INTERACTIVE EFFECTS OF SIZE, STORAGE METHOD AND DURATION ON QUALITY AND PHYSICAL CHARACTERISTICS OF TABLE EGGS

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ABSTRACT

A total of 252 fresh table eggs sorted into standard, large and extra-large sizes were either refrigerated or held at room temperature and used to study their weekly weight losses (WL), specific gravity (SG), egg index (EI), yolk index (YI) and albumen height (AH) over a six week period. The results showed that among room-stored eggs there were declines ($P < 0.01$) in AH, YI, SG and EI but an increase in WL with increased egg size. Similar trends in response to long storage were observed except that EI was not affected ($P > 0.05$). The depressive influences of long storage and larger sizes on egg quality observed in room stored eggs diminished with refrigeration. The general patterns of quality deterioration show that, irrespective of egg size, six-week refrigerated eggs had better quality indices than one-week old room-stored eggs. There was no significant ($P > 0.05$) influence of egg size on quality changes during storage. Based on the results, it was concluded that in the absence of refrigeration and when eggs are sold in assorted sizes, table eggs should be consumed within 2 weeks of lay and larger eggs should be used first. Key words: Egg size, Storage method, Egg quality.

INTRODUCTION

It is necessary to deliver eggs to the consumers while fresh because it is a delicate food product subject to rapid deterioration. In addition, the shell egg does not lend itself to accurate determination of the internal quality. Many years ago, consumers judged egg freshness by submerging the egg in brine. Fresh eggs normally sank while the stale ones floated. Although freshness does not affect the nutrient quality, it does influence the cooking and functional qualities of the eggs (American

Egg Board, 1981; Ikeme, 1987).

Several methods of preserving freshness of table eggs have been employed (Olomu, 1975; Ikeme, 1987 and Coleman, 1988) but cold storage at below 13°C has been found most ideal (American Egg Board, 1981). The evolution of efficient evacuation and transportation systems in some parts of the world has made it possible for eggs to reach the consumers within hours of being laid. However, the absence of these facilities and services in Nigeria, apart from causing delays in delivery to consumers, cannot guarantee the quality of such eggs. Invariably, eggs of various hidden stages of deterioration flood the market. In addition, eggs hitherto offered for sale in various separate sizes are now sold in mixed sizes thereby depriving consumers of choice of egg sizes. Separate influences of egg size or storage temperatures on egg quality variations during storage or periodic egg quality surveys have been reported by some workers (Fry and Newell, 1957; Korslund *et al.*, 1957; Kraft *et al.*, 1958; Card and Nesheim, 1975; Davies *et al.*, 1986 and Ikeme, 1987). However, there is paucity of information as to the effects of the interdependence of these factors on quality variations during storage. This becomes very relevant given the prevailing egg marketing situation in this country. This study evaluates the interactive influences of egg size and storage methods on changes in internal quality and some external physical characteristics of table eggs at varying periods of storage after lay.

MATERIALS AND METHODS

Egg Sampling and Storage:

A total of 252 brown presorted table eggs were obtained from 39-week old Brown Olympia birds in the Poultry Unit of the College of Agricultural Sciences, Ogun State

University, Nigeria. The birds were fed on normal commercial layers mash containing 15.8% Protein and 3.02 Mcal/kg-ME. All eggs were sorted and necessary sampling and measurements carried out within eighteen hours of lay. Eggs were classified into weight categories as described by David *et al.* (1986) and shown in Table 1. Sampling was not possible for the small size eggs apparently due to the flocks advanced age in lay. Eggs were weighed on the first day of collection and the weights inscribed on their shells. Each egg size was divided into two lots and each further divided into seven weight equalised groups of six eggs. One lot was stored in the refrigerator at an average temperature of 8.25°C while the other lot was stored at an average room temperature of 28.08°C and a relative humidity of 81%.

