



Evaluating the Effect of Storage Containers and Duration on Sasso Chicken Eggs Quality Traits at Mid-Production

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Abstract

For the egg industry worldwide, the production of eggs that are of good eggshell quality and good internal quality is critical to the economic viability of the industry. Therefore, there is a growing need for technologies to preserve poultry products, in this case eggs, to prevent or reduce post-harvest losses. The aim of this present study was to evaluate the effects of storage containers and duration on internal and external egg quality traits of eggs stored at five different storage conditions. A total of 120 eggs from Saso breed hens aged 51 weeks were used for the analysis. The storage methods to which the eggs were subjected included: refrigerator, mud pot, plastic jar, bamboo basket, and teff straw at a room temperature range. A factorial experiment 4*5 with a completely randomized design using storage containers and storage duration as treatment was used. The storage times were 0, 7, 14, and 21 days. Weight loss percent, albumen height, haugh unit, yolk, albumen weight, egg weight and egg pH have been found to be important parameters deteriorated by storage method and storage duration. The weight loss was linearly increased with storage duration in all containers. However, refrigerator storage maintained minimum loss of egg weight, yolk and albumen weight, whereas the bamboo baskets and teff straw maintained maximum weight loss at all stages of storage duration. Inconsistent but significant effect of storage durations, especially higher beyond the 14 days of storage, was observed on the yolk pH and albumen pH during the experiment. Storage duration and containers, except the refrigerator and mud pot during the experiment, showed linearly significant declining trends in albumen height and Haugh unit values. Albumen and yolk pH was dramatically increased with increasing storage duration in all containers. The results of the current study indicated that there was significant deterioration of egg quality traits with extended storage duration at different containers. Thus, it was concluded that beyond using refrigerator, cooling storage like mud pots before 14 days of storage could retain quality for a longer time than with the traditional methods compared in this experiment.

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Keywords: Egg quality; Egg storage containers; Haugh units; Saso chicken; Storage duration.



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Introduction

Egg quality is a general term that refers to general standards that define both internal and external quality (Emília *et al.*, 2015). For the egg industry worldwide, the production of eggs that are of good eggshell quality and good internal quality is critical to the economic viability of the industry (Juliet, 2004). Problems with egg quality currently cost the industry many millions of dollars per year. Egg quality is a factor that contributes to the better economical price of fertile and table eggs. The selection criteria to evaluate egg quality implies considering quality from different perspectives. For producers, quality is related to the egg mass and shell resistance; for consumers, quality is related to shelf life and sensory characteristics, such as yolk and shell color; for processors: the quality is also related to the ease of removing the shell and the separation of the yolk from the albumen to the functional properties [4].

The quality of the egg begins to decline as soon as it is laid (Vivian *et al.*, 2017). Hence, it is of great importance to understand the factors that affect eggshell quality and egg internal quality (Juliet, 2004). The management and nutrition of the hen do play a role in internal egg quality; egg handling and storage practices do have a significant impact on the quality of the egg reaching the consumer [8]. The main degradation factors for eggs are storage time, temperature [1,10], humidity, air movement, handling and, in addition, chicken breeds [15]. The shelf-life of food is characterized by a period where it does not suffer any changes in its chemical and organoleptic structure, varying according to the type of food, period of storage and the environment where it will be stored [7].

As a result, appropriate technology for storage of eggs is essential to retain quality. The major difference between fresh and stored eggs is in albumen pH and quality [15] (Vivian *et al.*, 2017). During storage, flattening of the yolk caused by the weakening of the vitelline membrane, the pH of the egg albumen increases, which is related to the deterioration of albumen quality or Haugh unit [10,11]. The albumen of a fresh egg is firm and thick, the air cell is very small, and the albumen and yolk contain no blood or meat spots (Vivian *et al.*, 2017). The increase of albumen pH mainly depends on the buffering capacity of the albumen. Not only this, it also depends on the temperature, storage duration, gaseous environment in the storage room and conductance of the eggshell [2]. Meanwhile, chicken eggs are highly perishable and susceptible to losses [10] hence information on possible storage conditions that would ensure its keeping quality is required, to lessen its deterioration, spoilage, increase its shelf life and make way for its availability all year round at an affordable rate [14]. A number of studies have

been conducted concerning the effects of storage time and temperature on egg quality. However, the interaction effects of time and containers are not fully known. Therefore, the present study was undertaken to evaluate the effects of storage containers and duration of storage on external and internal quality traits of chickens’ eggs in mid-production.

