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Evaluation of external and internal traits of eggs from three poultry species at different storage durations in tropical environment

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Target audience: Poultry farmers, Poultry Scientists, Poultry egg retailers, Egg consumers, Policy Makers

Abstract

This study evaluated the external and internal traits of eggs from three indigenous poultry species (domestic chicken, duck and guinea fowl) at different storage durations. A total of 147 freshly laid eggs of domestic chicken, duck and guinea fowl were collected from reputable poultry farms. Seven fresh egg samples for each species were measured within 2 hours at day 0 of being laid. Each egg was weighed and broken, and the height of the albumen and egg yolk was measured. Forty-two eggs of each species were thereafter stored for 5, 10, 15, 20, 25 and 30 days at room condition (Average temp 26.6°C and Relative humidity 88%). Data obtained were arranged in a 3 × 7 factorial experimental layout in a completely randomized design. All external and internal parameters measured were significantly ($p<0.05$) influenced except egg width and egg shape index. Guinea fowl eggs had the highest Haugh unit compared to other species of birds investigated. The Haugh unit of duck egg was adversely affected ($p<0.05$) by prolonged storage durations. Guinea fowl eggs had the least ($p<0.05$) egg weight loss and shell surface area while duck egg weight loss was highest. This study concluded that domestic chicken, duck and guinea fowl eggs can be stored at room temperature and relative humidity of about 26.6^{0}C and 88% for a maximum duration of about 20 days.

Keywords: egg traits, domestic chicken, duck, guinea fowl, storage durations

Description of the Problem

Egg production is on the increase in Nigeria but plagued by poor storage conditions which result in deterioration in egg quality and consequently waste of eggs. The economic success of a laying flock depends on the number of quality eggs produced. Egg quality comprises a number of aspects related to the shell, albumen and yolk and may be divided into external and internal qualities (1). Eggs are considered to be a perishable foodstuff, due to the low efficiency of their natural protection barriers. When eggs are stored for a long period of time and especially in inappropriate conditions, their initial quality goes impaired, not good for consumption (2).

The nature of egg as a perishable food, can lead to it been spoilt in homes within a short period of time. Immediately after the egg is laid, the internal contents and structure begin to change. This is a continual, irreversible process and even the most carefully controlled storage conditions can do no more than slow down the rate of deterioration.

Deterioration in egg quality is attributed to moisture loss and a decline in interior egg quality during extended storage (3). Factors associated with decline in quality are storage time, temperature, humidity and handling (4). The shelf life of shell eggs, during which they are of good quality and safe to consume, is a function of carbon dioxide (CO_2) content (5). Several chemical and physical modifications occur inside an egg during the storage period including thinning of the albumen and flattening of the yolk.

Proper storage of eggs is essential to preserve quality and cooking characteristics. Poor storage conditions can reduce egg grade within a few days. The principal degrading factors are high storage temperature and dehydration. Improper storage is reported to produce some observed changes (5): a reduction in the viscosity of the albumen, an enlargement yolk that breaks easily when the shell is broken, enlargement of the air cell, and absorption of off odours and off-flavours if stored near pungent foods. The quality of egg and their stability during storage are largely determined by their physical structure and chemical composition (6).

Therefore, this study evaluated some qualitative traits of eggs from three selected species of poultry birds (chicken, Duck, Guinea fowl) as well as the effect of storage duration on the changes that occur on the external and internal qualities of eggs, in order to identify the optimum duration (days) for stored eggs at room temperatures, as indicator for possible preservation method to improve the quality of table eggs in tropical environment.

Materials and Methods

Location of Experiment

The experiment was carried out between April and August, 2014 in the Animal Products and Processing Laboratory of the Department of Animal Production and Health, Federal University of Agriculture, Abeokuta. The area lies on latitude 7° 13'57.4"N, longitude 3° 26'12.1"E and altitude 76m above the sea level and located in the tropical rainforest vegetation zone with an average temperature of 31.9-34.7°C and relative humidity of 79.7 – 90.1%.

Source of Eggs

A total of 147 freshly laid eggs of domestic chicken, duck and guinea fowl were collected from reputable farms in Abeokuta, Ogun State, Nigeria. Forty-nine sample eggs of each species were stored at room temperature and relative humidity for all treatments. Egg quality parameters (external and internal) were measured at 0, 5, 10, 15, 20, 25 and 30 day. Seven (7) samples each of domestic fowls' eggs, duck eggs and guinea fowl eggs were randomly selected. The eggs were broken out on a flat transparent glass surface using a spatula to obtain various internal parameter measurements. Day zero (0) measurements were used as the baseline for length of storage for eggs of each poultry species. For sampling, each egg was weighed and broken, and the heights of the albumen and egg yolk were measured using spherometer.

