MODELS FOR THE PREDICTION OF QUALITY PARAMETERS OF TABLE EGGS STORED UNDER DIFFERENT CONDITIONS

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ABSTRACT

A total of 144 newly - laid eggs obtained from Lohmann Brown layers were distributed and stored under three storage conditions: room temperature, polythene bag/room temperature and refrigeration. Changes in Haugh unit, yolk index and percentage weight loss were evaluated between 0 and 14 days at intervals of two days each. Haugh unit, yolk index, and albumen index decreased significantly ($P > 0.001$), while percentage weight loss increased ($P < 0.001$) with storage duration. Generally, quality parameters of refrigerated eggs were significantly ($P < 0.05$) higher than those stored in polythene bag or those stored open in the room o. Polythene-bagged eggs had the least percentage weight loss. Significant ($P < 0.001$) storage method x storage duration interactions were obtained. Regressing the internal egg quality measurement (Y) over storage period (X) in simple linear ($\underline{Y} = a + \underline{bx}$) or the exponential ($\underline{Y} = \underline{ab}^x$) regression functions showed that the predictive ability meeasured by the r_2 - values was generally higher with the exponential than the simple linear model. The predictive ability of each egg quality parameter was higher with the polythene - bagged eggs than with other storage conditions. Using the simple linear prediction model, table eggs purchased randomly from retail egg shops had quality values of eggs that were about 4 - 11 days after lay prior to purchase.

Key Words: Egg quality, prediction model, storage condition, polythene-bagged eggs.

INTRODUCTION

In Nigeria, some table eggs with declining quality are sold to consumers due to inadequate or non-existent storage facilities. These eggs are sold either from open egg trays or in polythene bags under the existing environmental conditions. Since the deterioration of an egg begins immediately after laying, various methods aimed at preserving the internal quality of shell eggs have been used. These include dipping in vegetable oil (Kumar *et al.* 1969; Olomu, 1975a) lime sealing (Kumar *et al.* 1969); cold storage (Olomu, 1975b Austic and Nesheim 1990; Essien, 1990). Ihekoronye and Ngoddy (1985) have summarised the principles and advantages in the use of these methods. Apart from the report by Eruvbetine and Bamidele (1994), information on the quality changes of eggs stored in polythene bags is almost non - existent even though the method is widely used in Nigeria. Equally scarce or non-existent is information on the models for the prediction of egg quality parameters under various conditions. It was therefore the aim of this study to compare the changes in the quality of eggs stored in polythene bags with those kept under room or refrigerated conditions for up to two weeks. Egg quality prediction models as a function of storage duration were also developed for each storage condition. The models so developed were used to estimate the storage duration of table eggs sold in markets prior to purchase.

MATERIALS AND METHODS

A total of 144 fresh eggs laid by a flock of Lohmann Brown strain layers were used for this study. forty - eight eggs were gathered weekly for three consecutive weeks with each batch of the 48 eggs allocated to three storage conditions namely: room condition, polythene bag under room condition and refrigeration. There were eight storage periods; 0,2,4,6,8,10,12 and 14 days. From the weekly batch of 48 eggs, six eggs were allotted to each period such that all the three storage conditions and some of the periods had eggs from each batch until data for all the periods and the three storage conditions were collected. Egg weights used in this study ranged from 39.43 to 64.21 g.

Eggs stored under room conditions were placed in a bottom - perforated plastic egg tray while the refrigerated eggs were placed on plastic trays and stored in a good working refrigerator with an average temperature of 3.9°C.

In the third storage condition a set of six eggs were packed in transparent polythene bags (273 x 198 mm), knot - tied and placed under room conditions. Initial egg weights were recorded (to the nearest 0.01g) and at the end of each storage duration the final egg weights were taken and the eggs were broken on a flat plate for the determination of the internal quality parameters described below.

Percent Weight Loss: This was the difference between the initial egg weights and the weights of eggs after 2, 4, 6, 8, 10, 12 and 14 days of storage, expressed as a percentage of the initial egg weight.

Estimation of Quality Parameters of Market Eggs:

Forty - eight eggs were purchased such that 24 stored in polythene bags were purchased from egg shops tagged A, B, C, and D, and the other 24 from open egg trays under room conditions from egg shops tagged E, F, G and H. The eggs were weighed, broken and measurements taken for the determination of Haugh Units, yolk index and Albumen index respectively as described by Haugh (1937); Sharp and Powed (1930) and Heiman and Carves (1936).