Materials and methods

Study area description

The study was conducted at the Arba Minch Agricultural Research Center Livestock research laboratory. Arba Minch town is located in Ethiopia’s South Ethiopia region. It is located at 505 km to the southwest of the capital of Ethiopia, Addis Ababa. The average altitude of the study area was 1281 meters above sea level and the average annual temperature was 29.7°C, and the yearly rainfall was 900 mm (Engida, 2013).

Experimental eggs

To conduct the experiment, all eggs used were collected from a Sasso breed of equal age, in a similar laying stage and kept under the same management system of the poultry farm located at Arba Minch Agricultural research center. Eggs were collected twice within a day (in less than 24 hours of lay) following the usual procedure of the farm at 11: AM and 5: PM using plastic trays.

Sampling and storing of eggs

From a total of 1500 Sasso chickens introduced to Arba Minch Agricultural Research Center by the Yelemat tirufat initiative, a total of 120 eggs were collected at once within a day at the 50th week of hens’ age (mid-egg production period). Immediately after collecting enough fresh eggs, the eggs were vacuum packaged into a polyethylene bag, sealed, stored in the ice-box, and transported to the Arba Minch Agricultural Research Center laboratory. The eggs were weighed using sensitive balance and their initial weights were recorded. Codes referring to the storage container and duration were randomly given and marked on each egg by permanent marker per treatment. At the end of each marking, all eggs were allocated to the respective containers.

Design and treatment

A factorial arrangement with five storage materials and four storage durations (5x4) 20 treatments with 3 replications of each storage material were used. A total of 120 eggs were used in 20 treatments (4 storage periods x 5 storage containers) with 30 eggs examined in each storage period (0, 7, 14, and 21 days).

Table 1: Research design and treatments arrangement.

Storage duration (days)	Egg storage Material and Temperature															Total
	Refrigerator			Mud pot			Bamboo basket			Plastic Jar			Straw			
	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3	
Fresh	30 Fresh eggs for all in common															30
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	30
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	30
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	30
Total																120 eggs

Evaluation of egg quality

External egg quality traits

The external quality traits of eggs evaluated were egg weight (g), egg length, width (cm), shell weight (g), shell ratio, and shell thickness (mm). Egg weight was individually measured by weighing the egg using a sensitive 0.01g accuracy scale. After the eggs were broken, the eggshell was washed with water and dried at room temperature in order to clean up the remaining albumen. Shell weight (with membrane) was measured using a laboratory weighing scale, and the shell percentage proportion of the shell in the egg was determined by dividing shell weight by egg weight and multiplying by 100.

Internal egg quality traits

The eggs used for external egg quality measurements were also used to measure the internal egg quality traits. The internal egg quality traits that were evaluated include yolk weight, albumen weight, yolk ratio, albumen ratio, albumen height, albumen pH, yolk pH and Haugh unit. The internal egg quality measurements were obtained by carefully breaking the egg followed by separation of the albumen and the yolk contents. The yolk was separated from the albumen and weighed. Albumen height was determined using a digital, high precision caliper (mm). The albumen height was measured in the thick layer of albumen, close to the yolk. The albumen weight was calculated from the difference between the egg weight, and the yolk and shell weight. The percentage proportion of the albumen in the egg was also determined. Albumen weight was calculated from the difference between egg weight and weight of the yolk and shell. The pH of the albumen and yolk was measured individually using a portable instrument of battery drives and glass electrodes digital pH meter (*Ph-013 portable microprocessor-based pH/mV/temperature meter, temp range 0-100°C*). The pH meter electrode tip was rinsed with distilled water and immersed into a buffer solution of pH 6.86, then the electrode immersed in a buffer solution of pH 4.01 (25°C) and also pH 9.18 (25°C) stirred gently and after waiting a few minutes for the calibration after each sample, after that electrode was submerged into the meat and the value of pH was read after 30 seconds [3].