Room Temperature

Eggs were placed in egg tray and stored at room temperature and relative humidity on top of a table in a well-ventilated room, average temperature of 26.6°C and relative humidity of 88%.

Egg External Quality Evaluation

Egg Weight

Egg and shell weights (in grams) at 0, 5, 10, 15, 20, 25 and 30 days, were taken on individual eggs from each species using Mettler top loading electronic weighing balance having sensitivity of 0.01g.

Egg Length

A vernier caliper with accuracy of 0.1mm was used to determine the egg length. It was taken as the longitudinal distance between the narrow and the broad ends.

Egg Width

It was measured to the nearest 0.1mm with vernier caliper. The egg width was taken as the diameter of the widest cross-sectioned region.

Egg Shell Thickness

Thickness of individual air-dried shells was measured nearest 0.01mm using micrometer gauge.

Egg Shape Index (ESI)

It was calculated as the percentage of the egg breadth (width) to the length (7). The formula is as follows:

$$\text{Egg Shape Index} = \frac{\text{Width of egg (mm)}}{\text{Length of egg (mm)}} \times \frac{100}{1}$$

Egg Weight Loss

It was determined as the difference between successive weights of eggs relative to

Weight loss (C_x) =Weight at W_c – Weight at W_1

Where: c = (0 day), i = (5, 10, 15, 20, 25, 30 day)

Shell Surface Area

It was determined from the expression (8):

The shell surface area (SSA)= ($4.67 \times SW^{0.667}$)

Where: SW = Shell weight.

Egg Internal Quality Evaluation

The internal quality parameters were measured for all the 7 eggs of each poultry species in storage on each day of observation, to determine the quality traits of albumen, the following parameters were calculated:

Albumen Index

$$\text{The albumen index (AI)} = \frac{H}{0.5D}$$

where: H: height of thick albumen at the boundary with the yolk;

D: average of long and short diameters of albumen measured on the smooth surface (9).

Haugh Units:

$$HU = 100\log_{10}(H + 7.57 - 1.7EW^{0.37})$$

where: H= albumen height

EW= egg weight in gram (10).

Internal Quality Units:

$$IQU = 100\log_{10}(H + 4.18 - 0.898EW^{0.6674})$$

where: H= albumen height

EW= egg weight in gram (11)

Yolk Quality

Yolk quality was evaluated through the yolk index

$$(YI) = \frac{h}{D}$$

where: h: the yolk height

D: the yolk diameter (9).

Statistical Analysis

Data collected from were arranged in a 3 × 7 factorial experimental lay-out. Complete Randomized Design. Significant (P<0.05) differences among treatment means were separated using Duncan's Multiple Range Test as contained in Statistical Analyst System (12) package.

Experimental Model:

$\gamma_{ijkl} = \mu + \tau_i + S_j + (\tau S)_{ijk} + '_{ijkl}$

where: γ_{ijkl} = Observed of dependent variable/output

μ =Population mean

τ_i=Effect of ith Storage duration (day); (i = 0, 5, 10, 15, 20, 25, 30 days)

S_j=Effect of jth eggs of four poultry species; (j = domestic fowl, duck and guinea fowl)

$(\tau S)_{ijk}$=Interaction between the storage duration and eggs of four poultry species

$'_{ijkl}$=Random error

Results

Main effects of durations and poultry of storage on external and internal qualities of egg

The main effects of durations of storage and poultry on external and internal qualities of egg are presented in Tables 1 and 2, respectively. Duration of storage significantly (P<0.05) influenced all quality parameters considered except egg width and egg shell index. There was a gradual increase in the egg weight loss as the days of storage increase from 0 to 30 days with the values obtained at 25th and 30th day statistically similar.

The poultry species significantly (P<0.05) influenced all the parameter measured (Table 2) except yolk index. Duck egg had highest values for egg weight, egg weight loss, egg length, shell weight yolk weight and yolk diameter, guinea fowl egg had highest values for egg shell thickness, Haugh unit and egg shape index as well as least values of egg weight loss and albumen index.

Interaction effects of durations of storage and poultry species on external and internal qualities of egg

Tables 3, 4 and 5 show the effects of the interaction between durations and poultry species; domestic chickens, ducks guinea fowl, respectively on external and internal qualities of egg. All parameters measured were significantly (P<0.05) influenced by durations of storage except the initial weight, shell weight, albumen weight and shell surface area. The values obtained for egg weight loss increased as the durations of storage increased while values obtained for yolk index and yolk height decreased as the durations of storage increased. Initial weight, final weight, shell weight, internal quality unit and shell surface area were statistically highest at day 15 while the lowest values for the four indices were obtained on day 25 except for final weight which was lowest on day 0.

