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Effect of Eggs Storage Conditions on Some Egg Quality Characteristics of Hissex White Chicken

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ABSTRACT: *A 3-week study was conducted to evaluate the influence of storage temperature, type and time on egg quality of Hissex White chicken. Four dozens of fresh eggs were divided randomly into two groups: (A) and (B) of 24 eggs each. Eggs of group (A) were stored at 4 °C and Relative Humidity (RH) of 72%, compared to group (B) at room temperature. Weights of Egg, yolk, albumen, and shell, and shell thickness were recorded. A significant effect on storage time and interaction between storage time and egg weight revealed. Yolk height and diameter were significantly affected by storage type and the interaction. Albumen height was significantly affected by type and time of storage and the interaction. Albumen height and weight decrease with increase in storage time and temperature due to liquefaction of albumen. Shell weight decreased with an increase in storage time and greatly affected by the storage type and the interactions between storage temperatures. Shell thickness significantly decreased due to elevated temperature, which increases the number of pores. Storage of eggs at a relatively low temperature level and optimum RH plays a great role in the preservation of the egg quality for longer period under hot climatic conditions.*

Keywords: *Storage time; Storage type; Relative Humidity; storage temperature; Egg quality*

I. INTRODUCTION

Eggs are one of the rich sources of animal protein and other indispensable human nutrients which are required for body maintenance, growth and development worldwide [1]. Evidence has shown that the egg yolk alone provides excellent functional properties to a variety of food products [2]. Nevertheless, environmental causes including ambient temperature and Relative Humidity (RH) in addition to drastic storage conditions and transportation can seriously affect eggs quality. As such, it has been found that a proper packaging of eggs to keep better internal quality is imperative [3]. This is proved in cold storage which preserves eggs for 6 to 9 months particularly when kept at - 1.5°C [4]. Therefore, storage of poultry products requires special management techniques, and standard hygiene to maintain the eggs weight, shell intact, the yolk and albumen weight and length which are appropriate for human consumption and marketing. Moreover, the influence of chicken breed and age of hens on the yolk to albumen ratio has been demonstrated in two different genetic stocks [5].

Not surprisingly, the increase in human population creates a shortage in animal protein at the global level. This has prompted an entrepreneurship in poultry production, trade and marketability [6], which is challenged by the conditions of eggs storage. However, evidence has shown that the drier the atmosphere, the greater the water loss, leading to loss of vitality and egg quality. Maintenance of a relatively higher RH of 70-80 % in the egg storage area seems to be optimum conditions. Optimum egg storage is imperative for egg quality, this is simply explained as eggs are perishable food items losing the quality quickly if not stored properly [3].

In Sudan and South Sudan, facilities are available for preservation of eggs quality under the traditional management system. Eggs are always left in the open or kept in hot environment which may have a debilitating effect on their nutritive value and enhance the destruction of shelf life of products. The effect of a commercial housing system on egg quality during extended storage has been displayed [7]. As such the modern poultry production systems have developed precautionary measures which provide adequate strong facilities for egg preservation.

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A few studies have been conducted to investigate the effect of eggs storage conditions in Sudan and South Sudan. Hence, this study is planned to evaluate the influence of storage conditions on egg quality such that concrete information can be disseminated to key stakeholders for sustainable development of eggs production and marketability.

II. MATERIALS AND METHODS

The study was conducted at the premises of Animal Production Research Center in Hillat Kuku, East Nile Province, Khartoum-North, Sudan. The Hissex White chickens were kept in a battery cages/pens in a conventional East-western directional house system. They were fed with balanced ration and provided water *ad libitum*. Marek's, Gumboro, Newcastle and Fowl Pox disease-free eggs were collected twice daily in the morning and afternoon hours. They were placed in special cases for appropriate storage.

Four dozens of fresh eggs were randomly divided into two groups: (A) and (B) of 24 eggs each. Eggs in group (A) were stored in a refrigerator at 4^0C and RH of 72 % compared to eggs in group (B) which were stored in room temperature and acted as a control. Average temperatures were measured using thermometer.

Eggs were broken to test the interior egg quality every 2 to 4 days from the first day of storage period for 3 weeks. Eggs were stored at room temperature and under refrigeration. Temperature variation was measured by data loggers installed in each storage location. They were set to read the temperature and humidity every 30 min during the experiment. Records of weight loss (%) of the whole eggs during storage was performed [8].

Then eggs were broken, and the yolks separated from the albumen. The chalazae were carefully removed from the yolk, using forceps, and prior to weighing the yolk. Before weighing, all yolks were rolled on a paper towel to remove adhering albumen. The shells were carefully washed and dried at 21 °C for 48 hrs. using a drying oven and then weighed. Albumen weight was determined [5] as follows:

Albumen weight = Yolk- shell weight

Internal quality was assessed by eggs breakage and placement on a flat surface. The albumen and yolk heights and yolk diameter were measured with a digital caliper [WORKER® (in./mm)]. From egg weight and albumen height data, Haugh Unit (HU) method was used to calculate the Yolk Index (YI) [9] . Moreover, YI was calculated by dividing yolk height by its diameter [10].

