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Original Research Article

Effect of Handling and Storage on Eggs Quality in Khartoum State

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Abstract

This study was carried out to determine the effects of handling and storage of eggs in Khartoum State markets on quality parameters for table eggs. The experiment commenced by a questionnaire that studied the consumer's level of awareness about egg quality and associated information where, a group of people (Staff, officials, laborers and students) as representatives of Bahri University community were targeted. In addition, the effects of storage and handling on table egg quality were studied on table eggs that were collected from the poultry unit of the College of Animal production farm at Al Kadaro area, Khartoum North. Ninety eggs were collected and divided into 5 groups each containing 18 eggs. The collected eggs were subjected to external and internal egg quality measurements to determine egg quality as follow: group one at the time of collection. Each of the rest 4 groups was further divided into 2 groups; one of these 2 groups was stored at a refrigerator at 4 C^0. The other group was stored under room temperature. Quality measurements were carried out at the end of week one, two, three and four for respective groups. The status of egg purchase, knowledge about egg suitability for consumption, preservation of egg quality and the status of knowledge about deteriorated eggs were the parameters covered by the questionnaire. Weight of egg, egg condition, air cell, shape index, shell weight, shell strength and shell thickness, albumin index, albumin high, Haugh unit, yolk shape, odor, were the parameters measured to test the effects of storage on table egg quality. Results of the questionnaire indicated that, Bahri University community as an educated community is aware about most elements of egg quality attributes. On the other hand, results of external and internal parameters tested showed significant differences on egg weight loss, air-cell depth, albumen height and albumen index, Haugh unit and yolk shape. The study concluded that very little efforts are needed to raise the level of awareness for the studied community that, temperature and time of storage have negative effects on egg quality.

Keywords: Egg quality, storage, handling, shell strength, questionnaire.

INTRODUCTION

The egg is one of the most complete and palatable foods available. The nutritive content of an average large egg includes, 6.3 g protein, 0.6 g carbohydrates, 5.0 g fat. Egg protein is of high quality and easily digestible (Miles and Henry, 2004). In addition, eggs contain vitamins A, D, and B12, and also contain B1 and riboflavin (Jones, 2004). Moreover, eggs are a good source of most minerals. However, these properties can be reduced if

the egg is not maintained under good quality. Quality has been defined by Kramer (1951) as the properties of any given food that have an influence on the acceptance or rejection of this food by the consumer. Egg quality refers to several standards which define both internal and external quality such as shell, albumen and yolk (Kul and Seker, 2004). Egg quality is very important because egg is one of the most valuable food item consumed by humans. Due to this high-quality, eggs are used in many food preparations and many industries, which make them one of the factors that contribute to food borne diseases outbreaks. Bearing this public health importance in mind few efforts were exerted to secure their safe consumption for humans. This can be done through proper storage and efficient handling from the production areas to consumption centres.

In Sudan, most egg dealers (producers, wholesalers and retailers) do not handle and store their eggs properly when transporting them to consumers; instead they may sell them to shops or open markets where storing conditions are not controlled. The improper storage situations under these trading facilities may lead to rapid deterioration in egg quality. On the other hand, rough handling can cause smell, almost invisible cracks in the shell that make the egg more prone to bacterial infection (Codex, 2001). The above problems can sometimes be overlooked because many Sudanese consumers are not informed about egg quality and related deterioration and purchase from these places without self-inspection and attention to egg storage. Little work has been done in Sudan to determine the effects of handling and storage in table egg quality under the above-mentioned conditions. Such knowledge is very important to evaluate and correct the situation.

The objective of this study therefore, is to determine the effects of handling and storage of eggs in Khartoum State markets on table egg quality. This will help to increase the consumer's awareness about egg quality, Assess egg quality deterioration due to different storage time and determine the best way to market eggs without deterioration in its quality.

MATERIAL AND METHODS

Site of the experiment and duration

This study was conducted in Khartoum State, Sudan, during the period from- March to April-2018. Firstly, the study commenced by a questionnaire that studied the consumer's level of awareness about egg quality deterioration, Secondly, the effects of storage on egg quality was studied, on eggs that were collected from the poultry unit of the College of Animal production farm at Al Kadaro area. Ninety eggs were collected and divided into 5 groups each containing 18 eggs.