The results of the interaction effects of duck and storage durations on external and internal qualities of egg (Table 4) revealed significant (P<0.05) differences in shell weight, albumen height, albumen diameter, albumen index, yolk diameter, yolk index, yolk height and Haugh unit. However, the storage durations had no significant (P>0.05) effect on initial weight, final weight, egg weight loss, egg length, egg width, shell thick, albumen weight, yolk

Table 1: Main effects of Duration of storage on External and Internal Qualities of Egg

	Storage Durations (day)						
Parameter	**0**	**5**	**10**	**15**	**20**	**25**	**30**
External							
Initial weight (g)	$54.60^{ab}\pm2.80$	$55.17^{ab}\pm3.26$	$53.37^{ab}\pm2.70$	$56.70^{a}\pm3.13$	$53.70^{ab}\pm2.94$	$52.73^{b}\pm2.75$	$55.12^{ab}\pm2.97$
Final weight (g)	$0.00^{c}\pm0.00$	$54.77^{a}\pm3.27$	$52.70^{ab}\pm2.67$	$55.50^{a}\pm3.11$	$52.46^{ab}\pm2.88$	$50.50^{b}\pm2.66$	$52.78^{ab}\pm2.87$
Egg weight loss (g)	$0.00^{c}\pm0.00$	$0.40^{bc}\pm0.03$	$0.67^{bc}\pm0.04$	$1.20^{b}\pm0.16$	$1.24^{b}\pm0.11$	$2.23^{a}\pm0.77$	$2.34^{a}\pm0.21$
Egg length (mm)	55.56±1.48	55.4±1.79	54.29±1.48	55.8±1.63	54.66±1.54	55.26±1.51	55.1±1.58
Egg width (mm)	41.66±0.63	42.03±0.87	42.09±1.04	42.11±0.7	42.13±0.95	41.15±0.69	41.83±0.71
Shell weight (g)	$5.76^{bc}\pm0.2$	$6.05^{ab}\pm0.25$	$5.92^{abc}\pm0.16$	$6.36^{a}\pm0.24$	$5.96^{abc}\pm0.23$	$5.39^{c}\pm0.14$	$5.74^{bc}\pm0.14$
Shell thick (mm)	$0.44^{c}\pm0.02$	$0.48^{ab}\pm0.02$	$0.50^{a}\pm0.03$	$0.49^{a}\pm0.02$	$0.49^{a}\pm0.03$	$0.45^{bc}\pm0.02$	$0.44^{c}\pm0.02$
Shell surface area	$14.97^{bc}\pm0.34$	$15.46^{ab}\pm0.42$	$15.27^{abc}\pm2.16$	$16.00^{a}\pm0.38$	$15.31^{abc}\pm0.39$	$14.35^{c}\pm0.25$	$14.96^{bc}\pm0.24$
Egg shape index (%)	75.56±1.18	77.06±2.58	78.55±2.99	76.15±1.3	77.58±1.35	75.04±1.25	76.57±1.28
Internal							
Albumen weight (g)	$31.45^{ab}\pm2.04$	$31.74^{a}\pm2.36$	$29.08^{abc}\pm1.83$	$30.05^{abc}\pm2.16$	$28.61^{bc}\pm2.03$	$27.69^{c}\pm1.93$	$28.96^{abc}\pm2.07$
Albumen Height (mm)	$6.43^{a}\pm0.3$	$6.28^{a}\pm0.28$	$4.38^{bc}\pm0.23$	$4.93^{b}\pm0.22$	$4.26^{c}\pm0.21$	$4.14^{c}\pm0.32$	$4.27^{c}\pm0.2$
Albumen diameter (mm)	$49.96^{c}\pm2.74$	$84.9^{b}7\pm2.85$	$91.77^{a}\pm2.37$	$88.02^{ab}\pm2.18$	$87.37^{ab}\pm1.88$	$88.32^{ab}\pm1.43$	$88.60^{ab}\pm1.89$
Albumen Index	$0.27^{a}\pm0.02$	$0.15^{b}\pm0.01$	$0.10^{c}\pm0.01$	$0.11^{c}\pm0.01$	$0.10^{c}\pm0.00$	$0.09^{c}\pm0.01$	$0.10^{c}\pm0.00$
Yolk weight (g)	$17.40^{b}\pm1.37$	$16.98^{b}\pm1.35$	$17.70^{ab}\pm1.32$	$19.09^{a}\pm1.44$	$17.9^{ab}\pm1.26$	$17.42^{b}\pm1.17$	$18.08^{ab}\pm1.27$
Yolk height (mm)	$16.05^{a}\pm0.52$	$14.08^{b}\pm0.41$	$12.50^{c}\pm0.39$	$11.82^{cd}\pm0.20$	$11.04^{de}\pm0.38$	$11.08^{de}\pm0.51$	$10.19^{e}\pm0.43$
Yolk diameter (mm)	$38.95^{d}\pm1.08$	$44.09^{c}\pm1.39$	$44.87^{bc}\pm1.09$	$47.69^{a}\pm1.29$	$45.99^{abc}\pm1.16$	$46.79^{ab}\pm1.19$	$46.52^{ab}\pm1.09$
Yolk index	$0.41^{a}\pm0.01$	$0.32^{b}\pm0.01$	$0.28^{c}\pm0.01$	$0.25^{d}\pm0.01$	$0.24^{de}\pm0.01$	$0.24^{de}\pm0.01$	$0.22^{e}\pm0.01$
Haugh unit	$80.64^{a}\pm1.8$	$79.75^{a}\pm1.52$	$63.04^{bc}\pm3.42$	$68.70^{b}\pm1.46$	$63.25^{bc}\pm2.24$	$61.62^{c}\pm2.95$	$62.90^{bc}\pm1.91$
Internal egg quality unit	$172.30^{a}\pm1.57$	$172.20^{a}\pm1.79$	$170.16^{ab}\pm1.33$	$171.92^{a}\pm1.7$	$169.93^{b}\pm1.7$	$169.39^{b}\pm1.67$	$170.65^{ab}\pm1.68$

