

RELATIONSHIP OF TEMPERATURE AND LENGTH OF STORAGE ON pH OF INTERNAL CONTENTS OF CHICKEN TABLE EGG IN HUMID TROPICS

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Abstract: All foods have limited shelf life which vary depending on the food and storage conditions. Table eggs are perishable food and storage temperature is an important factor that affects the shelf life. In tropical countries like Nigeria, eggs are usually preserved under ambient condition due to erratic power supply, which reduces the efficiency of refrigeration system. The aim of the present study was to examine the effects of storage periods, temperature and their relationship on the pH of chicken egg internal properties (yolk, albumen and whole egg). Fresh chicken table eggs were randomly allotted to three treatments of storage temperatures; refrigerator ($4^{\circ}\text{C} \pm 2$), laboratory ($32^{\circ}\text{C} \pm 4$), and poultry store room ($37^{\circ}\text{C} \pm 4$). Eggs were assigned to treatments in a completely randomized design, and each treatment was replicated thrice. The pH was measured daily for each storage temperature in all treatments. Storage temperature and periods had significant ($P < 0.05$) effect on pH of measured parameters. The pH values increased with storage temperature and period of storage. The rate of pH increase was significantly ($P < 0.05$) higher in ambient as compared to refrigerator temperature. In this study, only the refrigerator storage has pH values within the range for fresh table eggs. At storage period above three weeks, pH values increased beyond the range for fresh egg. It is validated that storage temperature and period affected egg shelf life, the rate of freshness reduced with increased temperature, thus, storage beyond three weeks of ambient temperature is not advisable in humid tropics.

Keywords: Humid tropics, chicken eggs, yolk, albumen, pH and temperature

Introduction

The eggs are a common food and one of the most versatile ingredients used in cooking, and are important in many branches of the modern food industry. Eggs

are laid by females of many different species, including birds, reptiles, amphibians and fish but the most often consumed by humans is the chicken egg. Chicken eggs provide a good source of nutrients for man of all ages. Chicken egg, whole and hard-boiled, contains 12.6 g/100 g protein, 10.6 g/100 g fat, 1.12 g / 100 g carbohydrate, and 647KJ (155Kcal) /100 g energy (*Eke et al., 2013*). Egg yolks and whole eggs store significant amounts of protein and choline, and are widely used in cookery. Due to its high protein content, the United States Department of Agriculture categorized eggs as Meats within the Food Guide Pyramid. Despite the nutritional value of eggs, there are some potential health issues arising from egg quality, storage, and individual allergies (*Eke et al., 2013*).

The most important external and internal egg quality traits have been shown to be egg weight, egg shape, shell thickness, breaking strength, specific gravity, air cell, pH, albumen height, and weight, and yolk index (*Samli et al., 2005*). Egg quality can be affected by the environmental conditions such as temperature and humidity of storage time, gaseous environment and storage time. Storage can modify some characteristics of the egg including loss of water, carbon dioxide and a subsequent increase in the pH (*Decuyper et al., 2001*).

Researchers have reported the application of coatings on eggs (*Rhim 2004; Pamarin et al., 2009*). These results can be justified since such coatings help to maintain the functional properties of food by decreasing moisture loss and gas transport (oxygen and carbon dioxide), hence the application of coating on eggs reduces weight loss and maintains internal measurement such as albumen and yolk (*Nadia et al., 2012*). Though oiling of eggs is very effective in slowing down reduction in albumen and yolk quality, it does not replace the need for cool storage (*Faris et al., 2011*). The internal quality of eggs starts to decline as soon as eggs are laid by hens (*Rovana and Usturoi, 2012*). The major difference between freshly laid eggs and stored eggs are linked with internal egg qualities (*Nadia et al., 2012*). Albumen quality, a standard measure of egg quality, is influenced by genetic and environmental factors such as temperature, time and humidity of storage (*Rovana and Usturoi, 2012*).