Egg Measurements:

The initial values of egg index (EI) weight

TABLE 1: CLASSES OF TABLE EGGS AND THE MEAN WEIGHTS OF PRESORTED EGGS

Egg Size	Minimum* Weight (g)	Mean Weights (g $\pm$ s.e.) of sorted eggs (n = 84)
Small	45	
Standard	50	52.30 $\pm$ 0.17
Large	55	56.93 $\pm$ 0.15
Extra-Large	60	64.58 $\pm$ 0.51

*Weight Classification described by Davis *et al.* (1986)

loss (WL) and specific gravity (SG) of the intact egg and albumen height (AH) and yolk index (YI) of the same egg when opened were determined with one group of six eggs from each of the six size by storage method treatment combinations. All measurements were repeated at weekly intervals for a total of six weeks using the same number of eggs for each treatment combination. All refrigerated eggs were brought to room temperature before evaluation. Egg index was measured as the ratio of the distance along the widest width to that of the longest length and expressed as a percentage. The linear measurements were taken with vernier calipers. Weight losses were measured by the difference in weights between the initial weight and weights after 1,2,3,4,5

and 6 weeks. The weight difference was expressed as a percentage of the fresh egg weight. Specific gravity was estimated as a ratio of egg weight to its volume and expressed as g/ml. The egg volume was estimated by water displacement method as described by Carter (1968). Yolk index was estimated as the ratio of yolk height to the mean of its width from two different expanses. The height was measured using a tripod micrometer and the width was measured using the vernier calipers. Albumen height measured with the tripod micrometer, was taken on the thick albumen midway between its outer and yolk edges but away from the chalazae.

Statistical Analyses:

All data were analysed using the factorial analyses of variance with egg size, storage method, storage period and their various interactions as sources of variations. Means were separated using the Duncan's New Multiple Range Test as described by Steel and Torrie (1980).

RESULTS

The analysis of variance (Table 2) shows that storage method and period as well as their interactions influenced ($P < 0.001$) all measurements except the egg index with storage method having the most overriding effect in all cases. The egg size influenced YI ($P < 0.01$), WL and EI ($P < 0.001$) and AH ($P < 0.05$) but had no significant influence ($P > 0.05$) on SG. Significant influence of size-by-storage method interactions were also observed on AH ($P < 0.01$) and WL ($P < 0.001$). Table 3 shows the interactive effects of size and storage method on various quality and physical characteristics of table eggs. Generally with room-stored eggs, while WL was on the rise, declines in AH, YI, SG and EI were observed as the egg size increased. However, refrigerated eggs, apart from being better in quality than their respective room stored eggs, were not different across sizes. Table 4 shows the changes in quality characteristics of refrigerated and room-stored eggs during the six-week storage period. Generally as storage

QUALITY CHANGES IN STORED TABLE EGGS

TABLE 2: MEAN SQUARES OF ANALYSES OF VARIANCE FOR SOME EGG QUALITY AND PHYSICAL CHARACTERISTICS

Sources of variation	df	AH	YI	WL	SG	EI
Egg size(S)	2	4.976*	0.010**	16.346***	0.001	181.448***
Storage Method (M)	1	425.882***	2.544***	883.502***	0.032***	2.702
Storage Period (P)	6	26.680***	0.210***	183.313***	0.029***	7.886
S x M	2	6.944**	0.004	13.618***	0.002	13.025
S x P	12	1.145	0.002	1.149	0.001	9.028
M x P	6	16.233***	0.116***	42.141***	0.003***	14.870
S x M x P	12	0.225	0.002	1.234	0.002	17.289
Residual	210	1.491	0.002	1.443	0.001	11.764

*** P<0.001; ** P<0.01; *P<0.05

TABLE 3: QUALITY AND PHYSICAL CHARACTERISTICS OF REFRIGERATED OR ROOM-STORED TABLE EGGS OF VARYING SIZES

Egg Size	Storage Method	AH (mm)	YI	WL (%)	SG (g/ml)	EI
Standard	Room	3.98 _a	0.26 _a	4.78 _a	1.06 _a	75.04 _a
	Refrigeration	5.73 _a	0.43 _a	1.73 _a	1.09 _a	73.13 _a
Large	Room	3.25 _c	0.23 _{bc}	5.21 _a	1.05 _{ab}	74.67 _a
	Refrigeration	5.62 _a	0.40 _a	1.75 _a	1.08 _a	74.36 _a
Extra Large	Room	2.48 _d	0.20 _c	6.44 _a	1.03 _d	71.92 _b
	Refrigeration	6.15 _a	0.42 _a	1.75 _a	1.08 _{ab}	72.27 _a
	SEM	0.188	0.007	0.185	0.004	0.529