^{a,b,c,d,e}: Means in the same row by factor with different superscripts differ significantly ($P<0.05$)

Mean ± standard error

Table 2: The Main Effect of Poultry Species on External and Internal qualities of egg

	Poultry Species		
Parameter	**DC**	**D**	**GF**
External			
Initial weight (g)	$62.68^{a}\pm0.71$	$63.49^{a}\pm0.98$	$37.28^{b}\pm0.46$
Final weight (g)	$52.52^{ab}\pm3.16$	$53.06^{a}\pm3.28$	31.01 ± 1.88
Egg weight loss (g)	$1.24^{ab}\pm0.13$	$1.38^{a}\pm0.36$	$0.83^{c}\pm0.10$
Egg length (mm)	$57.66^{b}\pm0.49$	$61.59^{a}\pm0.37$	$46.22^{c}\pm0.28$
Egg width (mm)	$44.39^{a}\pm0.33$	$43.38^{b}\pm0.34$	$37.81^{c}\pm0.28$
Shell weight (g)	$5.83^{ab}\pm0.10$	$6.14^{a}\pm0.17$	$5.68^{b}\pm0.11$
Shell thick (mm)	$0.41^{b}\pm0.00$	$0.40^{b}\pm0.01$	$0.60^{a}\pm0.01$
Shell surface area	$15.11^{ab}\pm0.17$	$15.60^{a}\pm0.28$	$14.84^{b}\pm0.19$
Egg shape index (%)	$77.40^{b}\pm1.26$	$70.49^{c}\pm0.55$	$82.03^{a}\pm1.01$
Internal			
Albumen weight (g)	$39.22^{a}\pm0.66$	$30.84^{b}\pm0.74$	$18.91^{c}\pm0.38$
Albumen Height (mm)	$5.32^{a}\pm0.26$	$5.27^{a}\pm0.16$	$4.28^{b}\pm0.16$
Albumen diameter (mm)	$88.54^{a}\pm1.96$	$81.46^{b}\pm3.00$	$78.15^{c}\pm1.91$
Albumen index	$0.13^{b}\pm0.01$	$0.15^{a}\pm0.01$	$0.12^{b}\pm0.01$
Yolk weight (g)	$16.39^{b}\pm0.23$	25.14 ± 0.46	11.86 ± 0.12
Yolk height (mm)	$12.52^{b}\pm0.42$	$13.63^{a}\pm0.31$	$11.03^{c}\pm0.31$
Yolk diameter (mm)	$45.18^{b}\pm0.66$	$50.21^{a}\pm0.65$	$39.57^{c}\pm0.44$
Yolk index	0.29 ± 0.01	0.27 ± 0.01	0.28 ± 0.01
Haugh unit	$66.38^{b}\pm2.47$	$67.73^{ab}\pm1.47$	$71.55^{a}\pm1.29$
Internal quality unit	$175.70^{a}\pm0.34$	$175.94^{a}\pm0.43$	$161.17^{b}\pm0.39$

$^{a, b, c}$: Means in the same row by factor with different superscripts differ significantly(P<0.05)
DC: Domestic chicken
D: Duck
GF: Guinea fowl

weight, internal quality unit egg shape index and shell surface area.