Data collection

A questionnaire was designed and distributed. This was filled by Students, Laborers, Employees and Staff members of the College.

The collected eggs were subjected to external and internal egg quality measurements to determine egg quality as follow: group one at the time of collection. Each of rest 4 groups was further divided into 2 groups; one of these 2 groups was stored at a refrigerator at 4 C^0. And the other group was stored under room temperature. Quality measurement was carried out at the end of week one, two, three and four for respective groups.

Parameters studied

2.3.1 External measurements (Weight of egg, egg condition, air cell, shape index, shell weight, shell strength and shell thickness).

2.3.1.1 Egg condition or aging (fresh or old): The egg condition in this study was determined individually by two methods: (Floatation technique in which eggs was placed in a bowl filled with cold water. Eggs that sank and lay on their sides on the bottom of the bowl were counted as fresh while those floated and stayed on surface of the water were considered as not fresh. The other methods was: (Candling, candling was used to identify the age of eggs and dirtiness, cracked or broken eggs as well as eggs with imperfection such as blood spots away from clean, intact and shell eggs. Candling involves passing eggs over a strong light source which allows for very fine hair line cracks to be identified with the naked eye (Lake, et al., 2004).

2.3.1.2 Condition of the air cell: This was detected through candling using a Candler to determine the size and position of the air cell.

2.3.1.3 External changes that affect egg quality: These include appearance, size, shell cleanliness, shape index and thickness.

Appearance: This was determined by naked eye. The acceptable shape should have sharp and broad end with oval shape. Shell cleanliness: This was determined by external observations by naked eye. Eggs were described as clean, no stain and no dirt. Shape index: This was determined by measuring the width and the length of the egg using the slide caliper and shape index was expressed as follow: Shape index= (width/length) 100.

Shell thickness: It was determined with floating technique where eggs were immersed in brine solution 10% NacL solution.

2.3.2 Internal measurements (Albumin index, albumin high, Haugh unit, yolk shape and odor)

2.3.2.1 Internal characteristic: These include odor, yolk colour, firmness, yolk, white, stains and blood. Odor:

This was measured by smelling that may be in form of sulpharic hydrogen gas, offensive, soap and other odors. Firmness: This was measured by candling with the help of a Candler which express the white as firm or clear. The yolk: This was determined by measuring the yolk height with a micrometer and yolk width by a slide caliper to determine the standing up quality of the yolk. E.g. Yolk indices = height/ width. When the yolk is flattened the indices, number is lower indicating a low-quality egg. The white: This was determined by measuring the height of albumen. The mean of three measurements for any broken egg in petri dish taken at about 10mm from the yolk. Using slide caliper and the calculation as follow:
Hugh unit= log H+7.37-1, 7.
When H=height of white.
Lastly take the average of all the sample.
Stains and blood: This was determined by the naked eye.
Yolk colour: Yolk color was determined with Roche colour fan.

Albumen Index

Albumen index is defined as height of the albumen divided by the width of the albumen (Heiman and Carver, 1936). Albumen height measurements were recorded using the standard tripod micrometer. The albumen width was determined by averaging the minimum and maximum of the broken-out egg with dial calipers (Bel-Art Products, Pequannock, NJ). Egg was broken in a petri-dish and the yolk colour of each egg was compared with the same color in the Roche fan which consist about 15 degrees of colour. It thus provides an objectively defined colour standard for the evaluation of egg yolk.

Statistical analysis

Data obtained by the questionnaire was analyzed by using statistical package of social sciences (SPSS) computer program (version 12) Quintero, Dino; et al, (2012). While T test was employed in means separation of egg quality.