The pH was measured using digital pH meter and taken individually in albumen and yolk by emerging the probe inside the sample solution. Egg yolk color was measured visually using Roche Colorimetric Fan (RCF) scale, also named as DSM® yolk color fan [11]. Specific gravity was determined in normal salt (NaCl) concentrations varying from 1.066 to 1.102 g mL^{-1}[12] .Each egg was immersed in the solution until emerged to the surface, thereby determining the specific gravity. Egg length and width was measured using an electronic digital caliper.

A 2- way analysis of variance (ANOVA) using the factorial design was performed. Duncan Multiple Range Test (DMRT) was used for testing the means. Level of significance was set at $P<0.05$. Ethical considerations were taken into account prior to commencing the study [13].

III. RESULTS

No significant effect of time of storage on egg length and diameter found, but a change in egg weight was shown to decrease significantly with an increase in a storage time. Table 1 shows a highly significant effect on time and type of storage and their interaction on albumen type. Albumen height was shown to decrease with an increase in time of storage of albumen in the refrigerator which was significantly greater than that stored at room temperature. There is a significant effect on type and time of storage on albumen weight and decreasing rate of albumen weight at room temperature which is significantly greater than that stored in the refrigerator.

Table 2 shows a highly significant effect of storage time and type and the interaction on yolk height which decreased with increase in the storage time. Yolk height in the refrigerator is significantly greater than that stored at

room temperature. Similarly, yolk diameter increased with increase in time of storage and there was a significant effect of time of storage on yolk weight which increased with increase in time of storage.

Table 3 shows a significant effect of storage type and interaction between storage type and time on egg shell weight. Shell weight in the refrigerator is significantly small than that stored at room temperature and there was a significant effect of storage time on shell thickness. A highly significant effect of storage time and type on shell membrane weight and their interaction was shown. The shell membrane of eggs stored in the refrigerator is significantly greater than that stored at room temperature.

Table 1. Effect of storage time and type on albumen quality characteristics of Hissex White

Variables	Storage Time/day / Storage type	0	2	4	6	Over all mean	SE	LS
Albumen height (mm)	S_1	b 9.178	a 7.718	a 7.409	ab 7.969	8.07	0.30	**time **type **interaction
	S_2	b 8.516	a 7.053	a 7.211	ab 7.451	7.560		
Albumen weight (gm)	S_1	a 31.02	a 26.86	a 30.84	a 24.95	29.67	1.19	Time interaction
	S_2	a 28.12	a 31.14	a 30.79	a 27.81	29.46		

S1=Storage in a refrigerator, S2=Storage at room temperature, SE=Standard Error, LS=Level of Significance
*=Significant at P<0.05 **=Highly Significant at P <0.01
NS=Non-significant at (P> 0.05), Means with different superscript letters within the same row are significantly homogenous.

Table 2. Effect of storage time and type on yolk quality characteristics of Hissex White chicken

Variables	Storage time/day / Storage type	0	2	4	6	Overall mean	SE	LS
Yolk height (mm)	S_1	b 16.99	a 15.76	ab 16.49	A 16.19	16.36	0.35	**time **type **interaction
	S_2	b 16.34	a 14.45	ab 14.77	A 14.01	14.89		
Yolk diameter (mm)	S_1	a 35.54	b 36.73	ab 36.62	A 37.65	36.54	0.68	**time **type **interaction
	S_2	a 36.60	b 39.24	ab 38.42	A 39.82	38.52		
Yolk weight (gm)	S_1	a 11.90	a 12.20	a 11.92	A 12.15	12.04	0.60	**time **type **interaction
	S_2	a 12.34	a 11.81	a 11.68	A 13.58	12.38		

S1=Storage in refrigerator S2=Storage at room temperature SE=Standard Error

L.S=Level of significance *=Significant at P<0.05 **=Highly significant at P>0.01
NS=Non-significant at P >0.05
Means with different superscript letters within the same row are significantly homogenous.