Means in the same column having similar subscripts are not different (P>0.05).
SEM = Standard error (pooled) of the means

lengthened, there were continuously increasing gaps in quality characteristics between refrigerated and room-stored eggs with the former being better in all cases. For the entire storage period, refrigerated eggs had YI decline from 0.45 to 0.38 or 16% decline. The YI of refrigerated eggs after six weeks was higher than the YI value of 0.31 recorded for room-stored eggs after the first week of storage. At the end of six weeks, room-stored eggs had YI declines of about 77% from its initial value of 0.47 to 0.11. The trend in WL indicated that unrefrigerated eggs recorded WL value about seven times that for refrigerated eggs after one week of storage. This indicated that refrigerated eggs lost in one week a weight equivalent lost by room-stored eggs in one day during the first week of storage. Subsequent comparative losses were not as high. A total of 3.37% WL observed for refrigerated eggs after six weeks storage was similar to 3.55% recorded for room-stored eggs just after the first week of storage. The maximum mean WL value of 10.03% observed for unrefrigerated eggs at the

end of the storage period was about three times the value recorded for refrigerated eggs.

Table 4 also shows a rapid initial decline in AH from a value of 6.32mm to 4.02mm or 36% decline for room-stored eggs. Subsequent decline in AH for the eggs was gradual and appeared to level off after 2 weeks of storage. For refrigerated eggs the decline in AH was minimal with an initial value of 6.26mm decreasing to 5.46mm after the sixth week. Refrigerated eggs showed no significant (P>0.05) change in SG throughout the storage period. However, room-stored eggs declined significantly (P<0.01) after two weeks of storage. The rate of decline in SG slowed down afterwards and levelled off after 4 weeks of storage. The lowest SG value of 1.07g/ml recorded after 6 weeks for refrigerated eggs did not differ significantly (P>0.05) from 1.06g/ml recorded for room stored eggs after 3 weeks storage. The observed decrease in SG after 6 weeks of storage for refrigerated and room-stored eggs constituted 3.13 and 7.82% respectively.

TABLE 4: QUALITY AND PHYSICAL CHARACTERISTICS OF REFRIGERATED AND ROOM STORED EGGS AT DIFFERENT STORAGE PERIODS

Storage Period (wks)	Storage Method	AH (mm)	YI	WL (%)	SG (g/ml)	EI
0	Room	6.32 _a	0.47 _a	0.00	1.11 _a	73.96
	Refrigeration	6.26 _a	0.45 _{ab}	0.00	1.10 _{ab}	73.84
1	Room	4.02 _b	0.31 _c	3.55 _{ab}	1.08 _{abc}	74.15
	Refrigeration	5.97 _a	0.43 _{abc}	0.51 _g	1.08 _{abc}	74.41
2	Room	3.18 _c	0.26 _d	4.19 _d	1.07 _{bc}	73.04
	Refrigeration	5.74 _a	0.44 _{abc}	1.09 _g	1.08 _{abc}	73.97
3	Room	2.50 _c	0.17 _g	5.90 _c	1.06 _{cd}	74.27
	Refrigeration	5.80 _a	0.42 _{bcd}	1.71 _f	1.08 _{abc}	74.10
4	Room	2.28 _c	0.17 _g	6.92 _{bc}	1.03 _{de}	74.76
	Refrigeration	5.83 _a	0.40 _{cd}	2.42 _d	1.09 _{abc}	74.68
5	Room	2.14 _c	0.12 _h	7.99 _a	1.02 _e	74.17
	Refrigeration	5.77 _a	0.41 _{bcd}	2.62 _d	1.09 _{abc}	75.74
6	Room	2.22 _c	0.11 _h	10.03 _a	1.02 _e	74.81
	Refrigeration	5.46 _a	0.38 _d	3.37 _{de}	1.07 _{bc}	73.51
	SEM	0.288	0.011	0.283	0.007	0.808

Means in the same column having similar subscripts are not different ($P > 0.05$)
SEM = Standard error (pooled) of the means