RESULTS AND DISCUSSION

Questionnaire about egg quality

The following tables show obtained results on the status of egg purchase, knowledge about egg suitability for consumption, preservation of egg quality and the status of knowledge about deteriorated egg in a group of people (Staff, officials, laborers and students) as representatives of Bahri University community. Status of egg purchase at the university is shown in Table 1. The table shows that the majority (72.5%) of the respondent samples consume egg regularly, (57.5%) purchase from shops and (31, 5%) consume one or two trays of egg per month. These results indicate that the community is aware about the importance of egg as food but not know the importance of proper egg storage since considerable percentage purchased from shops instead of supermarkets where proper egg storage is found, and egg consumption is average in the community. The above results reveal that an extension message to raise the community awareness in these aspects is a necessity. This result contradicts what was reported by Kralik et al. (2013) who found that consumers purchased eggs from the store or supermarket less than 10% of respondents. The Knowledge about eggs suitability for consumption in Bahri University community is presented in Table 2. The table shows that the majority (70%) check egg suitability before purchase and (43.75%) check it from the external appearance and 20% of the community expects that quality is deteriorated by long storage period. This indicates that community is aware about the importance of egg suitability before using it. These results accords will with, (Hasan and Okur, 2009) who found that poor storage conditions can reduce eggs grading within a few days. Improper storage is reported to produce some observed changes: a change of thick albumen to watery albumen.

The community practices as regards the preservation of egg quality are indicated in Table 3. The table shows that 33.75% of the community consume the purchased eggs under one week, 75% store eggs in refrigerator, in addition the table also shows that the majority (68.75%) purchase deteriorated eggs and 30% found deteriorated eggs twice in their purchase. This result indicates that most community of the Bahri University know the importance of temperature as the main factor causing deterioration in eggs quality, but they have not exact informant about the range of the deterioration. The status of knowledge about deteriorated eggs is shown in Table 4. The table shows that 33% of the consumers observed eggs deterioration through foul odor. These imply that community knowledge about deteriorated eggs is good and 72.5% of them purchased broken eggs before cooking. In addition, the table also shows that 40% found broken eggs more than three times in their purchase. The current result indicates that most of the community members of Bahri University know the fact that proper handling is very important for eggs quality preservation. Moreover, most community members are ready to follow advices on eggs use if available which can ease any future efforts to raise the community awareness regarding eggs quality.

The effect of storage and time on table eggs quality

The results of weight loss and air cell depth of eggs stored in room and refrigerator for four consecutive

Table 1. Status of eggs purchase

Parameter	Question	Answer	Number	%
Eggs purchase	Do you consume eggs regularly	Yes	58	72.5
		No	22	27.5
Place of purchase	From which source do you purchase eggs	Supermarket	32	40
		Shops	46	57.5
		Moving seller	2	2.5
	How many trays you purchase in a month	Half	20	25
		One	25	31.25
		Two	25	31.25
		More	10	12.5

Table 2. Knowledge about eggs suitability for consumption

Parameter	Question	Answer	Number	%
Eggs suitability	Do you check eggs suitability	Yes	56	70
		No	24	30
Checking of eggs suitability	How do you check eggs suitability	Ask the trader	31	38.75
		External appearance	35	43.75
		After breaking	14	17.5
Eggs quality deterioration	What factors that affect eggs quality	Temp.	11	13.75
		Long storage	16	20
		Both of the above	53	66.25

Table 3. Preservation of eggs quality

Parameter	Question	Answer	Number	%
Time for eggs consumption	What is the average time during which you consumed the purchased eggs	One week	27	33.75
		Two weeks	25	31.25
		Three weeks	23	28.75
		More	5	6.25
Ways of eggs keeping	How do you keep eggs in your house	Inside the refrigerator	60	75
		Outside the refrigerator	20	25
Eggs quality deterioration	Did you purchased a deteriorated eggs	Yes	55	68.75
		No	25	31.25
Purchase of deteriorated eggs	How many times you purchased deteriorated eggs	Once	21	26.25
		Twice	24	30
		Thrice	12	15
		More	23	28.75

Table 4. Status of knowledge about deteriorated eggs

Parameter	Question	Answer	Number	%
Types of eggs faults	What type you observed	Foul odor	28	33
		Blood spots	29	36.25
		Change in color	23	28.75
Status of eggs breakage	Did you purchase eggs that broke before cooking	Yes	58	72.5
		No	22	27.5
	How many times you purchased eggs that broke	Once	15	18.75
		Twice	20	25
		Thrice	13	16.25
		More	32	40
Advices on eggs use	Do you follow advices on eggs use if available	Yes	76	95
		No	4	5