Statistical Analysis:

The data collected were subjected to the analysis of variance and where significant F - values were obtained the Ducan's Multiple Range Test as described by Steel and Torrie (1980) was used to compare the means for each storage condition and each period of storage. The data were also fitted to the simple linear function, $Y = a + bx$ and the growth decay function $Y = ab^x$ (transformed to give a semi - log plot). Each of the four egg quality measurements constitutes the dependent variable Y while the independent variable, x, was the storage duration (in days).

RESULTS

The mean values and standard errors of the four egg quality measurements obtained under the three storage condition are presented in Table 1. Haugh Units, yolk index and albumen index decreased significantly ($P<0.001$) with increased storage duration. Generally Haugh unit, yolk index and albumen index values of refrigerated eggs were significantly ($P<0.05$) higher than those stored in polythene bags or under room conditions. Haugh unit values of polythene bagged eggs were not significantly ($P>0.05$) different from those refrigerated eggs after, 2 and 6 days of storage, and room - stored eggs after 6, 8, 10 and 12 days. Yolk index values of eggs stored in the polythene bag were significantly less than refrigerated eggs between the 4th and 14th day of storage. Albumen index of polythene bagged eggs were mostly similar ($P>0.05$) to those of room - stored eggs while values for refrigerated eggs were significantly higher than those for eggs from the other storage methods. Percentage weight loss of shell eggs stored open under room conditions were significantly ($P<0.05$) higher than for eggs stored under the other two conditions. Percentage weight loss of polythene-bagged eggs was the least of the three methods.

In Table 2 thee analysis of variance showed highly ($P<0.001$) significant egg quality differences due to storage condition, storage duration and their interaction. The relationships between each of the egg quality measurements, Y, and the duration of storage, X, using the simple linear and the ex-ponential (growth decay) functions are presented in Tables 3 and 4. Using the prediction functions, daily rates of decline in egg quality measurements were highest for room - stored eggs and least for refrigerated eggs except for albumen index. The predictive ability (r^2 values) for the Haugh units using both the simple linear and exponential functions was higher for the polythene bag stored eggs than

TABLE 1: MEAN (±SEM) EGG QUALITY MEASUREMENTS IN TABLE EGGS STORED UNDER THREE DIFFERENT CONDITIONS

Egg quality Parameter	Storage Condition	Duration of Storage (Days) 0	2	4	6	8	10	12	14
Haugh Units	Room condition*	81.91^{a}	59.49^{b}	51.73^{b}	56.61^{b}	55.20^{b}	51.31^{b}	40.90^{b}	32.77^{c}
	Polythene bag	79.97^{a}	65.79^{a}	62.94^{b}	67.38^{ab}	55.50^{b}	55.63^{b}	49.86^{b}	48.58^{b}
	Refrigeration**	84.00^{a}	76.39^{a}	77.69^{a}	79.18^{a}	76.28^{a}	73.74^{a}	71.22^{a}	70.02^{a}
	S.E.M.(pooled)	1.21	2.44	2.69	2.55	2.88	2.91	3.54	3.90
Yolk Index	Room condition	0.45^{a}	0.42^{a}	0.35^{b}	0.37^{b}	0.32^{b}	0.26^{b}	0.23^{b}	0.21^{b}
	Polythene bag	0.44^{a}	0.41^{a}	0.38^{b}	0.39^{ab}	0.30^{b}	0.29^{b}	0.26^{b}	0.25^{b}
	Refrigeration	0.42^{ab}	0.43^{a}	0.44^{a}	0.43^{a}	0.42^{a}	0.42^{a}	0.40^{a}	0.41^{a}
	S. E. M. (pooled)	0.006	0.011	0.011	0.008	0.019	0.019	0.021	0.022
Albumen Index	Room condition	0.098^{a}	0.051^{b}	0.038^{c}	0.047^{b}	0.043^{b}	0.038^{b}	0.030^{b}	0.022^{c}
	Polythene bag	0.091^{a}	0.062^{ab}	0.050^{b}	0.061^{ab}	0.049^{b}	0.042^{b}	0.035^{b}	0.037^{b}
	Refrigeration	0.098^{a}	0.087^{a}	0.084^{a}	0.084^{a}	0.068^{a}	0.072^{a}	0.067^{a}	0.067^{a}
	SEM (pooled)	0.005	0.005	0.005	0.004	0.004	0.005	0.005	0.005
Percent Weight Loss	Room condition	-	0.85^{a}	1.09^{a}	1.88^{a}	1.63^{a}	2.57^{a}	2.63^{a}	3.07^{a}
	Polythene bag	-	0.30^{b}	0.50^{b}	0.57^{b}	0.86^{b}	0.87^{c}	1.09^{c}	1.37^{b}
	Refrigeration	-	0.40^{b}	0.64^{b}	1.05^{b}	0.93^{ab}	1.47^{b}	1.65^{b}	1.58^{b}
	S E M (pooled)	-	0.090	0.068	0.125	0.211	0.200	0.171	0.197

a,b,c, - Means along column without the same superscript are significantly different at $P < 0.05$.
* Temperature range = 17.8°C minimum and 35.1°C maximum
** Average refrigerated temperature = 3.9°C.