The storage durations had significant (P<0.05) influence on egg weight loss, shell thick, albumen height, albumen index, yolk weight, yolk diameter, yolk index, Haugh unit and internal quality unit of the egg in guinea fowl (Table 5). Initial egg weight, final egg weight, egg length, egg width, shell weight, albumen weight, albumen diameter, yolk height, egg shell index and shell surface of eggs from guinea fowl were not significantly (P>0.05) affected

Discussion

The main effect of storage durations on external and internal egg qualities revealed that egg weight declined with increased in storage durations. The observed losses could be due to loss of carbon dioxide, ammonia, nitrogen, hydrogen sulphide gas and water from the eggs (13). These declines in egg weight with storage are in agreement with the observation (4) of a decrease in weight within 10 days of storage at 29 ºC. In contrast, report (14) had it that for an unknown reason egg weight did not differ within 10 days of storage. The thickness of the egg shell could be responsible for low egg weight loss in guinea fowl egg compared to domestic chicken eggs and duck eggs. The

Table 3 : Interaction Effects of Domestic Chicken and Storage Duration s on external and internal qualities of egg

Poultry species	Domestic Chicken						
Storage duration (day)	**0**	**5**	**10**	**15**	**20**	**25**	**30**
External							
Initial weight (g)	62.39±2.32	63.69±2.58	60.74±1.50	65.24±1.16	61.71±1.56	60.57±1.96	64.43±1.62
Final weight (g)	0.00^{c}±0.00	63.19^{ab}±2.62	59.99^{ab}±1.51	64.17^{a}±1.13	60.2^{ab}±1.55	58.39^{b}±2.02	61.74^{ab}±1.56
Egg weight loss (g)	0.00^{f}±0.00	0.5^{e}±0.067	0.76^{e}±0.04	1.07^{d}±0.087	1.51^{c}±0.09	2.19^{b}±0.17	2.69^{a}±0.17
Egg length (mm)	58.22^{ab}±1.10	59.54^{a}±1.59	54.48^{b}±2.06	58.79^{a}±0.44	57.37^{ab}±0.82	57.3^{ab}±1.19	57.88^{ab}±0.83
Egg width (mm)	43.78±0.37	44.19±0.65	45.96±2.00	44.53±0.38	44.07±0.52	43.69±0.48	44.51±0.33
Shell weight (g)	5.79^{ab}±0.31	5.84^{ab}±0.40	5.74^{ab}±0.11	6.31^{a}±0.14	5.89^{ab}±0.15	5.40^{b}±0.24	5.84^{ab}±0.31
Shell thick (mm)	0.39^{b}±0.01	0.44^{a}±0.017	0.43^{a}±0.01	0.43^{a}±0.01	0.40^{ab}±0.01	0.39^{b}±0.00	0.38^{b}±0.01
Shell surface area	15.03^{ab}± 0.54	15.11^{ab}±0.72	14.98^{ab}±0.19	15.96^{a}±0.24	15.23^{ab}±0.25	14.36^{b}±0.42	15.13^{ab}±0.54
Egg shape index (%)	75.28^{b}±0.85	74.39^{b}±1.34	86.12^{a}±8.12	75.75^{b}±0.7	76.91^{ab}±1.39	76.39^{ab}±1.36	76.97^{ab}±1.04
Internal							
Albumen weight (mm)	47.43±2.29	48.13±2.64	44.53±1.49	47.91±1.11	44.99±1.60	44.10±1.71	46.97±1.79
Albumen height (mm)	7.52^{a}±0.38	7.44^{a}±0.37	4.02^{c}±0.44	5.48^{b}±0.27	4.35^{bc}±0.53	3.96^{c}±0.66	4.46^{bc}±0.34
Albumen diameter (mm)	63.32^{c}±1.77	88.79^{ab}±4.80	99.11^{a}±3.55	87.63^{b}±4.24	93.02^{ab}±1.58	92.97^{ab}±2.49	94.97^{ab}±3.41
Albumen Index	0.24^{a}±0.01	0.17^{b}±0.01	0.08^{d}±0.01	0.13^{c}±0.01	0.094^{cd}±0.01	0.08^{d}±0.01	0.10^{cd}±0.01
Yolk weight (g)	14.96^{c}±0.57	15.56^{bc}±0.19	16.21^{abc}±0.49	17.34^{ab}±0.78	16.73^{abc}±0.46	16.47^{abc}±0.48	17.50^{a}±0.79
Yolk height (mm)	16.98^{a}±0.99	15.36^{b}±0.39	12.85^{c}±0.41	11.71^{cd}±0.18	11.29^{cd}±0.42	10.43^{de}±0.65	9.00^{e}±0.44
Yolk diameter (mm)	36.96^{d}±1.01	42.5^{c}±0.59	45.51^{b}±0.58	48.15^{ab}±0.7	46.42^{b}±1.06	46.68^{b}±1.43	50.05^{a}±0.70
Yolk index	0.46^{a}±0.03	0.36^{b}±0.01	0.28^{c}±0.01	0.24^{cd}±0.01	0.24^{cd}±0.01	0.23^{d}±0.02	0.18^{e}±0.01
Haugh unit	85.09^{a}±2.74	84.28^{a}±2.62	55.31^{bc}±5.7	69.55^{b}±2.4	58.06^{bc}±6.10	53.36^{c}±6.8	59.02^{bc}±4.87
Internal quality unit	177.22^{a}±0.85	177.66^{a}±0.99	173.91^{b}±0.61	176.93^{a}±0.58	174.58^{b}±0.66	173.74^{b}±0.9	175.83^{ab}±0.58