The increased in rate of egg storage, weakens the vitelline layer (*Jin, et al., 2011*). Changes in albumen pH is an important indicator associated with altered of vitelline layer weight and reduction in protein and hexosamine content of egg (*Akyurek and Agma Okur, 2009*). During egg storage, the yolk becomes more susceptible to breaking (*Nadia et al., 2012*). The yolk absorbs water from albumen and increases in size thereby weakening the vitelline membrane. The flattening of the yolk is primarily due to increase in water content caused by osmotic migration from the albumen through the vitelline membrane. The decrease in vitelline layer strength observed during storage has been associated with loss of moisture from

egg through evaporation, influenced by temperature and storage environment. (From, 1967 in *Akyurek and Agma Okur, 2009*)

Studies have shown that storage of eggs in refrigerator at ($4^{\circ}\text{C} \pm 2$) will retain its nutritional value and wholesomeness for about five weeks (*Faris et al., 2011, Nadia et al., 2012*). However, in tropical countries like Nigeria, egg preservation is a serious problem. The common practice is to store under ambient condition due to inadequate refrigeration facilities, resulting from erratic power supply. To the best of our knowledge, little is known about relationship of storage temperature and storage length on pH of table eggs in humid tropics. Therefore, the aim of the present study was to examine effects and relationship of storage period and temperature on pH of some internal qualities of egg.

Materials and Methods

Experimental procedure

Five hundred and four (504) of freshly laid eggs were obtained from Isa brown hens at the poultry unit, teaching and research farm, Bowen University, Iwo, Nigeria. All the eggs were weighed using digital weighing scale (model: AX 1000) and the weight of each egg was recorded. The eggs were separated into 24 groups of 21 eggs each; poultry store room ($37^{\circ}\text{C} \pm 4$), refrigerator ($4^{\circ}\text{C} \pm 2$), and laboratory ($32^{\circ}\text{C} \pm 4$), were evaluated over 8 weeks. Three eggs were selected randomly from each group daily to measure egg internal content parameters.

Chemical analysis

The yolk was separated from the albumen and both were distributed into three replicates of glass beakers. The pH of the albumen and the yolk were measured with a pH meter (Electronic Instrument Ltd). About 2.0 g of the sample was homogenised in 20.0 ml of de-ionised water in a beaker. The pH meter was first standardised using buffer solution of pH 4.01 and 9.20. The electrode was then rinsed with de-ionised water and dipped into the homogenate allowing sufficient time for stabilisation before taking reading. The yolk and albumen were then mixed thoroughly for each egg sample, and the pH reading was recorded as whole egg.

Statistical analysis

A two way analysis of variance (ANOVA) was performed using the fixed effect model. Bonferroni was used to test for the significance ($P < 0.05$) of variance for all recorded and calculated data between different treatments, main effect of factors (storage temperature and storage length are considered) using model:

$$Y_{ijk} = \mu + T_i + S_j + e_{ijk}$$

Where Y_{ij} = Individual observation

μ = General mean

T_i = Fixed effect of storage temperature ($i = 1 \dots 3$)

S_j = Fixed effect of storage length ($j = 1 \dots 8$)

e_{ijk} = Expected error

Coefficient of determination (R^2) and regression analysis model was used to investigate relationship existing between effect of temperature and storage length on egg (yolk, albumen and whole egg) pH.

The regression model used was of the form:

$$Y = a + b_1X_1 + b_2X_2 + e$$

Where,

Y = Dependent variable (pH)

a = Constant/intercept

b_1 = Regression coefficient of storage temperature

b_2 = Regression coefficient of storage length

X_1 = Storage temperature

X_2 = Storage length

e = Error term

All statistical analyses were carried out with SPSS (2001) version 16.