Water loss measurements during storage

An egg was weighed at each sampling time. The same eggs were weighed over the 3-week study. Egg weight loss (%) calculation of whole eggs during storage was adapted from (Vivian *et al.*, 2017).

Total egg weight loss (g) = Initial weight (g) - final weight (g)

The weight loss percentage was calculated in relation to day 0 egg weight (g):

$$\text{Weight loss (\%)} = \frac{\text{Weight loss (g)}}{\text{Initial weight (g)}} * 100$$

To correlate the height of the thick albumen layer with the egg weight, an individual Haugh Unit score [9] was calculated using the egg weight and albumen height. The Haugh Unit values were calculated (the standard measure of quality used and accepted throughout the egg industry) for an individual egg using the Haugh equation:

$$HU = 100 \log (H + 7.57 - 1.7W^{0.37})$$

Where:

HU – Haugh Unit

H – Albumen height (mm)

W – Weight of egg (g)

All measurements were conducted in triplicate.

Statistical analysis

Data analysis of the experiment was performed using the Statistical Analysis System software package (SAS, 2009). An ANOVA using a general linear model included the main effects of storage duration and storage containers of eggs and the two-way interactions between these factors. Significant differences among the means of the treatment groups were determined by Duncan's multiple range tests. All statements of significance are based on the 5% level of probability.

The model used was:

$$Y_{ijk} = \mu + D_i + C_j + DC_{ij} + e_{ijk}$$

Where:

- Y_{ij} – characteristic of egg quality traits
- μ – the intercept
- D_i - the effect of duration (Fresh, 7, 14, 21 days)
- C_j - the effect of storage containers (CP, PJ, BB, TS, and refrigerator)
- DC_{ij} - the interaction effect of temperature, container, and duration
- e_{ijk} – random error

Results and discussions

External egg quality traits

The results of the effects of storage containers over duration on eggs' external qualities are presented in Table 2. Both storage duration and storage containers affect numerically almost all parameters of external egg qualities. Eggs lost their initial weights during holding them in different materials other than a refrigerator from storage time to time strictly and so that egg weight loss percentage was increased significantly ($p < 0.05$) by storage duration from 0 to 21 days in all storage containers. When the storage duration was extended for long days, the overall egg weight loss percentage (mean \pm SD) dramatically increased from 0.51 \pm 0.33% to 4.41 \pm 2.54 % at 7 and 21 days of storage time, respectively (Table 2). The current result is in line with the findings of Kurtu *et al.* [13] and Vivian *et al.* (2017), who reported that the rate of weight loss increased when the storage duration was extended beyond 16 days. These losses could be due to the duration of the storage. The egg starts losing water through its membrane and shell pores to the environment from the time it is laid. Water loss depends on the temperature, airflow and relative humidity during storage. The longer the storage period, the worse critical these factors become, because carbon dioxide transfer through the eggshell is favored by temperature and humidity, especially under room temperature. The drier the atmosphere, the greater the water loss, thus egg vitality is also lost, overall quality [10] (Vivian *et al.*, 2017).

During the experiments, eggs stored in are refrigerator and mud pot were recorded relatively the lowest weight loss for all storage durations. Accordingly, eggs stored in the refrigerator lost only 2.11 \pm 1.07 percent, whereas eggs stored in *teff* straw lost 5.52 \pm 3.10 percent of their initial weights at the end

of 21 days of experiments. This result is in line with the report of Kurtu *et al.* [13] who reported, eggs stored in clay pots and polythene bags were recorded for the lowest weight loss for all storage durations. The low weight loss of eggs kept in the refrigerator and mud pot may be attributed to the ability of the material to prevent moisture loss from eggs by lowering the direct air blowing around the eggs. This is in agreement with the

findings of several authors, such as Kurtu *et al.* [13] and Vivian *et al.* (2017) who recommended the enclosure of eggs in plastic containers during storage for an extended period.

Although there was no statistical difference ($P>0.05$) in weight loss percentage between the bamboo baskets and *teff* straw storage, numerically the heaviest weight loss was noted for *teff* straw throughout the experiment.

