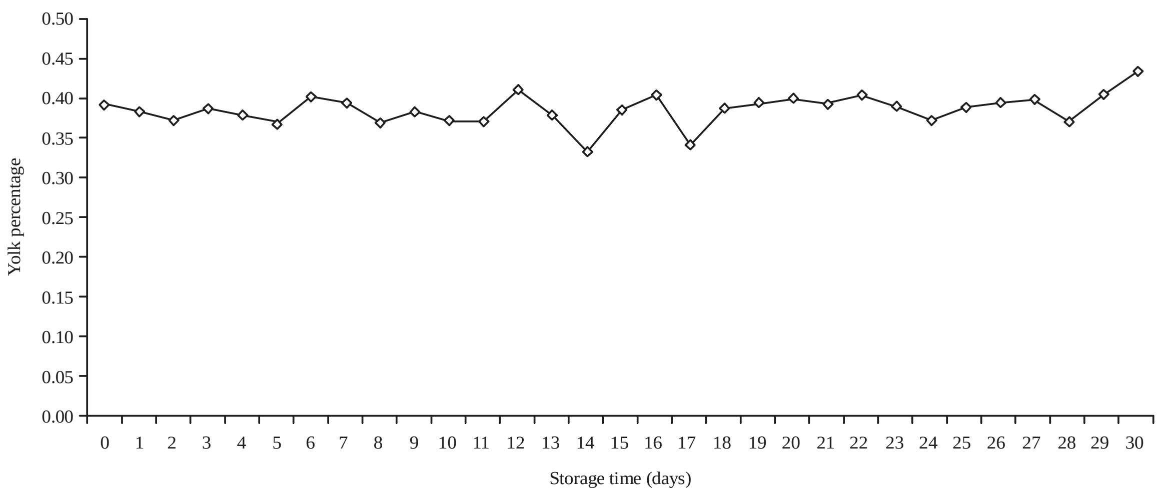

Fig. 13: Effects of different storage periods on yolk percentage

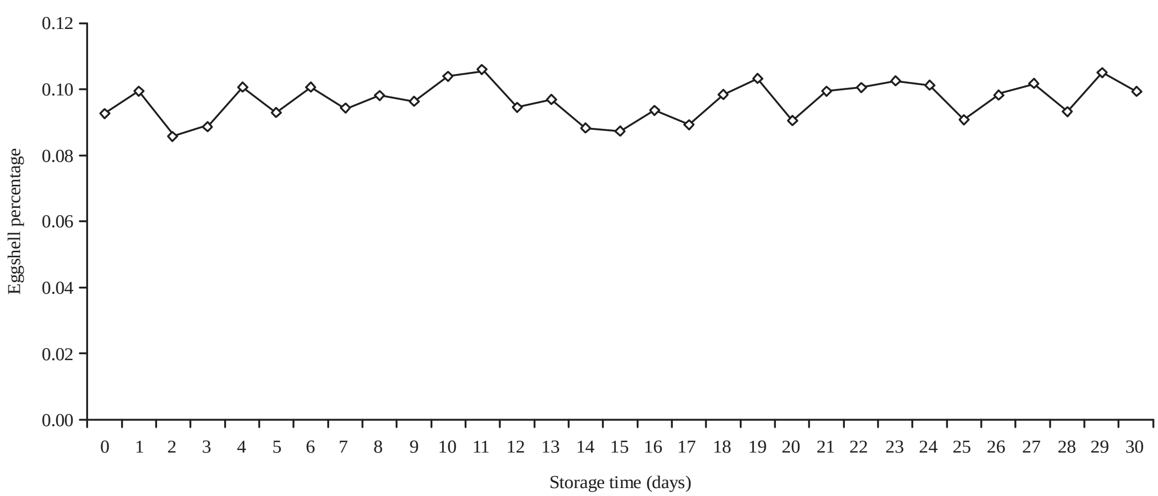

Fig. 14: Effects of different storage periods on eggshell percentage

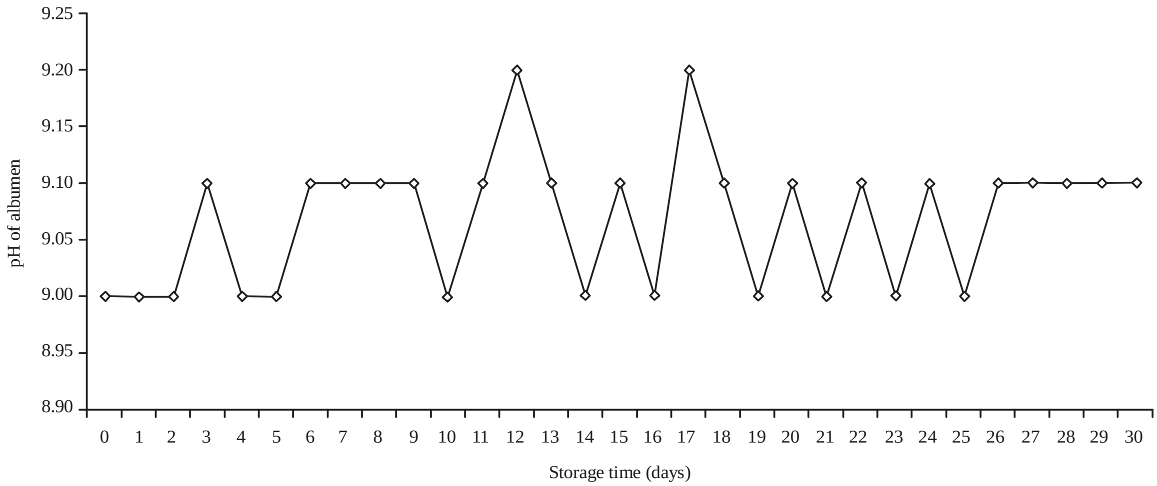

Fig. 15: Effects of different storage periods on pH of albumen

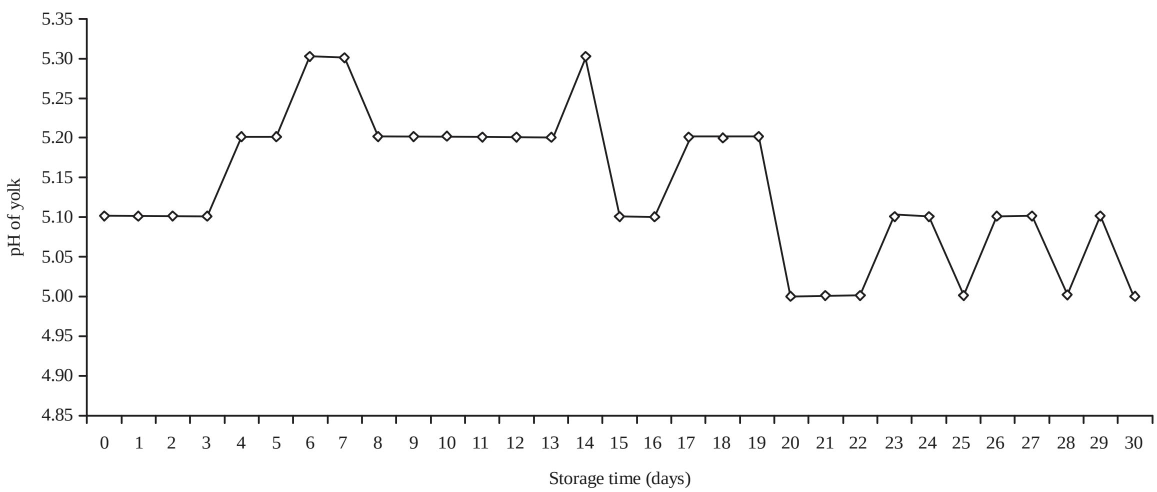

Fig. 16: Effects of different storage periods on pH of yolk

indicator for egg freshness[19] and this level was not reach until after 11 days at room temperature. The findings were generally in agreement with the results reported by Pandian *et al.*[8], at 60°F and 75% relative humidity, the albumen and yolk index decreased from 0.10-0.09 and from 0.36-0.33, respectively, during 7 day of storage. However, the shape index and shell thickness recorded in the current study were different with those of Pandian *et al.*[8]. This may have been due to the eggs losing weight due to water loss. The yolk color is known to be influenced mostly by hen diet[20] and xanthophylls are a main source of red and yellow pigments found in alfalfa meal, corn and gluten meal[21]. Hidalgo *et al.*[22] reported water moves into the yolk during egg storage which results in a widening and flattening of the yolk. Environmental factors such as temperature, humidity and storage time are also of prime importance in terms of the maintenance of egg quality[16]. In our laboratory, the yolk color was affected by the storage time at 30°C and 78% relative humidity. Moreover, the shell color (L*, a* ad b*) was also significantly affected by an increased storage period. Brake *et al.*[23] reported that eggshell consists of crystalline calcium carbonate. About 2 to 3% of this calcified layer is an organic matrix comprised mainly of protein. Eggshell color has always received more attention from the consumer than it deserves. Cavero *et al.