Table 5. The effect of storage temperature and storage days on egg weight or weight loss and air-cell depth[1]

Parameters/ Days	Weight loss		Air cell depth	
	Room temp.	Refrigerator	Room temp.	Refrigerator
1	0.0± 0.0	0.0 ± 0.0	16.96 ± 1.65	17.22 ± 1.42
7	1.88 ± 0.37	0.33 ± 0.14	8.29 ± 1.03	4.13 ± 0.39
14	5.72 ± 4.70	0.63 ± 0.07	11.88 ± 3.03	6.70 ± 1.59
21	8.08 ± 1.38	2.38 ± 3.61	16.52 ± 1.45	7.30 ± 0.98
28	23.38 ± 0.88	21.56 ± 0.82	14.38 ± 1.91	6.78 ± 1.02
Mean	7.82± 9.26 a	4.98 ± 9.31 b	13.60 ± 3.59 a	8.43± 5.07 b
LS.	**(0.0001)		**(0.0001)	

1= Means are values of 9 egg each
a, b = values with different superscript letters are significantly different
LS = Level of Significance.
*** = Highly significant difference*

Table 6. The effect of storage temperature and storage days on shape index and shell weight[1]

Parameters/Days	Shape index		Shell weight	
	Room temp.	Refrigerator	Room temp.	Refrigerator
1	73.74 ± 3.23	73.60 ± 2.21	6.54 ± 0.56	5.99 ± 0.81
7	74.27 ± 2.45	74.84 ± 1.55	6.24 ± 0.50	6.47 ± 0.68
14	73.77 ± 2.62	74.29 ± 1.92	6.51 ± 0.72	6.70 ± 0.19
21	75.48 ± 2.30	75.04 ± 1.48	3.67 ± 0.17	3.83 ± 0.47
28	71.78 ± 1.29	74.43 ± 2.51	6.07 ± 0.57	6.34 ± 0.49
Mean	73.81 ±1.33	74.44 ± 0.56	5.81 ± 1.21	5.87 ± 1.17
LS.	N.S (0.1803)		N.S (0.1803)	

1= Means are values of 9 egg each
LS = Level of Significance.
N.S = Not Significant

weeks are shown in Table 5. The table indicates that both parameters deteriorated with the increase in time of storage in both room and refrigerator; however, eggs kept under room temperature showed the worse result compared to those kept inside refrigerator. This result confirms the role of temperature on the preservation of both of egg weight loss and air cell depth. As far as egg weight loss is concerned similar results were reported by (Protais et al., 1989) who found that, the loss in weight is attributed to loss of humidity from inside the egg due to evaporation effects. It also accords well with Jones and Musgrove (2005) who reported a decrease in albumin height and weight of eggs with storage leading to decreased egg weight. Samli et al., (2005) observed a decrease in egg weight within 10 days of storage. The rate of weight loss of stored eggs is dependent on the temperature and humidity, with weight loss being greatest at higher temperature and lower humidity (Washburn, 1998). These results are similar to that reported by (Abonajmi et al., 2010) who reported significant difference between the eggs stored at room temperature and those stored in refrigerator. They found deterioration in all quantitative parameters especially the weight in eggs stored at room temperature.

Concerning the results of air cell depth, it is consistent with what reported by (Protais et al., 1989) who found that, the impact of the type and duration of storage has negative effects on air cell depth. The increase in air cell was mainly due to loss of water and CO_2 through the shell pores and also due to the ageing of the albumen and the yolk (Stadelman and Cotterill, 1995).

The effect of storage temperature and storage days on shape index and shell weight of eggs stored in room and refrigerator for four consecutive weeks are presented in Table 6. The table shows no difference between treatments in both measured parameters. The same result was reported by (Protais et al., 1989) who illustrated the non-existence of significant differences ($p > 0.05$) among the average of shape index and shell weight for eggs stored in a room (74.53) or a refrigerator (73.87). He also reported that there is no impact for the period of storage on the shape index from the room or the refrigerator. Concerning the results of shell weight, it disagrees with that reported by (Samli et al., 2005) who found that egg shell weight changed significantly with storage time and temperature.