Table 2: External egg quality parameters.

Egg storage duration (days)	Egg Storage Container	Variables (Mean ± SD)			
		Egg weight (g)	Egg shell weight (g)	Egg shell ratio (%)	Egg weight loss (%)
Fresh egg	MP	53.67±1.81	5.83±0.76	10.83±1.10	-
	PJ	53.60±1.31	6.17±0.29	11.51±0.79	-
	BB	56.40±0.92	6.00±1.00	10.65±1.73	-
	TS	55.00±2.31	6.33±0.58	11.57±1.51	-
	RF	53.80±0.00	5.67±0.58	10.53±1.07	-
	Overall	54.49±1.69	6±0.63	11.02±1.18	-
	P-value	0.18	0.77	0.78	-
	SL	NS	NS	NS	-
7	MP	53.30±1.92	4.17±0.29 ^b	7.81±0.50	0.69±0.30 ^a
	PJ	53.27±1.22	4.83±0.29 ^{ab}	9.07±0.42	0.62±0.21 ^a
	BB	56.10±0.79	5.00±0.00 ^a	8.90±0.10	0.53±0.30 ^{ab}
	TS	54.60±2.31	5.00±0.50 ^a	9.17±1.12	0.73±0.03 ^a
	RF	53.80±0.00	5.00±0.00 ^a	9.30±0.00	0.00±0.00 ^b
	Overall	54.21±1.67	4.80±0.41	8.85±0.74	0.51±0.33
	P-value	0.19	0.02	0.06	0.01
	SL	NS	*	NS	*
14	MP	52.70±2.04	4.00±1.00	7.58±1.68	1.87±0.51 ^{ab}
	PJ	52.60±1.44	4.00±0.00	7.63±0.21	1.87±0.35 ^{ab}
	BB	54.88±1.20	4.67±0.58	8.54±1.24	2.67±0.68 ^{ab}
	TS	52.90±1.39	5.33±0.58	10.07±1.00	3.77±2.19 ^a
	RF	53.33±0.23	5.00±0.00	9.38±0.04	0.47±0.23 ^b
	Overall	53.28±1.46	4.60±0.74	8.64±1.33	2.13±1.44
	P-value	0.31	0.06	0.06	0.04
	SL	NS	NS	NS	*
21	MP	50.63±0.85	4.67±0.58	9.21±1.06 ^a	4.29±4.52 ^{ab}
	PJ	51.33±1.53	4.67±0.58	9.08±0.95 ^a	4.23±1.92 ^{ab}
	BB	53.50±2.21	4.33±0.58	8.09±0.87 ^{ab}	5.17±2.70 ^a
	TS	51.90±0.85	4.20±0.00	7.71±0.13 ^b	5.52±3.10 ^a
	RF	52.67±0.58	4.70±0.30	8.93±0.66 ^{ab}	2.11±1.07 ^b
	Overall	51.87±1.53	4.47±0.48	8.62±0.91	4.41±2.54
	P-value	0.22	0.34	0.02	0.009
	SL	NS	NS	*	**

^{a, b, ab}=Means within a row not bearing a common superscript are significantly different; *=($p<0.05$); **=($P < 0.01$); ***=($P < 0.001$); MP: Mud pot; PJ: Plastic jar; BB: Bamboo basket; TS: Teff straw; RF: Refrigerator; SL: Significant Level; NS: Non-Significant; SD: Standard Deviation.

This could be attributed to the nature of the baskets and open straw bedding that allows free movement of air around the eggs so that the higher water evaporation of eggs due to heat provision of *teff* straw than the other containers. The other reason could be associated with exposure of eggs to external environmental temperature, which leads to higher loss of carbon dioxide and internal vitality so that weight loss. The other reason could be associated with exposure of eggs to external

environmental temperature, which leads to higher loss of carbon dioxide and internal vitality so that weight loss. The temperature of the basket was similar to that of room temperature. Kurtu *et al.* [13] and Vivian *et al.* (2017) concluded that the rate at which the egg loses weight by evaporation tends to be greater if the air surrounding the egg is moving rapidly. These results are in agreement with those of Samli *et al.* [15], who reported significant ($p<0.001$) egg weight reductions of 2.08 and 3.11%,

respectively, within 5 and 10 days of storage at 29°C. Similar weight loss increment (1.74 to 3.67% at 5 and 10 d of storage time) were also reported by Jin *et al.* [10].