^{a,b,c,d,e}: Means in the same row by factor with different superscripts differ significantly($P<0.05$)

Mean ± standard error

Table 4: Interaction effects of Duck and Storage Durations on external and internal qualities of egg

Poultry species				Duck			
Storage duration (day)	**0**	**5**	**10**	**15**	**20**	**25**	**30**
External							
Initial weight (g)	63.36±1.66	64.99±3.76	61.44±2.95	66.27±3.71	63.34±2.07	61.34±1.47	63.68±2.12
Final weight (g)	0.00^{b}±0.00	64.67^{a}±3.78	60.71^{a}±2.90	64.64^{a}±3.89	61.97^{a}±2.09	58.41^{a}±1.38	60.99^{a}±2.21
Egg weight loss (g)	0.00±0.00	0.31±0.03	0.73±0.08	1.63±0.45	1.37±0.23	2.93±2.38	2.69±0.43
Egg length (mm)	61.44±0.86	61.47±1.32	61.23±1.02	62.44±1.34	61.07±0.89	61.75±0.75	61.71±0.95
Egg width (mm)	43.14±0.51	43.48±0.98	42.68±0.83	43.60±0.91	44.87±1.72	42.57±0.37	43.30±0.50
Shell weight (g)	6.30^{a}±0.37	6.71^{a}±0.54	5.97^{ab}±0.22	6.84^{a}±0.64	6.51^{a}±0.58	4.94^{b}±0.07	5.67^{ab}±0.19
Shell thick (mm)	0.41±0.01	0.42±0.02	0.40±0.02	0.42±0.02	0.40±0.02	0.40±0.02	0.38±0.02
Shell surface area	15.91^{a}±0.60	16.56^{a}±0.89	15.37^{ab}±0.38	16.75^{a}±0.99	16.22^{a}±0.933	13.54^{b}±0.13	14.85^{ab}±0.33
Egg shape index (%)	70.26±0.96	70.79±1.12	69.71±0.70	69.89±1.13	73.54±2.85	68.98±0.87	70.27±1.36
Internal							
Albumen weight (mm)	37.79±1.20	40.96±2.86	36.54±1.50	38.96±2.78	38.22±2.19	37.26±1.57	38.74±2.04
Albumen height (mm)	6.21^{ab}±0.41	6.40^{a}±0.23	4.15^{d}±0.41	5.34^{bc}±0.14	4.84^{cd}±0.18	5.13^{cd}±0.45	4.82^{cd}±0.27
Albumen diameter (mm)	35.79^{b}±1.38	84.19^{a}±6.27	93.28^{a}±2.87	93.81^{a}±3.56	91.02^{a}±2.21	86.30^{a}±2.29	85.81^{a}±3.38
Albumen Index	0.35^{a}±0.03	0.16^{b}±0.01	0.09^{c}±0.01	0.12^{bc}±0.01	0.11^{c}±0.00	0.12^{bc}±0.01	0.11^{c}±0.01
Yolk weight (g)	25.57±0.91	24.03±2.04	24.90±1.56	27.31±1.17	25.12±0.77`	24.09±0.61	24.94±1.03
Yolk height (mm)	17.26^{a}±0.56	14.09^{b}±0.78	13.44^{b}±0.76	12.53^{b}±0.36	12.39^{b}±0.42	13.31^{b}±0.61	12.42^{b}±0.49
Yolk diameter (mm)	44.76^{b}±1.14	51.15^{a}±2.17	50.01^{a}±1.19	53.48^{a}±1.85	51.33^{a}±1.31	51.46^{a}±1.62	49.25^{a}±0.81
Yolk index	0.39^{a}±0.02	0.28^{b}±0.01	0.27^{b}±0.02	0.24^{b}±0.01	0.24^{b}±0.01	0.26^{b}±0.02	0.25^{b}±0.01
Haugh unit	76.02^{a}±2.66	77.10^{a}±2.39	56.53^{c}±5.51	68.34^{ab}±1.29	64.53^{bc}±2.17	67.45^{ab}±3.72	64.17^{bc}±2.47
Internal quality unit	176.67±0.84	177.27±1.61	174.22±1.06	177.04±1.5	175.62±0.84	175.00±0.89	175.74±0.98