DISCUSSION

There were changes in egg quality due to storage method, duration of storage and egg size. Eggs stored at room temperature deteriorated more in quality particularly in the first week of storage than those refrigerated. This is in agreement with the reports of Fry *et al* (1965) and Ikeme (1987), who reported that quality decline of unrefrigerated eggs in the first seven days was greater than that over a period of 7 to 14 days or 14 to 21 days. On the average, the rates of decline in AH, YI and WL of room-stored eggs were respectively 6.3, 5.3 and 2.6 times the values for refrigerated eggs. Albumen quality was measured in terms of its height and not converted to Haugh Unit (HU). This was done to avoid the bias inherent in the measurement of HU as reported by Eisen *et al* (1962). The authors revealed that HU overestimates the albumen quality of eggs smaller than 56.5g and underestimates the albumen quality of those greater than 56.5g. From the third week, the AH of room-stored eggs had declined below 3.0mm. In addition, the thick and thin albumen had become miscible and inseparable. It had also detached from the yolk and become watery. Refrigerated eggs showed none of these signs even at the end of six weeks of storage. The albumen was still firm and attached to the yolk and the thick and thin albumen were still discernible.

The YI decline was greater in the first week than at any other time later, thus confirming an earlier observation made by Olomu (1975). The decline in AH and YI with egg size is in agreement with earlier reports by Romanoff and Romanoff (1949) and David *et al* (1986). The trends in the decline of AH and YI as measures of egg quality indicate that consumable eggs should not be stored for more than two weeks under room temperature. In fact Olomu (1975) and Essien (1990) had suggested the disposal of table eggs within one week of lay in absence of cold storage. The significant influence of egg size-by-storage period interaction on quality and physical characteristics of table eggs is an indication that the two factors had independent influences on the various measurements. It is expected, therefore, that the variations observed in response to period of storage would hold for the range of egg sizes tested in this study. The increased weight losses with size observed in room-stored eggs could be due to larger surface area. High and positive correlation have been shown to exist between egg weight and surface area (Carter, 1975). Losses in egg weight are due to outward diffusion of moisture and gases (Ikeme, 1987). The rate of diffusion is increased at higher temperature. Eggs under refrigeration are denser and less mobile especially the yolk (Baker, 1953) presumably due to greater proportion of fat content (Marion *et al*, 1965). Heath *et al* (1976) have shown that age after

lay and temperature have very strong influence on egg quality. However, influence of age on egg quality is greatly reduced in refrigeration. It is apparent from the results of the current study that refrigeration suppressed not only the effects of storage period but also effectively the influence of egg size (Table 3).

The width and length of the eggs as components of egg indices or shape did not change throughout the six week period. The indices of the Standard and Large eggs were, however, higher than for Extra-large eggs. It is not known if variations in EI could be directly linked to changes in egg quality. It is, however, known that increase in egg length and breadth increase surface area of shell eggs (Carter, 1975; Olori and Sonaiya, 1992). Larger surface area, in turn, enhances outward diffusion of volatile materials, hence increased WL as observed in Extra-large eggs. Losses in egg weight while the egg volume remains unchanged will undoubtedly result in decline in SG of eggs. Factors that enhance WL, therefore, will result in SG decline. As revealed in this study, storage period and method, more than size, have great influence in this regard.

The pattern of egg purchase in this country is such that majority of consumers purchase eggs in small quantities more from retailers than wholesalers or at farm points. In fact for most consumers, especially those without cold storage facilities, eggs are purchased only if and when the need arises. The eggs are maintained at ambient temperature by most if not all the dealers and are usually offered for sale in assorted sizes. The volume of sales obviously determines how long an egg stays with the retailers and invariably its internal quality status at the time of sale. Since it is difficult for consumers to determine the age of an egg, it is advisable that his choice be made among the smaller eggs. The alternative is to purchase, at farm locations, eggs that can be consumed within two weeks. Even in such a situation larger eggs are better consumed first. It should however be born in mind that the quality of an egg normally at its best when freshly laid strongly influences its quality at

any particular time (Card and Nasheim, 1975; Davis *et al*, 1986). The initial quality itself is also influenced by many factors including flock breed and strain, age in lay and diet (Ruth *et al*, 1960; Noles and Tindell, 1966; Davis *et al*, 1986).

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