There was no difference in shell weight ratio from 0 to 14 days of storage for all storage materials, whereas during the 21 days of *teff* straw storage, there were significant ($p < 0.05$) decreases in shell weight with increasing storage time. These results are in agreement with those of Samli *et al.* [15] who found that shell weight changed significantly ($p < 0.05$) with storage time and temperature. Similarly, Jin *et al.* [10] report revealed no difference in shell weight from 0 to 10 d of storage at 21°C, whereas at the storage temperatures of 5 and 29°C there were significant ($p < 0.001$) decreases in shell weight with increasing storage time. In contrast, Kurtu *et al.* [13] reported that changes in shell weight were unclear within 20 days of storage duration.

Internal egg quality parameters

Nearly all internal egg quality traits were affected numerically by duration as well as storage materials (Table 3). Except the first 7 days' storage duration, yolk and albumen weight tends to decrease with storage time, so that their weight ratio decreases with storage time. When considered as storage containers for the egg, the weights of the yolk and albumen stored in *teff* straw and bamboo baskets were highly decreased numerically but not statistically different from those stored in refrigerator and mud pot. These results are in agreement with those of Kurtu *et al.* [13] and Vivian *et al.* (2017), who reported that measuring components as proportions of the whole egg removed any inconsistencies, and longer periods of storage resulted in lesser percentages of yolk and albumen. In contrast, Samli *et al.* [15] reported that albumen and yolk weights did not change within 10 days of storage at any temperature.

Table 3: Internal egg quality parameters.

