International Journal of Agriculture and Food Security Vol. 2 (1), pp. 012-017, February, 2015. Available online at www.advancedscholarsjournals.org © Advanced Scholars Journals

Full Length Research Paper

Evaluation of egg storage methods in Easter Wellega, Ethiopia

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Accepted 03, April 2014

The five common traditional egg storage containers bamboo basket, cartons, clay pots, polythene bags and Teff grains that were identified as storage methods during a preliminary survey carried out in the rural and urban areas of East Wollega Two experiments, of similar experimental materials, procedures and designs, were conducted at different time of the year (May and August) to evaluate these traditional storage methods at Haramaya University poultry farm. A factorial experiment 5 by 5 with completely randomized design using storage containers and storage time as treatment was used. The storage times were 4, 6,8,12 and 20 days. Among the quality parameters considered, weight loss (%) and daily weight loss (%) of eggs were highly affected (P<0.001) by storage containers, durations and their interactions during both experiments. The maximum weight loss was observed after storage period of 16 days for all containers. Polythene bags storage maintained minimum weight loss Vs the baskets at all stages of storage duration. Only storage durations had significant effects (P<0.05) on the egg shell thickness during experiment I. Inconsistent but significant effect of storage durations was observed on the shell weight during experiment I, and weights of yolk and albumen during experiment II. Storage containers during experiment I, and storage durations during experiment II showed significant effects on albumen height and haugh unit values. Except polythene bags which had higher albumen height and haugh unit values, the other containers did not show significant variations for both parameters. The effect of storage duration on these parameters was linear with increasing storage duration; and higher beyond the 16 days of storage. Thus, it was concluded that using polyethylene bags and 16 days of storage could give the best result to store eggs among the traditional methods compared in this experiment.

Key words: Traditional/ egg storage/ changes in egg quality/ optimum egg storage duration/ Eastern Region Wellga/Ethiopia.

INTRODUCTION

The majority of poultry in Ethiopia are raised under traditional system of production. These birds contribute eggs for hatching and consumption (market). Alemu (1995) stated that collecting agents gather together larger numbers of eggs stored in various methods before marking them. The marketing places are usually larger towns and cities where distances to these marketing points are long hence, there is marked deterioration of egg quality. This may create problems on quality and hatchability of eggs from the traditional system of production. Thus, eggs decline in quality and hatchability very easily from the time of laying the different storage methods coupled with storage time practiced by farmers can aggravate the loss in egg quality.

The quality deteriorations are mainly associated to the external and internal quality of eggs (Romanoff and Romanoff, 1949; Stadelman and Cotterril, 1977 and Mountney, 1989)).

Consequently a lot of eggs could be lost and hatchability would dramatically be affected.
Little work has been done in this regard especially under Ethiopian condition, hence there is a knowledge gap in understanding the traditional egg storage methods used in Ethiopia particularly in Welega region despite the prevailing of various traditional methods being used by farmer. This study is therefore, designed to investigate and assess the effect of different storage methods on internal and external qualities of eggs.

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Table 1. Total weight loss (percent) of eggs stored using different containers each at different length of storage period (experiment I)

	Storage durations (days)				
Containers	4	8	12	16	20
Control	0.78q[Ψ]	1.49n	1.90lm	2.26j	4.73d
Baskets	1.2o	2.03kl	2.64hi	3.78e	6.30a
Cartons	1.07op	1.98kl	2.48i	3.60e	5.76b
Clay pots	0.88pq	0.75q	1.75m	2.80gh	5.57c
Polythene	0.88pq	0.36r	0.35r	0.50r	2.16jk
Teff grain	1.02op	2.89g	2.50i	3.28f	5.50c
Containers X durations interaction ***					

[Ψ]Means followed by the same letters within rows and columns are not significantly different; *** = significant at 0.1% level of probability; DMRT.

Table 2. Total weight loss (percent) of eggs stored using different containers each at different length of storage period (experiment II)

	Storage durations (days)				
Containers	**4**	**8**	**12**	**16**	**20**
Control	1.31k[Ψ]	1.36jk	1.58ij	1.61ij	2.61d
Baskets	1.28k	1.68hi	2.01fg	2.37de	3.48a
Cartons	1.21k	1.67hi	1.83jhi	1.90gh	2.95c
Clay pots	1.14k	1.66hi	1.80ghi	1.6ij	2.51d
Polythene	0.64l	0.48lm	0.42lm	0.25m	0.34m
Teff grain	1.26k	1.71hi	2.18ef	2.44d	3.23b
Containers X durations interaction **					

[Ψ]Means followed by the same letters within rows and columns are not significantly different, ** = significant at 1% level of probability, DMRT.