Results and Discussion

Effect of storage temperature

The results of the effects of storage temperatures on pH of yolk, albumen and whole egg are presented in Table 1. The study conducted over eight weeks period showed that storage temperature had significant ($P < 0.05$) effect on the pH of yolk, albumen and whole egg. The pH values of fresh table egg internal properties measured before storage were yolk (6.05), albumen (7.10) and whole egg (7.21). The pH for yolk, albumen and whole egg had higher values with increase storage temperature over the study period. The yolk pH had the least

values significantly ($P < 0.05$), while the albumen pH had the highest values as the storage temperature increased.

Table 1. Effect of temperature on pH of internal egg contents

pH	Treatments			SEM
	Refrigerator (4 ^o c ± 2)	Laboratory (32 ^o c ± 4)	Poultry (37 ^o c ± 4)	
Yolk	6.37 ^c	6.90 ^b	7.06 ^a	0.05
Albumen	7.72 ^b	9.01 ^a	9.09 ^a	0.11
Whole egg	7.57 ^b	8.65 ^a	8.80 ^a	0.15

^{abc} Means along the same column with different superscripts are significantly ($P < 0.05$) different using Bonferroni as post hoc analysis

Effect of storage length

As reported in Table 2, storage periods had significant ($P < 0.05$) effect on pH of measured internal properties. The pH values increased significantly ($P < 0.05$) with storage period in all measured internal egg properties. A rapid increase in albumen pH towards alkalinity scale was observed as compared to yolk after the 1st week, and a slower rate of increase throughout the remainder of the storage period. The pH of whole egg for 1st – 4th week only differed significantly ($P < 0.05$) as compared to 5th – 8th week. The egg stored under ambient conditions (32^oc and 37^oc) had higher pH values when compared to those that were refrigerated.

Table 2. Effect of storage period on pH of internal egg contents

pH	Period (Weeks)								SEM
	1	2	3	4	5	6	7	8	
Yolk	6.42 ^c	6.53 ^{de}	6.68 ^{cd}	6.73 ^c	6.84 ^{bc}	6.92 ^b	7.00 ^{ab}	7.11 ^a	0.04
Albumen	7.33 ^b	8.60 ^a	8.67 ^a	8.72 ^a	8.80 ^a	8.86 ^a	8.90 ^a	8.97 ^a	0.11
Whole egg	7.50 ^b	7.59 ^b	7.64 ^b	7.78 ^b	8.70 ^a	8.80 ^a	8.93 ^a	9.13 ^a	0.12

^{abc} Means along the same column with different superscripts are significantly ($P < 0.05$) different using Bonferroni as post hoc analysis

Regression analysis

Regression analysis of storage temperature and storage length on pH of internal properties of chicken table egg revealed significant ($P < 0.05$) relationship. The generated regression equation using standardize coefficients of the two factors on measured internal properties and their R^2 are:

$$\text{Yolk, } Y = 5.855 + 0.793X_1 + 0.590X_2 + e, \quad R^2 = 0.976 \text{ -----}$$

(Equation 1)

Albumen, $Y = 6.782 + 0.750X_1 + 0.503X_2 + e$, $R^2 = 0.816$ -----
(Equation 2)

Whole egg, $Y = 6.01 + 0.661X_1 + 0.621X_2 + e$, $R^2 = 0.822$ -----
(Equation 3)

These results showed high positive correlation between storage temperature and length based on the high values for R^2 .

The increase in yolk pH was not as high as the increase in albumen pH. The present results are in disagreement with those of previous researchers (*Samli et al., 2005; Akyurel and Okur, 2009*) who reported that increase in yolk pH was significantly affected by storage time, but not by temperature. However, these findings are in agreement with the results reported by Silversides and Villeneuve (1994), *Scot and Silversides (2000)*, and *Lapao et al. (2009)*. The rise in yolk pH of the eggs may be attributed to loss of carbon dioxide and moisture from the egg through the pores in the shell. This could be attributed to dilution of the egg yolk. As the storage temperature increases, the internal temperature of an egg increases, and leads to increase in yolk pH (*Jones 2006*). This effect of high storage temperature breakdown vitelline membrane and protein structure faster. As the membrane degenerates during increase storage period, water enters the yolk in the form of moisture and shell pores open for microorganism (*Ahn et al., 1999*)