Egg storage duration (days)	Egg Storage Container	Variables (Mean ± SD)							
		Yolk weight (g)	Albumen weight (g)	Yolk ratio (%)	Albumen ratio (%)	Albumen height (mm)	Albumen pH	Yolk pH	Haugh unit
Fresh egg	MP	15.33±0.58	32.50±0.78	28.53±0.81	60.57±0.60	7.00±0.50	7.60±0.10	6.20±0.20	85.38±2.51
	PJ	15.33±0.58	31.43±1.38	28.63±1.35	58.67±1.53	6.87±0.15	7.60±0.10	6.20±0.20	84.63±0.56
	BB	15.67±1.53	32.73±2.04	27.80±3.03	58.10±4.45	7.07±0.38	7.60±0.10	6.20±0.20	84.95±2.47
	TS	16.00±1.00	32.67±2.34	29.07±1.53	59.37±1.85	7.30±0.30	7.60±0.10	6.20±0.20	86.81±1.48
	RF	16.00±0.00	32.57±2.08	29.700±.00	60.52±3.88	6.90±0.10	7.60±0.10	6.20±0.20	84.77±0.62
	Overall	15.67±0.82	32.38±1.61	28.75±1.56	59.44±2.63	7.03±0.32	7.60±0.08	6.20±0.17	85.31±1.69
	P-value	0.79	0.90	0.72	0.78	0.52	1.00	1.00	0.57
	SL	NS	NS	NS	NS	NS	NS	NS	NS
7	MP	15.13±0.49	34.00±1.47	28.40±0.80	63.78±0.51	6.37±0.55	7.90±0.10	6.30±0.10	81.20±2.87 ^{ab}
	PJ	14.90±0.56	33.53±1.46	27.99±1.47	62.94±1.58	6.17±0.15	7.90±0.10	6.33±0.12	80.21±0.94 ^b
	BB	16.30±0.61	34.80±0.66	29.05±0.91	62.03±0.89	6.50±0.20	7.93±0.06	6.50±0.10	81.45±1.11 ^{ab}
	TS	15.60±1.10	34.00±2.34	28.57±1.65	62.25±2.58	6.33±0.21	7.80±0.20	6.40±0.00	80.83±0.72 ^{ab}
	RF	15.33±1.15	33.47±1.15	28.50±2.15	62.21±2.14	6.90±0.10	7.70±0.10	6.40±0.00	84.66±0.65 ^a
	Overall	15.45±0.86	33.96±1.37	28.50±1.30	62.64±1.60	6.45±0.35	7.85±0.14	6.39±0.10	81.67±2.05
	P-value	0.35	0.83	0.93	0.72	0.09	0.19	0.10	0.03
	SL	NS	NS	NS	NS	NS	NS	NS	*
14	MP	15.33±1.53	33.37±0.95	29.08±2.39	63.37±2.81	5.33±0.58 ^{ab}	7.77±0.47	6.67±0.32	74.16±4.26 ^{ab}
	PJ	15.00±1.00	33.60±0.53	28.50±1.16	63.89±0.97	5.33±0.58 ^{ab}	8.70±0.17	6.53±0.15	74.22±3.88 ^{ab}
	BB	16.00±1.73	34.22±3.13	29.19±3.61	62.29±4.48	4.67±0.42 ^b	8.87±0.90	6.90±0.36	67.60±3.43 ^b
	TS	15.67±0.58	31.90±1.39	29.64±1.60	60.28±1.06	4.67±0.58 ^b	8.10±0.36	6.80±0.26	68.38±5.69 ^b
	RF	14.00±0.00	34.33±0.23	26.25±0.12	64.38±0.15	6.33±0.42 ^a	8.03±0.25	6.33±0.12	81.22±2.70 ^a
	Overall	15.20±1.21	33.48±1.63	28.53±2.19	62.84±2.56	5.27±0.77	8.29±0.61	6.65±0.30	73.12±6.16
	P-value	0.33	0.41	0.38	0.33	0.016	0.10	0.14	0.014
	SL	NS	NS	NS	NS	***	NS	NS	**
21	MP	15.17±1.52	30.80±2.17	29.98±3.33	60.81±3.66	4.67±0.58 ^{ab}	8.50±0.17 ^{ab}	6.73±0.21 ^b	69.46±4.95 ^{ab}
	PJ	14.50±1.32	32.1±1.04	28.25±2.42	62.68±1.79	3.60±0.36 ^{ab}	8.90±0.10 ^{ab}	6.83±0.15 ^b	58.63±4.52 ^{ab}
	BB	15.10±1.28	34.07±3.11	28.32±3.61	63.59±3.28	3.40±0.53 ^b	9.03±0.35 ^a	7.50±0.36 ^a	54.89±5.27 ^b
	TS	14.00±1.00	33.90±1.01	27.97±1.78	65.32±1.76	3.27±0.29 ^b	9.30±0.10 ^a	7.70±0.36 ^a	53.15±3.60 ^b
	RF	15.93±0.12	32.03±0.9	30.26±0.49	60.82±1.04	5.03±0.11 ^a	8.10±0.10 ^b	6.43±0.06 ^b	72.17±0.62 ^a
	Overall	14.94±1.19	32.46±2.09	28.83±2.59	62.54±2.84	3.97±0.84	8.77±0.47	7.02±0.55	61.66±8.74
	P-value	0.37	0.19	0.47	0.17	0.00	0.00	0.00	0.00
	SL	NS	NS	NS	NS	**	***	***	**

^{a,b,ab}=Means within a row not bearing a common superscript are significantly different; *=($p < 0.05$); **=($P < 0.01$); ***=($P < 0.001$); MP: Mud pot; PJ: Plastic jar; BB: Bamboo basket; TS: Teff straw; Rf: Refrigerator; SL: Significant level; NS: Non-significant; SD: Standard deviation.

Both albumen height and Haugh Unit (HU) values were significantly affected by storage containers during the experiment (Table 3), whereas the effect was non-significant for albumen height during the first 7 days. The interaction of storage containers and durations had significant effects ($p < 0.05$) on the albumen height and HU values after a week of storage. Under refrigeration, there were no differences ($p > 0.05$) among HU values. As fresh egg overall albumen height decreased from 7.03 ± 0.32 mm to 3.97 ± 0.84 mm, overall HU decreased from 85.31 ± 1.69 to 61.66 ± 8.74 during 21 days of storage, whereas at refrigerator and mud pot decline was insignificant ($p > 0.05$). These results are in agreement with the report of Samli *et al.* [15] and Jin *et al.* [10] who reported that storage time and temperature adversely affected albumen height and HU ($p < 0.001$). Similar results were demonstrated by other scholars [10] (Vivian *et al.*, 2017). However, albumen height and Haugh unit were highest for eggs stored using a refrigerator and lowest for eggs stored using *teff* straw and bamboo baskets (Figure 1). This result agrees with that of [13] (Vivian *et al.*, 2017) who found that albumen height was higher in eggs stored in a refrigerator compared to that obtained from eggs which were subjected to storage at room temperature.