MATERIALS AND METHODS

Two experiments of similar materials and procedures were conducted factorial experiment 2 by 5 in a completely randomized design using different storage containers and storage time as treatment. The storage containers were bamboo basket, cartons, clay pots, polythene bags and Teff grains and the storage times used were 4, 6,8,12 and 20 days. The experiments were conducted at different times of the year (May and August) at Haramya University (HU) poultry farm in year 2000.

All eggs used in the experiment were obtained from white leghorn layers having equal age, in similar laying stage and kept under the same standard management of the HU poultry farm. Eggs were collected twice per day (following the usual procedure of the farm) at 11: AM and 5: PM using plastic trays. Eggs from four consecutive collections were used for each of the storage durations. Storage periods were calculated from the time the eggs were allocated to the storage containers.

After collection eggs were candled and eggs with visible cracks were removed. Eggs were then weighed using a sensitive balance and their initial weights were recorded and marked on the blunt end of each egg. Codes referring to the storage container and duration were randomly given and marked on each egg. At the end of each collection period, all eggs were allocated to the respective containers at random. Except the polythene bags whose open side were folded once, the containers were not covered during the storage period.

The temperature of the room was recorded four times daily during the entire period of the storage using a thermo-hygrometer.

Measurements

All eggs stored in each container (bamboo baskets, cartons, clay pots polyethylene bags, and teff grains) and for each specific storage period i.e. 2,6,8.12.and 20 days (treatments) were taken out for measurement. The parameters used to measure the effect of storage methods on internal and external egg quality were:

Egg weight loss
Percentage weight loss
Daily weight loss of eggs (%)
Eggshell thickness

Table 3. Average daily weight loss (percent) of eggs stored using different containers each at different length of storage period (Experiment I)

	Storage durations (days)				
Containers	**4**	**8**	**12**	**16**	**20**
Control	0.20hijk[Ψ]	0.19ijkl	0.16kl	0.14lm	0.24efgh
Baskets	0.30bc	0.25cdefg	0.22fghij	0.24efgh	0.32b
Cartons	0.27bcdef	0.25def	0.21ghij	0.22fghi	0.29bcd
Clay pots	0.22fghij	0.09n	0.15lm	0.18ijkl	0.28bcde
Polythene	0.22fghij	0.04o	0.03o	0.03o	0.11mn
Teff grain	0.25cdefg	0.36a	0.21ghij	0.20ghjk	0.27bcde
Containers X durations interaction ***					
s.e.m. (±) = 0.015					
C.V. (%) = 10.19					

[Ψ]Means followed by the same letters within rows and columns are not significantly different; ***= significant at 0.1% level of probability; s.e.m. = Standard error of the mean; c.v. = Coefficient of variation.

Table 4. Average daily weight loss (percent) of eggs stored using different containers each at different length of storage period (Experiment II).

	Storage durations (days)				
Containers	**4**	**8**	**12**	**16**	**20**
Control	0.33a[Ψ]	0.17efg	0.13hij	0.10k	0.13hij
Baskets	0.32ab	0.21d	0.17efg	0.15ghi	0.17ef
Cartons	0.30bc	0.21d	0.15fgh	0.12jk	0.15ghi
Clay pots	0.28c	0.21d	0.15gh	0.10k	0.13ij
Polythene	0.16efg	0.06l	0.03m	0.02m	0.02m
Teff grain	0.31ab	0.21d	0.18e	0.15fgh	0.16efg
Containers X durations interaction ***					
s.e.m. (±) =0.015					
C.V. (%) =10.19					

[Ψ]Means followed by the same letters within rows and columns are not significantly different; ***= significant at 0.1% level of probability; s.e.m. = Standard error of the mean; c.v. = Coefficient of variation.

Albumen height (AH)
Haugh unit (HU)

Data analysis

Data analysis of the experiment was performed using the computer software (MSTAT, 1989). Whenever the ANOVA revealed significant differences among the treatment means, Duncan's Multiple Range Test (DMRT) was used to separate the means.

All statements of significance are based on the 5 % level of probability.

RESULTS AND DISCUSSION

Storage containers, durations and their interactions had highly significant effects ($p<0.001$) on the percent weight loss of eggs during both experiments. The mean percent loss of egg weights due to the interaction effects of storage containers and durations during experiments I and II are shown in (Tables 1 and 2) respectively.