TABLE 3: RELATIONSHIP BETWEEN EGG QUALITY PARAMETERS (Y) AND DURATION OF EGG STORAGE, (X) USING THE SIMPLE LINEAR FUNCTION Y = a + bx

Egg Quality Parameter (Y)	Independent Variable (X days)	Storage Mehtod	Regression Equation	Correlation Coefficient (r)	Coefficient of Determination (r^2)	SEE[1]
Haugh Unit	Storage duration	Room condition	Y = 72.14 -2.60x	-0.8724***	0.7610	2.78
		Polythene bag	Y = 74.59 - 1.98x	-0.9302***	0.8654	2.60
		Refrigeration	Y = 81.83 -0.82x	-0.8998***	0.8096	0.76
Yolk Index	Storage duration	Room condition	Y = 0.0453 - 0.015x	-0.8870***	0.7868	0.015
		Polythene bag	Y = 0.442 - 0.014x	-0.9692***	0.9394	0.007
		Refrigeration	Y = 0.434 - 0.002x	- 0.6498***	0.4222	0.004
Albumen Index	Storage Duration	Room condition	Y = 0.073 - 0.0038x	-0.8151***	0.6644	0.005
		Polythene bag	Y = 0.078 - 0.0038x	-0.9156***	0.8383	0.145
		Refrigeration	Y = 0.089 - 0.0015x	-0.6826***	0.4660	0.010
Percent Weight Loss	Storage duration	Room condition	Y = 0.410 + 0.186x	0.9654***	0.9320	0.078
		Polythene bag	Y = 0.124 + 0.084x	0.9813***	0.9630	0.026
		Refrigeration	Y = 0.246 + 0.107x	0.9528***	0.9078	0.053

1 Standard Error of estimate
*** Significance of 'r' at 0.1%.

TABLE 2: MEAN SQUARES OF THE ANALYSIS OF VARIANCE FOR EGG QUALITY PARAMETERS

Sources of Variation	Degrees of Freedom	Haugh Unit	Yolk Index	Albumen Index	Percent Weight Loss
Storage method (S.M.)	2	6057.61***	0.1322***	0.0138***	15.17***
Storage Duration (S.D.)	7	1649.16***	0.056***	0.0052***	5.51***
Method x Duration	14	188.83***	0.011***	0.00034***	0.457***
Residual	120	41.06	0.00082	0.00012	0.121***

***P<0.001

for the other two storage methods. Percentage egg weight loss was positively correlated (P<0.001) with storage duration. The low SEE values indicate the efficiency of the independent variable is estimating the quality parameters.

In Tables 5, the Haugh units, yolk index and albument index values of table eggs purchased from different egg shops are presented. These values were used to estimate the duration of egg storage at the time of purchase, employing the simple linear model. Sampled shell eggs stored open under room conditions had quality indices equivalent to 4 - 11 days after lay and 6 - 9 days after lay for the polythene bagged eggs.

DISCUSSION

The Haugh units, yolk index and albumen index values of fresh eggs obtained in this study are within the range reported by Kader *et al.* (1982); Ihekoronye and Ngoddy (1985); Austic and Nesheim (1990) and Essien, (1990). Increase in percentage egg weight loss with increased storage duration was in line with earlier reports by Olomu (1975a, b) and Essien (1990). The comparatively higher values of the quality parameters of refrigerated eggs established in previous studies have been further confirmed in the present study. The mean Haugh units, yolk index and albumen index values of the freshly - laid (0 - day) eggs were used as the base and compared with the values after 14 days of storage. Haugh units declined by 60.0%, 39.3% and 16.6% for room condition, polythene bag and refrigerated eggs respectively. Similarly the declines in yolk index values were 53.3%, 43.2% and 2.4% while the albumen index values declined by 77.1%, 59.3% and 31.6%

The observation that the quality parameters of polythene bagged eggs were generally higher than those stored openly under room conditions could be ascribed to the micro environment existing within the polythene bag which reduced, significantly, the weight losses from these eggs. This, in turn, could have checked the outward movement of CO_2 and water from the eggs thereby resulting in slightly higher Haugh unit and index values than those observed in eggs stored openly under room conditions.