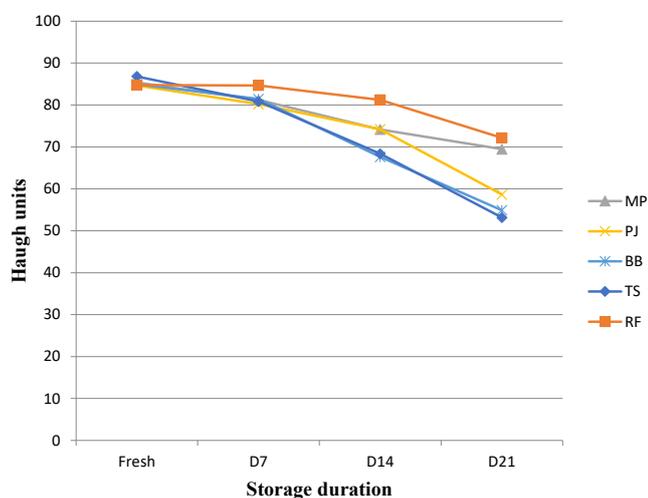


Figure 1: Effect of duration and storage containers on Haugh units.

MP: Mud pot; PJ: Plastic jar; BB: Bamboo basket; TS: Teff straw; Rf: Refrigerator

The dramatic deteriorations in albumen height and HU due to storage time and containers were shown in figure 1 above. Kurtu *et al.* [13] indicated that as the environmental temperature increases, the carbonic acid held in the albumen breaks yielding additional carbon dioxide and water which will escape to the environment through the eggshell. As a result, the mucin fibers lose their firmness and the proportion of the thick albumen decreases. A highly significant interaction effect between storage time and storage containers was observed for albumen pH, yolk pH and HU ($p < 0.001$). Significant increases in albumen and yolk pH values were observed with increasing storage duration. A rapid increase in albumen alkalinity was observed, even during 7 days of storage, regardless of the storage materials. Albumen pH stored in the *teff* straw at the room temperature increased from 7.60 ± 0.10 to 9.30 ± 0.10 (Mean \pm SD). However, a significant increase occurred during the 21 days of storage. The rise in pH detected in yolk was not as large as in albumen; however, there was a significant ($P < 0.001$) difference during 21 days of storage at different storage materials. The present results are in agreement with results reported by other researchers, Samli *et al.* [15]; Jin *et al.* [10]; and Vivian *et al.* (2017) who also found

that increases in yolk pH were significantly affected by storage time. In contrast, Samli *et al.* [15] showed that yolk pH differed from 5.75 to 6.08 during 10 days of storage at 29°C. Most of these changes in egg quality in terms of albumen height, HU, albumen pH, yolk pH were attributed to water loss by evaporation through the pores in the shell and the escape of carbon dioxide from albumen [10,15] (Vivian *et al.*, 2017). As the egg gets older, the dense albumen becomes liquid due to numerous chemical reactions occurring therein; under natural conditions, CO₂ contained therein diffuses through the shell pores and evaporates, decreasing albumen acidity, increasing pH (Vivian *et al.*, 2017). The net effect of these changes is a progressive loss in egg weight and a continual decline in albumen quality as well as HU [10].