The effect of storage temperature and storage days on shell strength and shell thickness stored in room and refrigerator for four consecutive weeks are presented in Table 7. The table shows no difference between treatments in both measured parameters. This result disagrees with the result of (Hill and Hall 1980) who said

Table 7. The effect of storage temperature and storage days on shell strength and shell thickness[1]

Parameters/ Days	Shell strength		Shell thickness	
	Room temp.	Refrigerator	Room temp.	Refrigerator
1	3.88 ± 1.16	3.70 ±1.07	0.36 ± 0.10	0.32 ± 0.03
7	3.67 ± 0.35	3.84 ± 0.67	0.33 ± 0.01	0.33 ± 0.03
14	3.77 ± 0.61	3.63 ± 0.48	0.32 ± 0.03	0.30 ± 0.02
21	3.49 ± 0.83	3.31 ± 0.62	0.31 ± 0.05	0.32 ± 0.04
28	3.80 ± 0.52	3.62 ± 0.51	0.31 ± 0.02	0.32 ± 0.02
Mean	3.72 ± 0.15	3.62 ± 0.19	0.33 ± 0.02	0.32 ± 0.01
LS.	N.S (0.5027)		N.S (0.1657)	

1= Means are values of 9 egg each.
LS = Level of Significance.
N.S = Not Significant.

Table 8. The effect of storage temperature and storage days on albumen height and albumen index[1]

Parameters/ Days	Albumen height		Albumen index	
	Room temp.	Refrigerator	Room temp.	Refrigerator
1	7.17 ± 1.30	7.26 ± 0.77	9.47 ± 2.18	9.79 ± 1.09
7	5.01 ± 0.87	6.93 ± 1.45	5.59 ± 1.17	8.94 ± 2.13
14	3.97 ± 0.80	7.50 ± 0.65	3.86 ± 0.80	10.64 ± 1.64
21	3.83 ± 0.48	5.52 ± 1.13	5.83 ± 3.32	6.94 ± 1.73
28	3.59 ± 0.63	6.45 ± 1.11	6.37 ± 2.20	8.43 ± 2.16
Mean	4.71 ± 1.48 [a]	6.73 ± 0.78 [b]	6.22 ± 2.04[a]	8.95 ± 1.40[b]
LS.	** (0.0001)		** (0.0001)	

1= Means are values of 9 egg each
a, b = values with different superscript letters are significantly different
LS = Level of Significance.
*** = Highly significant difference*

shell thickness between the averages of the eggs stored in the room and the eggs stored in the refrigerator. His results illustrated that the shell thickness in the two storage types (room and refrigerator) decreases according to duration of storage. Shell quality is one of the most important factors in maintaining eggs quality. The shell thickness and porosity regulate the exchange of carbon dioxide and oxygen between the developing embryo and the air during embryo development. Shell thickness also has a very significant effect on moisture loss during storage (Washburn, 1998). Thin-shelled eggs also have a much greater degree of being cracked during handling. Concerning the results of shell strength reported by (www.isapolutry.com, 2009) which stated that storage period did not affect strength of shell in conventional eggs ($P>0.05$). Other trait important in external quality evaluation is shell thickness.

The results of albumen height and albumen index of eggs stored in room and refrigerator for four consecutive weeks are shown in Table 8. The table indicates that both parameters decreases with the increase in time of storage in both room and refrigerator, however eggs kept under room temperature showed significantly lower values compared to those kept inside the refrigerator. This result validates the assumption that, temperature has negative effects on both measured parameters. As far as lower albumen weight is concerned, similar results were reported by (Portais et al., 1989) Who reported significant ($p<0.05$) increase of the averages height of albumen of the eggs for the eggs stored in a refrigerator (7.47 mm) and those which are stored at room temperature (7.00 mm). It is also seemed that height of albumen decreases due to the duration of storage as seen in the rate of decrease in height of albumen for various storage types and periods. He also observed that there is high albumen in the eggs stored at the room compared with that eggs stored in the refrigerator (Villa, 1990). This was attributed to effect of rise of temperature in decreasing albumen height. This indicates that the temperature is one of the main factors influencing the egg quality during storage. The liquefaction of the thick white is largely influenced by the storage temperature. However, during storage the concentration of the free amino acid content in the egg white increases from 0.14 to 2.3 µ mole under various conditions of storage. During storage, some well-known physical and chemical modifications take place. These are the thinning of the thickness of albumen and mainly the increase of albumen pH caused by the loss of carbon dioxide from the egg through the pores in the shell. A rapid loss of CO_2 occurs