$^{a, b}$: Means in the same row by factor with different superscripts differ significantly($P<0.05$)

Mean ± standard error

Table 5: Interaction effects of Guinea Fowl and Storage Durations on external and internal qualities of egg

Poultry species	Guinea Fowl						
Storage duration (day)	**0**	**5**	**10**	**15**	**20**	**25**	**30**
External							
Initial weight (g)	38.07±1.36	36.83±1.21	37.94±1.47	38.58±0.86	36.04±1.17	36.29±1.45	37.24±1.04
Final weight (g)	0.00^{b}±0.00	36.46^{a}±1.2	37.41^{a}±1.46	37.69^{a}±0.83	35.21^{a}±1.16	34.7^{a}±1.49	35.61^{a}±1.20
Egg weight loss (g)	0.00^{d}±0.00	0.37^{cd}±0.03	0.52^{bc}±0.037	0.89^{b}±0.037	0.82^{bc}±0.07	1.59^{a}±0.29	1.63^{a}±0.32
Egg length (mm)	47.00±0.85	45.19±1.16	47.17±0.51	46.17±0.54	45.53±0.39	46.73±0.99	45.71±0.37
Egg width (mm)	38.07±0.53	38.43±1.69	37.64±0.43	38.20±0.27	37.45±0.55	37.19±0.56	37.69±0.46
Shell weight (g)	5.19±0.23	5.6±0.25	6.04±0.45	5.93±0.25	5.47±0.31	5.84±0.28	5.70±0.25
Shell thick (mm)	0.51^{c}±0.02	0.58^{bc}±0.03	0.67^{a}±0.03	0.63^{ab}±0.01	0.66^{a}±0.03	0.57^{bc}±0.03	0.57^{bc}±0.02
Shell surface area	13.98±0.43	14.72±0.44	15.44±0.76	15.29±0.43	14.48±0.54	15.13±0.48	14.89±0.44
Egg shape index (%)	81.12±1.59	85.99±6.53	79.81±0.56	82.80±1.06	82.28±1.32	79.73±1.68	82.47±0.97
Internal							
Albumen weight (mm)	26.39±1.21	25.49±0.97	25.94±1.22	25.97±0.73	24.19±1.24	24.59±1.46	25.40±0.84
Albumen Height (mm)	5.57^{a}±0.53	5.01^{a}±0.28	4.98^{a}±0.25	3.97^{b}±0.37	3.6^{b}±0.085	3.35^{b}±0.3	3.52^{b}±0.20
Albumen Diameter (mm)	50.78^{b}±2.63	81.93^{a}±3.81	82.93^{a}±3.62	82.64^{a}±2.56	78.06^{a}±2.47	85.69^{a}±1.85	85.04^{a}±1.55
Albumen Index	0.23^{a}±0.03	0.12^{b}±0.01	0.12^{b}±0.01	0.1^{b}±0.01	0.09^{b}±0.00	0.08^{b}±0.01	0.08^{b}±0.01
Yolk weight (g)	11.68^{ab}±0.30	11.34^{b}±0.38	12^{ab}±0.52	12.61^{a}±0.21	11.84^{ab}±0.26	11.69^{ab}±0.21	11.84^{ab}±0.24
Yolk height (mm)	13.93^{a}±0.48	12.79^{ab}±0.63	11.21^{b}±0.55	11.21^{b}±0.26	9.43^{c}±0.61	9.49^{c}±0.67	9.14^{c}±0.46
Yolk Diameter (mm)	35.13^{d}±0.77	38.63^{c}±0.71	39.08^{bc}±0.41	41.45^{ab}±0.7	40.23^{abc}±0.61	42.23^{a}±1.56	40.27^{abc}±0.98
Yolk index	0.40^{a}±0.01	0.33^{b}±0.013	0.29^{c}±0.01	0.27^{cd}±0.01	0.23^{de}±0.02	0.23^{e}±0.02	0.23^{e}±0.01
Haugh unit	80.83^{a}±3.28	77.87^{a}±2.28	77.28^{a}±1.81	68.21^{b}±3.69	67.16^{b}±1.0	64.04^{b}±3.03	65.50^{b}±1.71
Internal quality unit	163.02^{a}±1.23	161.67^{ab}±0.78	162.35^{ab}±1.03	161.80^{ab}±0.75	159.58^{b}±0.90	159.43^{b}±1.16	160.38^{ab}±0.84