In experiment one, the mean percent weight loss of eggs during the first 4 days of storage was not significant for all containers. But eggs stored in all containers lost about 1 percent of their original weights during the first 4 days of holding in both experiments.

In both experiments, the rate of weight loss was increasing when the storage duration was extended beyond 16 days (Tables 1 and 2) with the exception of polyethylene which was lowest 2.2 and 0.03 for experiment 1 and 2 respectively.

As indicated in (Table 3) for experiment I, the percent loss of weight from eggs kept in all containers except polythene bag increased linearly; the rate of increment being highest beyond the 16th day of holding for all containers. Similar trend was also observed during experiment II (Table 4). At the end of the 20 days of storage, the maximum weight loss was recorded from eggs

Table 5. Effects of storage containers on some external and internal qualities of eggs during experiment I.

	Parameters							
Containers	WL (%)	WLPD (%)	SHT (mm)	SHW (%)	YKW (%)	ALBW (%)	AH (mm)	HU
Control	2.33d[Ψ]	0.18b	0.339	9.9	31.7	58.6	4.3b	76b
Baskets	3.19a	0.27a	0.326	9.7	31.1	59.2	4.0b	74b
Cartons	2.98b	0.25a	0.322	9.7	31.9	58.4	4.4b	76b
Clay pots	2.35c	0.18b	0.331	9.6	31.5	58.9	4.3b	76b
Polythene	0.85e	0.09c	0.331	10.2	31.1	58.8	5.6a	86a
Teff grain	3.04b	0.26a	0.334	10.2	31.2	58.6	4.3b	77b
Prob. [#]	***	***	NS	NS	NS	NS	**	*
s.e.m. (±)	0.028	0.007	0.002	0.027	0.03	0.026	0.008	1.815
C.V. (%)	3.68	10.19	4.83	2.75	1.72	1.08	15.72	6.22

WL = percentage weight loss; WLPD = percentage weight loss per day; SHW = percentage weights of shell; YKW = yolk weight; ALBW = albumen weight; SHT = shell thickness; AH = albumen height and HU = Haugh unit; [Ψ]= Means within columns followed by common letters are not significantly different from each other; * = significant at 5%; ** = significant at 1%; *** = significant at 0.1%; NS = not significant at 5%; s.e.m. = Standard error of the mean; c.v. = coefficient of variation.

kept in basket, carton, clay pot and Teff grain during both experiments. During experiment I, the mean weight loss from eggs kept in these containers was more than 5 percent during the longest (20 days) of storage.

In both experiments, eggs stored in polythene bags were recorded the lowest weight loss for all storage durations. Accordingly, eggs stored in polythene bags lost only 2 and 0.34 percent of their initial weights at the end of 20 days during the first and second experiments respectively.

The low weight loss of eggs kept in polythene bags 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 Romanoff and Romanoff (1949) and Smith (1930) who recommended the enclosure of eggs in plastic containers during storage for an extended period.

Conversely, eggs stored in bamboo baskets with straw bedding 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. Smith (1990) and Romanoff (1940) concluded that the rate at which the egg looses weight by evaporation tends to be greater if the air surrounding the egg is moving rapidly. The temperature of the basket was similar to that of the room.

The effects of storage containers x duration interaction on the mean percent egg weight losses per day during the entire period of experiment I and II are presented in (Tables 3 and 4) respectively. Similar pattern as the total egg weight loss was observed for the daily percent weight loss of eggs. Though the figures are inconsistent for experiment I, the daily percent weight loss of eggs kept in all containers showed a linearly declining trend up to the 16th day of storage during both experiments. In agreement with this point, Romanoff (1940, 1943b) concluded that in terms of the egg's original weight, the daily loss diminishes throughout the holding periods. However, in both experiments of the present study the daily percent weight loss of eggs kept in all containers showed a marked increase during the last 17 to 20 days of holding.

During the first experiment, eggs stored in polythene bags and clay pots lost small weights per day when storage period was extended from 8 to 16 days.

After 20 days of storage (experiment I), the daily weight loss (%) of eggs from all containers except the polythene bag did not show significant variation. The mean daily weight losses of eggs kept in the polythene bag were 0.22, 0.04, 0.03, 0.03, and 0.11 percent during storage periods of 4, 8, 12, 16, and 20 days respectively. Except for the first 4 days of holding, the mean percent weight loss of eggs kept in polythene bags was significantly lower than eggs kept in cold room. During experiment II, on the other hand, the daily weight loss of eggs from polythene bags were significantly lower than the control for all storage periods.