Table 9. The effect of storage temperature and storage days on Haugh unit and yolk shape[1]

Parameters/ Days	Haugh unit		Yolk shape	
	Room temp.	Refrigerator	Room temp.	Refrigerator
1	83.66 ± 8.93	85.66 ± 5.00	38.63 ± 2.64	40.52 ± 2.19
7	69.93 ± 7.77	87.01 ± 4.63	28.26 ± 1.31	40.03 ± 1.64
14	59.51 ± 8.71	87.33 ± 3.98	22.80 ± 2.83	45.05 ± 2.42
21	73.33 ± 3.90	81.21 ± 7.68	12.04 ± 1.52	43.51 ± 2.36
28	60.59 ± 6.56	80.66 ± 7.01	9.96 ± 3.56	41.06 ± 2.48
Mean	69.40 ± 9.93 [a]	84.37 ± 3.21[b]	22.34 ± 11.83[a]	42.03 ± 2.15[b]
LS.	**		**	

1= Means are values of 9 egg each
a, b = values with different superscript letters are significantly different
LS = Level of Significance.
*** = Highly significant difference*

particularly with the albumen, leading to a decrease in quality until the state of gas balance is reached between the inside. Concerning the results of albumin index, it was reported by Akyuret and Okur (2009) and Jin et al. (2011), who reported that albumin index was affected by storage periods and temperature.

The results of Haugh unit and yolk shape of eggs stored in room and refrigerator for four consecutive weeks are shown in Table 9. The table indicates that both parameters decreased with the increase in time of storage in both room and refrigerator, however eggs kept under room temperature showed significantly lower values as compared to those kept inside refrigerator. This result confirm the negative effect of temperature on the preservation of both Haugh unit and yolk shape .As far as decreased Haugh unit is concerned similar results were reported by (Villa, 1990) who absorbed a significant differences ($p < 0.05$) between the average values of Hough -unit for the eggs stored in the refrigerator (86.34) and at room (83.70). Results have also shown the decrease in the Haugh unit according to the increase in the storage duration. This is because of the weight decrease and the increase of whiteness .Haugh unit quickly decreases. However, the changes in the quality of eggs kept in the refrigerator (from 92.26 to 68.83 HU) were lower than those of the eggs kept in the room (from 93.06 to 76.70 HU), concerning the results of yolk shape, it was consistent with what was reported by (Kato et al., 1994) who found that the yolk shape decrease as the storage time increase.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

A. Based on the results obtained by the questionnaire the following can be cited as conclusions: Bahri University as a sample of Khartoum state community was aware about most of egg quality parameters due to their cultural background as educated community and hence very little efforts are needed to raise their level of awareness. Based on the result, ministry of animal production should make extant programmers that can available required data about egg deterioration. Also, consumers should culture themselves through following egg quality deterioration projects to achieve the best aware points about eggs quality.

B. Based on the results the effects of storage time on eggs quality of this study the following can be cited as conclusions: Temperature and time of storage have negative effects on egg weight, air cell, albumin index, albumin high, Hugh unit, and yolk shape. Temperature and storage time has no effects on shape index, shell weight, shell strength, shell thickness. Egg storage under optimum temperature is the best way to market eggs without deterioration in its quality.

Recommendations

Certain extension messages should be developed to increase Bahri university community awareness in the areas of egg place and purchase, checking of egg suitability, time for egg consumption, how to detect egg faults. Extension campaigns should be carried out to enlighten the community on the negative effects of bad handling and improper storage on eggs quality. Further studies with larger sample size and more egg quality parameters are to be done to confirm the results of this study.

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