$^{a, b, c, d}$: Means in the same row by factor with different superscripts differ significantly ($P<0.05$)

Mean ± standard error

albumen diameter and yolk diameter increased with the increase storage duration. The egg shell weight showed significant difference, these results are in agreement with that of findings that noticed significant change in shell weight during storage at different time and temperature (4). These findings contradicted the report (15) of no effect of storage time on egg shell weight. Albumen weight of domestic chicken egg and guinea fowl egg decreased with storage durations while yolk weight increased with the storage durations. These results are in agreement with the findings (16) that measuring components as proportions of the whole egg removed any inconsistencies, while longer periods of storage resulted in greater percentages of shell and yolk and a lesser percentage of albumen. The albumen diameter of duck eggs increased sharply from day 0 to day 5, however the increased was gradual from day 5 to day 30, along with domestic chicken and guinea fowl egg. The poultry species albumen weights were consistent with the findings (17) that gave no change in albumen and yolk weights within 10 days of storage at any temperature. The height of the albumen indicates the freshness of the egg; the thicker the albumen, the better the quality of the egg, with heights of 8-10mm being considered superior (18). Albumen height, yolk height, albumen index and yolk index decreased as the storage duration increased (19). But as the interior quality deteriorates, the yolk flattens out more and more, these were corroborated by the findings (20) that during egg storage, the quality of the vitelline membrane declines, making the yolk more susceptible to breaking. The decrease in yolk height and yolk index observed in the study could be attributed to degeneration of the vitelline membrane which allows water from the albumen to move into the yolk and gives the yolk a flattened shape (21). These were also responsible for the decrease in albumen height and albumen index. The Haugh unit reduced as the storage durations increased thereby corroborating the findings (4, 22) that storage time and temperature adversely influenced Haugh unit.

The values of the egg shape index reported in this work are in agreement with the range of 0.75-0.78 reported for laying hens (23). A value of 79.57 was reported (24) for guinea fowl egg in Nigeria while 73.7 and 74.7 was reported for French and Polish domestic strains (1) of guinea fowl which did not differ statistically. The values of egg shape index observed in domestic chicken egg; 77.40, duck egg 70.49 and guinea fowl egg 82.03 suggests that eggs of these species are less prone to breakage, Although the egg shape index values from this study shown no significance different during the storage duration in duck and guinea fowl egg, they reflect high genetic value for shell strength which can make them resistance to environmental stress. These results were also supported by the observations (25, 26) that showed no effects of storage time and temperature on shape index of eggs.

Conclusion and Applications

✓ Guinea fowl egg had highest values than domestic egg and duck egg for most of the internal qualities.

✓ Guinea fowl had least weight loss followed by domestic chicken egg while duck had highest weight loss.

✓ Haugh unit decreased with increased in storage durations, domestic chicken egg had highest Haugh unit values on day 0 and day 5, followed by guinea fowl egg while duck egg was least. Guinea fowl egg had highest Haugh unit but became undesirable from above 20 days of storage.

✓ The guinea fowl egg shells were varying shades of brown, domestic chicken egg is brown and duck egg shell are off-white shell. The much larger amount of shell organic matter and stronger shell of the guinea fowl egg may be necessary to cope with the inclement conditions in the wild.

Recommendation

The rate of deterioration of guinea fowl egg internal qualities was lowest when compared to that of domestic chicken and duck eggs and this could be attributed to its shell thickness. On a unit basis, guinea fowl egg has a smaller surface area than the chicken egg which reduce the rate of water loss in guinea fowl egg. Observations on guinea fowl and chicken eggs stored at room temperature for a period of 20 days revealed that the yolk and albumen of the guinea fowl egg retained their qualities better and longer than the chicken egg and duck egg.

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