In experiment I, the daily percent weight loss of eggs stored in all containers at the end of 20 days was slightly higher than the corresponding values observed at 4 days of storage, where as the reverse was true during the second experiment.

The relatively high environmental temperature that prevailed during the entire period of the first experiment might be one of the main reasons for the high weight losses of eggs during the first experiment than the second. It has been indicated by many investigators that temperature and relative humidity are the most important environmental variables to affect the loss of moisture from eggs during holding; other factors being kept constant.

Table 6. Effects of storage durations on some external and internal qualities of eggs during experiment I.

Parameter	Storage duration (days) 4	8	12	16	20	Significance	s.e.m (±)
WL (%)	0.97e[Ψ]	1.58d	1.94c	2.70b	5.00a	***	0.026
WLPD (%)	0.24a	0.20b	0.16c	0.17c	0.25a	***	0.006
SHT (mm)	0.322b	0.336ab	0.321b	0.342a	0.332ab	*	0.002
SHW (%)	9.6b	9.8ab	9.6b	10.2a	10.0ab	*	0.025
YKW (%)	30.8	31.7	31.6	31.4	31.5	NS	0.028
ALBW (%)	59.6	58.5	58.9	58.3	58.3	NS	0.024
AH (mm)	5.5a	4.6b	4.8ab	3.9c	3.5c	***	0.007
HU	84a	79a	80a	73b	70b	***	1.657

WL = percentage weight loss; WLPD = percentage weight loss per day; SHW = percentage weights of shell; YKW = yolk weight; ALBW = albumen weight; SHT = shell thickness; AH = albumen height and HU = Haugh unit; [Ψ]= Means within rows followed by common letters are not significantly different from each other; *= significant at 5%; **= significant at 1%; ***= significant at 0.1%; NS = not significant at 5%; s.e.m. = Standard error of the mean.

Table 7. Effects of storage containers on some external and internal qualities of eggs experiment II.

Containers	WL (%)	WLPD (%)	SHT (mm)	SHW (%)	YKW (%)	ALBW (%)	AH (mm)	HU
Control	1.70c	0.17c	0.341	9.0	31.5	59.5	5.6	88
Baskets	2.16a	0.20a	0.351	9.3	31.6	59.1	5.7	90
Cartons	1.91b	0.19b	0.336	9.1	32.2	58.7	5.4	86
Clay pots	1.74c	0.17c	0.328	8.7	32.1	59.2	5.1	86
Polythene	0.43d	0.06d	0.332	9.3	31.1	59.5	5.6	87
Teff grain	2.16a	0.20a	0.343	9.3	32.5	58.7	5.0	84
Significance	***	***	NS	NS	NS	NS	NS	NS
s.e.m. (±)	0.038	0.003	0.006	0.196	0.304	0.358	0.024	1.648
C.V. (%)	7.22	6.14	5.41	6.81	3.03	1.92	14	6.02

WL = percentage weight loss; WLPD = percentage weight loss per day; SHW = percentage weights of shell; YKW = yolk weight; ALBW = albumen weight; SHT = shell thickness; AH = albumen height and HU = Haugh unit; [Ψ]= Means within columns followed by common letters are not significantly different from each other; ***= significant at 0.1%; NS = not significant at 5%; s.e.m. = standard error of the mean; c.v. = coefficient of variation.

Romanoff (1940) stated that the rate of weight loss is accelerated at higher temperatures and retarded at higher relative humidity.

Egg Shell Thickness

Only the storage durations had significant effects on shell thickness ($p<0.05$) during the first experiment (Table 8). Statistically, no significant differences were observed ($p>0.05$) among the means of egg shell thickness for storage containers (Table 7), durations (Table 8), and their interactions during experiment II.

Percentage Weights of the Major Egg Parts

There were no significant effects of type of storage containers and container X duration interaction observed ($P>0.05$) on the mean percentages of the shell, yolk and albumen during both experiments (Table 7). Storage durations had significant effects on the weight of egg shell ($P<0.05$) during experiment I (Table 8).

As indicated in table 10 during experiment II, the percent weights of yolk and albumen were significantly affected ($P<0.05$) by storage duration.