Conclusions and recommendations

This study has shown the effect of using different storage containers to store eggs over a time frame in order to determine the most suitable means of preserving them. Cold storages (refrigerator and mud pot) happen to be better than the other methods, since it has values higher than the other storage methods in terms of albumen height, Haugh unit, shell thickness, egg weight and lesser egg weight loss percentage, which are considered to be important parameters in the determination of egg quality. The low weight loss may be attributed to the ability of the material to prevent moisture loss from eggs by lowering the direct air blowing around the eggs. Conversely, eggs stored in bamboo baskets and *teff* straw lost the highest weight for all storage periods, which could be due to the nature of the basket that allows free movement of air around the eggs. The overall results of the present study show that eggs kept for a period of more than 14 days should be stored in a refrigerator or mud pots to delay quality loss of eggs. Moreover, eggs should not be held for longer periods, especially in the hot season during which the environmental temperature is high. Plastic jars, bamboo baskets and *teff* straw can be used to store eggs that would be consumed within very few days of storage. The quality of egg, especially the internal quality, deteriorated greatly with extended duration. The yolk began to stick to the shells and the thick albumen became completely watery and immeasurable. Therefore, eggs should be consumed as soon as possible; otherwise, they should be preserved using cold storage.

Author declarations

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References

1. Bell D. Effects of temperature and storage time on egg weight loss. *Poultry Int.* 1996; 35: 56–64.
2. Benton CE, Brake J. The effect of broiler breeder flock age and length of egg storage on egg albumen during early incubation. *Poult Sci.* 1996; 75: 1069–75.
3. Birhanu AF, Mammed YY, Kurtu MY, O'Quinn T, Jiru YT. Level of pre-slaughter stress and quality of beef from Arsi, Boran and Harar cattle breeds in Ethiopia. *Cogent Food Agric.* 2019; 5:

- 1694233.
4. Carvalho JX, Suarez RO. Extensão da vida de prateleira de ovos pela cobertura com própolis. *Semina Cienc Agrar*. 2013; 34: 2287–96.
 5. Hanusová E, Hrnčár C, Hanus A, Oravcová M. Effect of breed on some parameters of egg quality in laying hens. *Acta Fytotech Zootech*. 2015; 18: 20–4.
 6. Dube EE. Urban planning and land management challenges in emerging towns of Ethiopia: The case of Arba Minch. *J Urban Environ Eng*. 2013; 7: 340–8.
 7. Garcia ERM, Alves MCF, Cruz FK, Conti ACM, Batista NR, Filho JAB. Qualidade interna de ovos: efeito do armazenamento, linhagem e idade da poedeira. *Rev Bras Agropecu Sustent*. 2015; 5: 101–9.
 8. Gerber N. Factors affecting egg quality in the commercial laying hen: A review. 2012. Available from: http://eggfarmers.org.nz/eggfarmers/wp-content/uploads/2012/04/factors_affecting_egg_quality.pdf. Accessed 2013-06-01.
 9. Haugh R. The Haugh unit for measuring egg quality. *US Egg Poultry Mag*. 1937; 43: 552–5.
 10. Jin YH, Lee KT, Lee WI, Han YK. Effects of storage temperature and time on the quality of eggs from laying hens at peak production. *Asian Australas J Anim Sci*. 2011; 24: 279–84.
 11. Jones DR, Tharrington JB, Curtis PA, Anderson KE, Keener KM, Jones FT. Effects of cryogenic cooling of shell eggs on egg quality. *Poult Sci*. 2002; 81: 727–33.
 12. Roberts JR. Factors affecting egg internal and eggshell quality in laying hens: A review. *J Poult Sci*. 2004; 41: 161–77.
 13. Kurtu MY, Duressa D, Yami A. Evaluation of egg storage methods in Eastern Wellelega, Ethiopia. *Int J Agric Food Secur*. 2015; 2: 12–7.
 14. Romao JM, Moraes TGV, Teixeira RSC, Cardoso WM, Buxadé CC. Effects of egg storage length on hatchability and weight loss in incubation of egg and meat type Japanese quails. *Braz J Poult Sci*. 2008; 10: 143–7.
 15. Samli HE, Agna A, Senkoylu N. Effects of storage time and temperature on egg quality in old laying hens. *J Appl Poult Res*. 2005; 14: 548–53.
 16. Feddern V, De Prá MC, Mores R, Nicoloso RS, Coldebella A, de Abreu PG. Egg quality assessment at different storage conditions, seasons and laying hen strains. *Cienc Agrotec*. 2017; 41: 322–33.