This result supports the findings of Eurvbetiine and Bamidele (1994) who reported higher Haugh units with polythene bagged eggs. Although Essien (1990) had reported significant negative correlations between each of the quality parameters and percent weight loss, the significantly higher values of quality parameters of refrigerated eggs than polythene bagged eggs (which had the lowest percent weight loss) clearly indicate the overriding effect of storage temperature in preserving shell eggs. Austic and Nesheim (1990) had shown that the lower the storage temperature the longer the maintenance of the internal shell egg quality.

The prediction equations so developed have shown strong indications for the estimation of egg quality under various storage conditions. The comparatively higher r^2 - values associated with the polythene bagged eggs is an indication of the stability of the micro

TABLE 4: RELATIONSHIPS BETWEEN EGG QUALITY PARAMETERS (Y) AND DURATION OF STORAGE (Y) USING THE GROWTH DECAY FUNCTION ($Y = ab^x$)

Dependent Variable (Y)	Independent Variable X	Storage Method	Prediction Equation	Correlation Coefficient (r)	Coefficient of Determination (r^2)	SEE 1
Haugh Unit (HU)	Storage duration	Room condition	$Y = 74.44e\ 0.050^x$	-0.9041***	0.8174	0.045
		Polythene bag	$Y = 75.19e\ -0.032^x$	-0.9457***	0.8943	0.021
		Refrigeration	$Y = 81.86e\ -0.011^x$	-0.9144***	0.8363	0.009
Yolk Index (YI)	Storage duration	Room condition	$Y = 0.45e\ -0.044^x$	-0.9719***	0.9446	0.020
		Polythene bag	$Y = 0.472e\ -0.048^x$	-0.8622***	0.7434	0.054
		Refrigeration	$Y = 0.435e\ -0.004^x$	-0.6141***	0.3771	0.010
Albumen Index (AI)	Storage duration	Room condition	$Y = 0.073e\ -0.079^x$	-0.8862***	0.7853	0.079
		Polythene bag	$Y = 0.082e\ -0.075^x$	-0.9402***	0.8840	0.052
		Refrigeration	$Y = 0.093e\ -0.027^x$	-0.9353***	0.8748	0.019
Percent Weight Loss (PWL)	Storage duration	Room condition	$Y = 0.77e\ 0.106^x$	0.9581***	0.9179	0.049
		Polythene bag	$Y = 0.32e\ 0.117^x$	0.9750***	0.9507	0.041
		Refrigeration	$Y = 0.40e\ 0.114^x$	0.9361***	0.8763	0.061

1 Standard Error of Estimate
*** Significance of 'r' at 0.1% ($P < 0.001$)

TABLE 5: ESTIMATION OF STORAGE DURATION OF TABLE EGGS PURCHASED FROM SOME EGG SHOPS 1

Egg Shop	Haugh Units: Mean Values Obtained [2]	Haugh Units: Estimated Storage Duration (Days)	Yolk Index: Mean Values Obtained [2]	Yolk Index: Estimated Storage Duration (Days)	Albumen Index: Mean Values Obtained [2]	Albumen Index: Estimated Storage Duration(Days)	Mean Estimated Storage[1] Duration (Days) 3
Room Condition A	45.85	10.10	0.226	12.76	0.030	10.75	11.2±0.80
B	50.16	8.45	0.233	12.85	0.035	9.58	10.1±1.17
C	64.42	3.03	0.385	3.72	0.052	5.17	3.97±0.63
D	61.67	4.07	0.321	7.50	0.043	7.55	6.37±1.15
Polythene bag							
E	64.30	5.19	0.334	7.43	0.055	7.00	6.54±0.69
F	62.81	5.95	0.343	6.79	0.046	10.00	7.58±1.23
G	54.54	10.13	0.352	6.14	0.045	10.33	8.87±1.36
H	64.21	5.24	0.369	4.93	0.056	6.67	5.61±0.54

[1] Based on the simple linear model in Table 3.5
[2] 6 Eggs used per shop;
[3] Mean estmates per shop.

environment in the polythene bag which regulated the changes in quality parameters in relation to storage duration. Eggs purchased form shops should be consumed without much delay or refrigerated to minimise the extent of deterioration.

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