Though the trend seems inconsistent with days of holding, the percent weights (proportion) of yolk and albumen fluctuates with a negatively correlated manner. The significant weight loss of albumen was observed at day 8 of holding during which the yolk gained the maximum weight. The inconsistency of the proportion of the two components might be due to the fluctuating environmental temperature during the entire period of the experiment. It has been indicated that during the early holding period, the albumen looses water not only by evaporation through the shell, but also by diffusion to the

Table 8. Effects of storage durations on some external and internal qualities of eggs during experiment II.

	Storage duration (days)						
Parameter	4	8	12	16	20	Significance	s.e.m (±)
WL (%)	1.14d	1.43c	1.64a	1.70b	2.52a	***	0.035
WLPD (%)	0.28a	0.18b	0.14c	0.11e	0.13d	***	0.003
SHT (mm)	0.331	0.347	0.341	0.337	0.337	NS	0.005
SHW (%)	9.1	9.4	9.0	9.2	9.0	NS	0.179
YKW (%)	31.0c	32.3a	31.9ab	31.4bc	32.2ab	*	0.278
ALBW (%)	59.9a	58.3c	59.2abc	59.4ab	58.8bc	*	0.327
AH (mm)	6.5a	5.5b	5.4b	4.9bc	4.6c	***	0.022
HU	94a	87b	88b	83bc	81c	***	1.504

WL = percentage weight loss; WLPD = percentage weight loss per day; SHW = percentage weights of shell; YKW = yolk weight; ALBW = albumen weight; SHT = shell thickness; AH = albumen height and HU = Haugh unit; $^{\Psi}$= Means within rows followed by common letters are not significantly different from each other; *= significant at 5%; **= significant at 1%; ***= significant at 0.1%; NS = not significant at 5%; s.e.m. = standard error of the mean; c.v. = coefficient of variation.

yolk. This movement of water between the components is the result of osmotic gradient across the vitelline membrane. Romanoff (1949) reported that the direction of diffusion is initially from albumen to yolk, because the osmotic pressure of the yolk is greater. The movement of water reverses when albumen, becomes more concentrated as a result of diffusion. Smith (1990) also reported that the noticeable enlargement of the yolk in the aging egg is due to its increased content of water.

Albumen height (AH) and Haugh units (HU)

Both albumen height and haugh unit values were significantly affected by storage containers during experiment I, (Table 7) whereas the effect was non significant for both parameters during experiment II (Table 8). The interaction of storage containers and durations had no significant effects (p>0.05) on the albumen height and HU values (Table 3) for both experiments.

Except the polythene bag that had significantly higher AH and HU values (5.6 and 86 respectively), the other containers did not show significant difference for the mean values of both parameters. The highest albumen height observed for eggs stored in polythene bags might be attributed to the ability of the plastic material to minimize the rate of water loss mainly from the albumen. North (1984) indicated that water comprises about 84 percent of the albumen and whenever the rate of water loss is minimum the albumen retains its water content and the dense part will remain firm giving higher AH and HU values which is an indication of internal quality.

During experiment II, (Table 7) the mean HU values were in descending order and the variation was not statistically significant (P>0.05).

Storage durations had highly significant effects (P<0.001) on the albumen height and HU values during both experiments (Table 7 and Table 8). During experiment I, the mean AH values were moreover, higher rates of AH and HU losses observed from eggs held beyond 12 days.

During experiment II the loss of albumen height (AH) and haugh unit (HU) values were linear with extended storage periods compared to experiment I Table 7 and 8).

The relatively lower environmental temperature and higher initial egg weights during the second experiment might be the reasons for the higher albumen height (AH) and Hough unit (HU) values observed in experiment II than the first. Mountney (1989) 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 loose their firmness and the proportion of the thick albumen decreases.

CONCLUSION

In both experiments, eggs stored in polythene bags were found to have the lowest weight loss for all storage durations. 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 with straw bedding 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.

Except the polythene bag that had significantly higher AH and HU values (5.6 and 86 respectively), the other containers did not show significant difference for the mean mean values of both parameters. The highest albumen height observed for eggs stored in polythene bags might be attributed to the ability of the plastic material to minimize the rate of water loss mainly from the albumen. The overall result of the present study show that egg kept for a period of more than 16 days could be stored in a polythene bag to maintain its quality. Moreover, egg should not be held for longer periods especially in hot season during which the environmental temperature is high.

ACKNOWLEDGEMENT

The authors fully appreciate Haramaya University for providing the main author with both material and financial support to undertake this work. All staff in the Department of Animal Sciences that have directly or indirectly made an important contribution to the success of this work are highly acknowledged.

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