Table 3. Effect of storage time and type on shell quality characteristics of Hissex White Chicken

Variables	Storage time/day / Storage type	0	2	4	6	Overall mean	SE	LS
Shell weight (gm)	S_1	a 3.89	a 3.54	a 3.97	a 3.95	3.84	0.22	**type
	S_2	a 4.31	a 4.03	a 3.38	a 3.98	3.92		**interaction
Shell membrane weight (gm)	S_1	ab 1.08	a 0.75	a 0.64	a 0.47	0.77	0.12	**time **type **interaction
	S_2	ab 0.79	a 0.41	a 0.54	a 0.54	0.57		
Shell thickness (mm)	S_1	b 0.30	a 0.27	a 0.28	ab 0.27	0.28	0.01	**type
	S_2	a 0.29	a 0.27	a 0.26	ab 0.29	0.28		

S1=Storage in refrigerator, S2=Storage at room temperature, SE=Standard Error
L.S=Level of Significance, *=Significant at P<0.05, **=Highly Significant at P <0.01
NS=Non-Significant at P >0.05
Means with different superscript letters within the same row are significantly homogenous.

IV. DISCUSSIONS

Storage of eggs under optimum conditions is very crucial for maintaining the egg quality for a tangible period of time. In this study the egg weight seems to decrease significantly with an increase in a storage time due to evaporation of moisture from eggs during storage. It has been found that the rise in temperature culminates in the loss of egg weight [4]. Moreover, similar results for eggs stored at lower temperature was reported [14]. Daghir, [15] recommends eggs storage for seven days at 16-17°C and 80% RH, and at 10°C and 70-80% RH to avoid both losses of humidity and egg weight. In this study, weight loss was affected by storage period and all interactions which is in line with the findings of Suresh et al [8].

The decrease in yolk height and increase in yolk diameter and weight are likely due to transfer of moisture from albumen to yolk across the vitelline membrane as result of a difference in osmotic pressure. The albumen height decreases with increase in time of storage due to liquefaction of albumen as a result of migration of water and escape of Carbon Dioxide (Co_2) from inside the egg. The release of Co_2 from the egg was due to increase in storage temperature. The decrease of shell weight with increase in storage temperature could be attributed to an increase in number of pores. Moreover, there is slight interaction between storage time and type of shell thickness. Albumen height and HU values tend to decrease during storage, which concurs with the findings of other investigators [16,17]. Albumen height values ranging between 5.5 and 5.8 mm for different housing systems are similar to the refrigerated values reported by Jones et al. [7] .

On the other hand, albumen height decreased from 7.05 to 4.85 mm comparing the 1st and 10th week of extended cold storage [16]. In our study, HU decreased significantly when eggs remained at room temperature, particularly after the 2nd week of storage. Nevertheless, no significant differences (P > 0.05) among HU values found under refrigeration. Our results show that albumen height, yolk height, HU and yolk pH can be expressed as a function of storage time. As these measurements are particularly related to egg freshness, it can be assumed that fresh eggs and of good quality are maintained under refrigerated storage. A decrease in those parameters is related to short shelf life, since it has been claimed to be responsible for 78% and 77% decrease in HU and albumen height, respectively [18]

This study shows that most refrigerated eggs are of good inner quality remaining stable regarding yolk index (YI), however eggs stored at room temperature showed significant differences from the 2nd week onwards. Therefore, eggs stored at room temperature did not meet 0.45 as standard reference of a good YI [19]. Once YI is related to height and diameter, as egg gets older, these characteristics are affected, demonstrating quality loss. It has been observed that YI decreases with increasing storage time compared to control eggs having YI=0.44 and along 7, 14, 21 and 28 days of storage, with values decreased to 0.38, 0.36, 0.32 and 0.32, respectively [20].

Comparatively, as from the 1st week to the 4th week of storage, egg weight decreased either at room temperature (2.78 g) or at refrigerated temperature (2.37 g), however egg weight was not significantly different ($P > 0.05$) among the storage conditions. The means of eggs stored at room and refrigerated temperatures were 61.2 and 60.7 g, respectively. The Quality Control Programme of the United States Department of Agriculture (USDA) determines quality conditions of eggs for consumption, which shows that eggs may be classified as excellent quality (AA) that exhibit HU values of 72 or higher; eggs of high quality (A) exhibit HU values between 60 and 72; and eggs of low quality (B) with HU values lower than 60 [21].

As an egg gets older, the dense albumen becomes liquid due to numerous chemical reactions, which possibly involve carbonic acid (H_2Co_3) formation and increase in albumen pH. Seemingly, H_2Co_3 is one of the components of albumen buffer system, dissociating to form water and Co_2. Under natural conditions, Co_2 diffuses through the shell pores and evaporates, decreasing albumen acidity, increasing pH and chemical cleavage of the protein complex.

V. CONCLUSIONS

Cold storage facilities have shown a good result in preservation of egg quality and reducing the egg deterioration during storage period. It is recommended that eggs be stored at 10-13°C or at 5 °C for up to 30 days, clean eggs be segregated from dirty, cracked or leaking eggs. Eggs be gathered frequently two or three times per day if possible, Eggs be coated with oil or plastic sheet before storage to provide a promising outcome particularly when stored at room temperature. Adequate storage facilities are required under the natural tropical condition to prevent eggs deterioration and maintain eggs quality.

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