*[24], indicated shell color is not an indication of nutritive value of the quality of egg. There is little or no direct relation between the shell color and storage time but the eggshell color does give an indication of the breeding history of the hen. The shell breaking strength, albumen percentage, yolk percentage, shell percentage, albumen and yolk pH of Khaki Campbell duck eggs was not affected by the storage time. Alsobayel and Albadry[25], reported shell and egg quality characteristics have been shown to be influenced by genotype and age. The current results corresponded with no changes of shell breaking strength reported by Jones[4] and of albumen percentage, yolk percentage and shell percentage reported by Akyurek and Okur[26]. However, Lengkey *et al.*[6] reported the albumen pH and yolk pH of duck egg increased over storage time. The albumen pH at oviposition is about 7.6, which is slightly more basic than the uterine fluid[27] and rises to about 9.0 during storage as the dissolved carbon dioxide diffuses out[3]. This rise in pH probably limits the microbial properties of albumen proteins[28]. The buffering capacity of albumen is weakest between 7.5 and 8.5, which accounts for the rapid increase as carbon dioxide is lost[23]. The yolk pH is about 6.0 and contains no carbon dioxide but the addition of carbon dioxide to the storage environment retards the movement of water from albumen to the yolk[29]. Samli *et al.*[16] reported the pH in yolk increased from 5.75-6.08 during 10 day of storage at 29°C. In the current study, no significant differences in albumen and yolk pH were found with storage at room temperature. However, very sparse information is available on the external and internal quality of commercial Khaki Campbell duck eggs produced locally and little has been published with respect to the effect of storage period on the egg external and internal quality.

CONCLUSION

It was concluded from the current study that the shelf life of unrefrigerated Khaki Campbell duck eggs would not be greater than 11 days at 30°C and 78% relative humidity.

SIGNIFICANCE STATEMENTS

This study discovers a shelf life of unrefrigerated Khaki Campbell duck eggs. Khaki Campbell duck eggs stored for 11 days at 30°C and 78% relative humidity still maintained relatively good internal quality characteristics for human consumption.

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