The results for albumen were in agreement with findings reported by *Silversides and Villeneuve (1994)*. Freshly laid eggs contain 1.44 to 2.05 mg CO_2/g of albumen (*Keener et al., 2001; Biladeau and Keener, 2009*) and have an albumen pH value of 7.6 to 8.7 (*Rhim et al., 2004; Waimaleongora-Ek et al., 2009; Ryu, et al., 2011*). In this study, the initial albumen pH was 7.10. During storage, only refrigerated storage had albumen pH range within the freshness category after eight weeks of storage, while loss in freshness started after 4weeks storage period. These results are consistent with the report of *Scott, and Silversides (2000)*, and *Samli et al. (2005)*, who reported significant increases in pH of albumen with increased storage time and temperature. In contrast, *Walsh et al. (1995)* reported that neither temperature nor storage time influenced albumen pH. The decrease in albumen pH may be due to the continuing breakdown of the constituents of the egg white and or a change in the bicarbonate buffer system due to loss of carbondioxide and moisture during storage at temperature above $4^{\circ}C$ (*Biladeau and Keener, 2009. Ryu et al., 2011*).

Related researches on relationship of storage temperature and length with egg pH are scarce to validate result obtained in this present study. As shown in equations (1....3), comparative evaluation of contribution of these two factors (temperature and period) to the deterioration of egg freshness through their

standardized coefficient indicated that storage temperature contributed more than storage period in loss of egg freshness using pH measurement as indicator in yolk, albumen and whole egg. The combined effect of these two factors (temperature and length of storage), had 97.6 %, 81.6%, and 82.2%, while Other factors that were not considered in this study contributed 2.4%, 18.4%, and 17.8% influence on deterioration of egg freshness in yolk, albumen and whole egg respectively based on R^2 values. The generated regression equation revealed positive relationship between storage temperature and period on egg pH (yolk, albumen and whole egg). The positive relationship implies that both storage temperature and period on pH of egg quality parameter go in the same direction, i.e. their increase induced increase in egg pH, hence, deterioration of egg freshness.

In fig (1...3), pH of yolk, albumen and whole egg increased with the storage length at all storage temperature in a nonlinear manner, which depicts that deterioration of internal egg parameters measured is a function of both storage temperature and length. These results are in agreement with results reported by *Samli et al. (2005)*, *Akyurel and Okur (2009)*, *Jin et al. (2011)* who found a similar relationship with temperature and storage length.

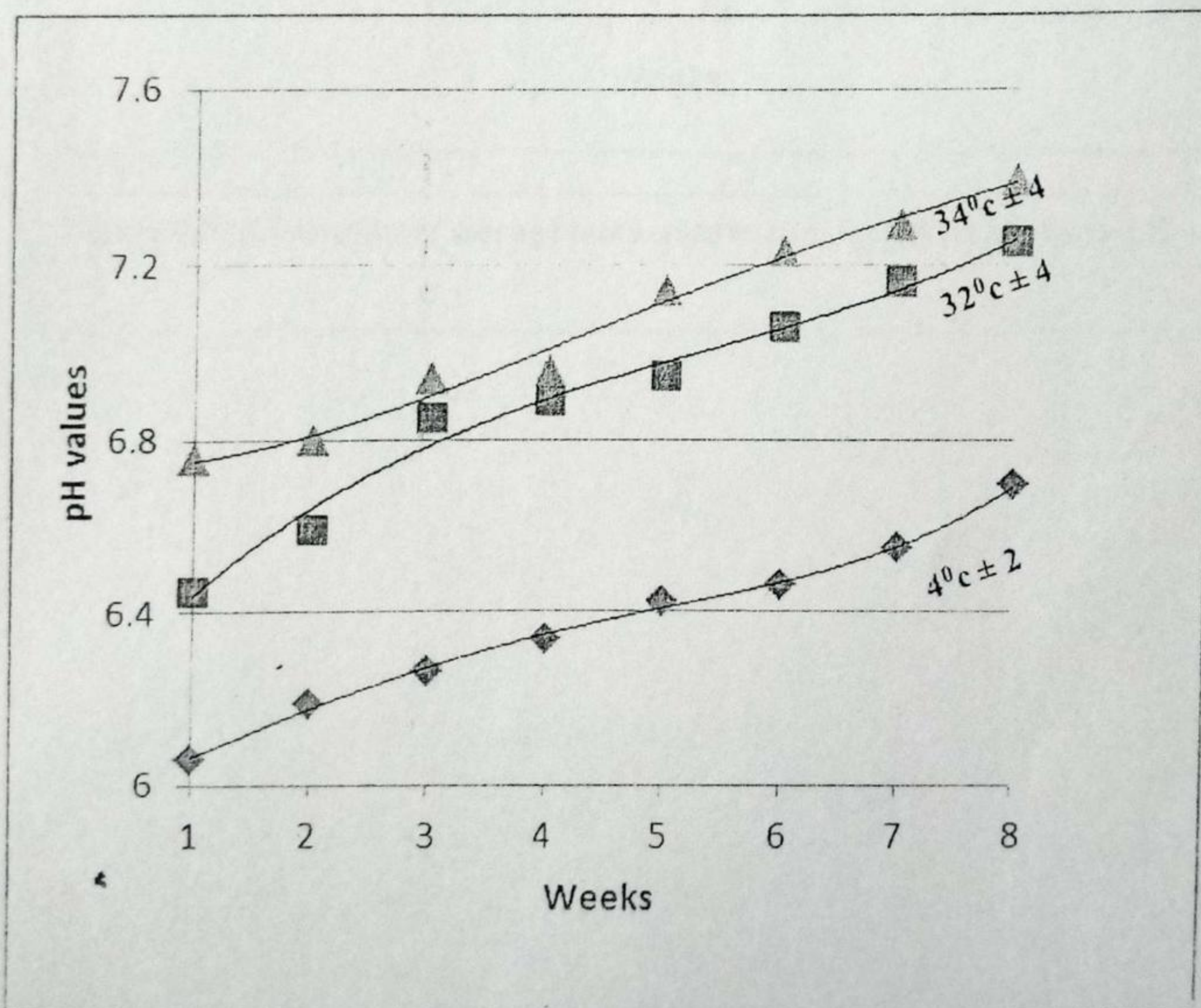


Figure 1. Relationship of storage temperature with length on Yolk pH

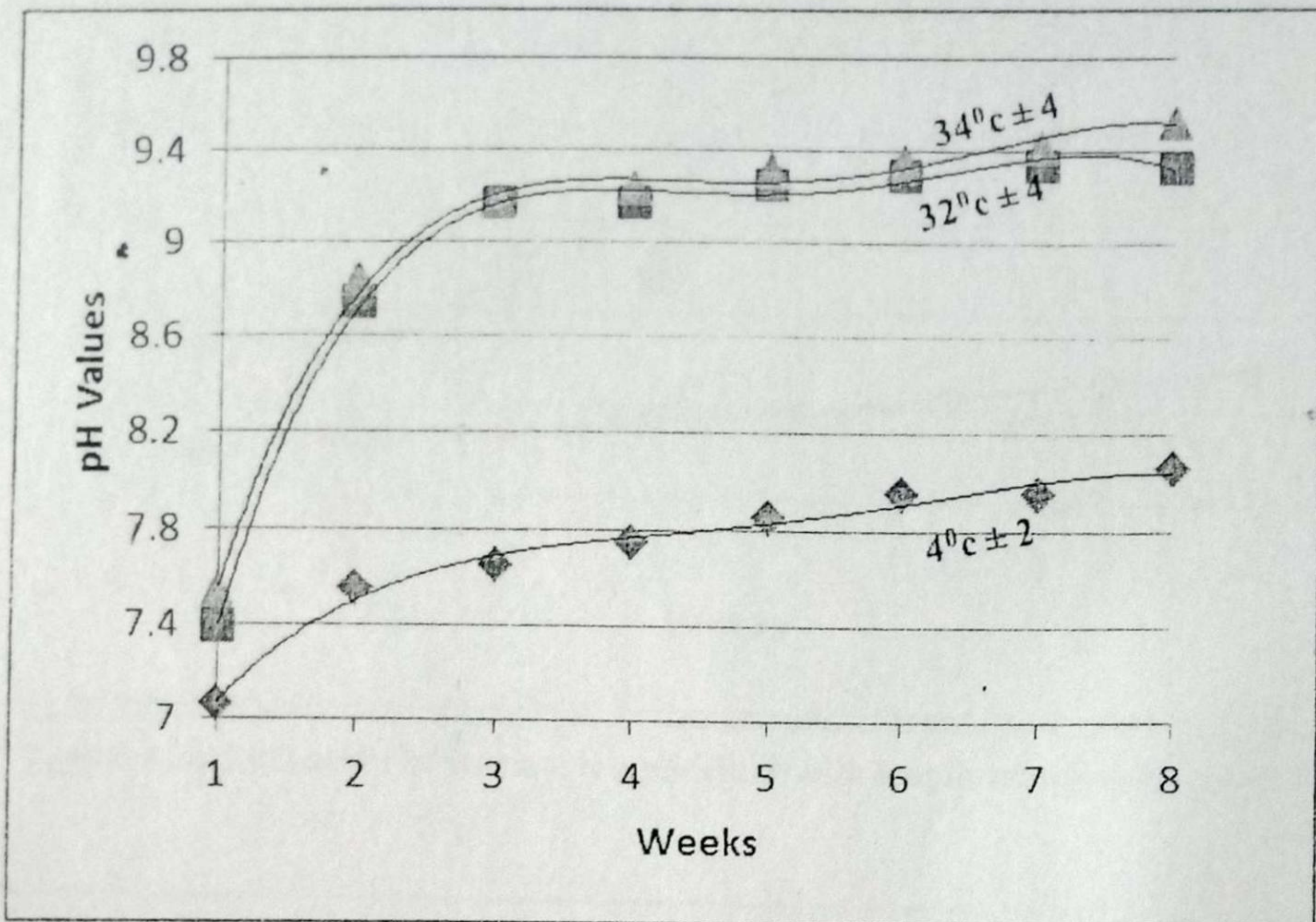


Figure 2. Relationship of storage temperature with length on albumen pH

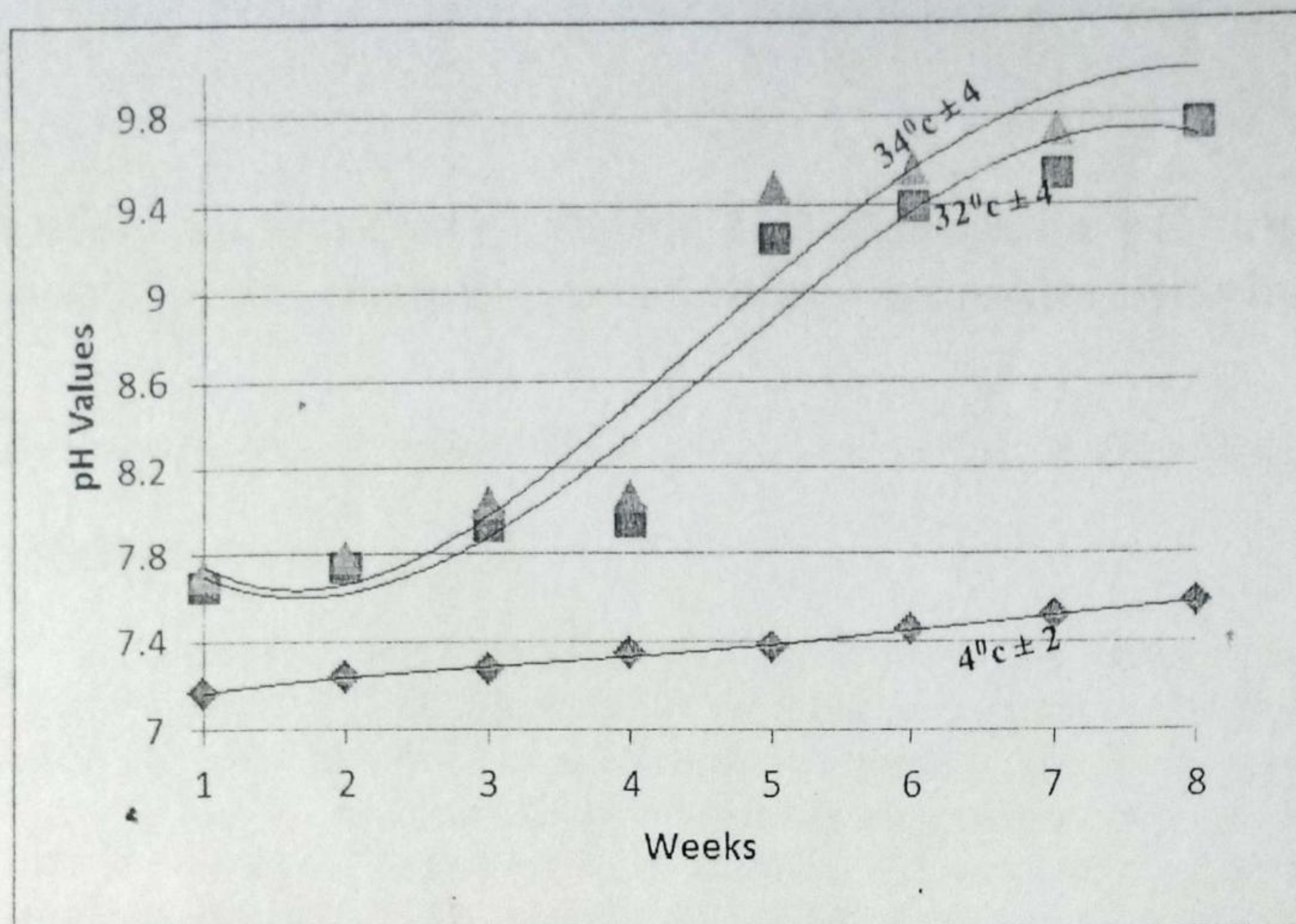


Figure 3. Relationship of storage temperature with length on whole egg pH

Staldelman and Cotteril (2007) stated that pH of fresh eggs should be 7.5 – 7.6, only storage temperature ($4^{\circ}\text{C} \pm 2$) with pH (7.57) is within this range at the end of the study. However, pH of whole egg increased beyond this range after three weeks. This result suggested that in the humid tropics, freshness of egg cannot be preserved for more than three weeks at ambient temperatures 32°C and 37°C .

Conclusion

It could be concluded that, both storage temperature and period play a significant role in maintaining egg freshness. However, storage temperature had more influence than storage period. Also, this study validated that refrigerator storage temperature is superior to ambient storage temperature for maintenance of egg freshness for table egg storage in humid tropics. Poultry farmers and egg users are advised to strictly consider storage temperature, in order to prevent economic and nutritional loss. Hence, it is recommended that chicken table egg should not be stored more than three weeks at ambient temperature to maintain egg freshness in humid tropics.