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(Original Article)

Effect of Edible Coating and Storage Temperature on the Quality of Table Eggs

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Abstract

Storage temperature (30°C& 4°C), coating by edible packaging, and storage time have been studied in order to know their effect on the quality of table eggs. The data showed that eggs stored at high temperatures (30°C) lost weight more quickly than the ones kept at (4°C). The uncoated eggs showed the same pattern. Every sample under examination decreased in yolk index, Haugh value over the course of storage. The rate of reduction was much higher in samples stored at high temperature (30°C). The data showed that as storage time extended, the pH values for the tested (coated and uncoated) eggs rose. Egg albumen's ability to foam and the stability of its foam are both negatively impacted by the rise in pH values that arises from storage duration and temperature of storage. All the samples experienced increase in the total bacterial count along with the progressing of the storage period. The increment was much higher for the samples stored at high temperature (30°C).

Keywords: *Storage, Eggs, Good quality.*

Introduction

Table eggs are a satisfying, low-calorie food and the most affordable source of animal protein (75 kcal per egg). As a result of their efficient digestion and well-balanced amino acid composition, it is a high-quality protein source for humans. It is a basic human food product that is extensively consumed all over the world because it is exempt from the majority of religious prohibitions. According to (Gautron *et al*., 2022), Asia produced the most in 2018, accounting for 53.3% of global output, surpassing both the United States (8.6%) and the 28 members of the European Union (10%). Eggs can become contaminated in a number of ways, including by pathogenic bacteria that can enter the egg's internal contents, survive the entire time the egg is stored, and result in a number of food-borne disorders. (Chousalkar and coworkers, 2021). The quality of eggs decreases over time when they are kept in storage. Keeping eggs at a high temperature also degrades their quality (Senbeta *et al*., 2015). The characteristics of a product that influence a consumer's acceptance or rejection of it are referred to as the egg's quality, claim Saleh *et al*. (2020). It was stated that the interior and outside qualities of eggs are what appeal to consumers. The focus of the external quality is on the egg

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cleanliness, weight, shell thickness and strength, as well as specific gravity, whereas the interior quality is focused on the albumen and yolk quality. After cold storage, leaving eggs on store shelves at ambient temperature runs the risk of water condensing on the shells, which would provide the ideal conditions for microbe growth, according to Tomczyk *et al*. (2019). Long-term storage causes the air chamber to expand, the dense albumen to liquefy, and the vitelline membrane surrounding the yolk to weaken. The yolk absorbs water from the white, expanding it and weakening the vitelline membrane at the same time.

Eggs lose moisture and carbon dioxide while being stored. The quality of the albumen and yolk also decreases when microbes are present. The quantity of bacteria present on the filthy surface of eggshells depends on how hygienic the egg-laying facility is. The exchange of CO2 and water vapor through the eggshell raises the pH of the albumen and yolk, lowers the protein's water content, and reduces the egg's total mass (Al-Hajo *et al*., 2012). As eggs age in storage, their defense mechanisms degrade. In order for bacteria and fungi to pass through the shell and subshell's membranes (Tomczyk *et al*., 2019). Due to the unfriendliness of polymers like polyethylene, polypropylene, and polyethylene terephthalate, edible packaging is a material and packaging method that protects food while also being environmentally friendly (Porta *et al*., 2022). Because plastic wraps have a negative environmental impact and prices have increased, eggs are nevertheless frequently stored and sold without packaging. Therefore, it is vital to look into coated materials that are both safe and degradable in order to maintain the quality of the preserved eggs throughout storage and sale. Edible coatings are frequently added to food goods to increase shelf life, stop weight loss during storage and transport, and save the environment. One of the various materials that can be used as edible packaging is aloe vera gel. Researchers in Spain have now created an aloe vera-based gel that keeps fruits fresh longer. One of the properties of this gel is that it is tasteless, colorless, and odorless. Being natural makes it secure and environmentally friendly. Because of their role in food manufacturing processes-which includes their unique ability to freeze when exposed to heat, the extent of the structural change in texture when whipping, the ability of egg yolk to emulsify, its ability to stick things together, as well as giving some foods like pasta and cakes the yellow color and luster-eggs can be considered one of the best functional foods.

The objectives of this study are studying the effects of temperature and time of storage on the quality of table eggs, and examine the role of edible packaging on keeping the quality of table eggs.

Materials and Methods

Four hundreds recently laid table brown shell eggs were purchased from a poultry farm in Minia, Egypt. The selected eggs (had no cracks or imperfections and were infertile) were cleaned with a piece of steel wool to get rid of any potential shell debris, then split into two groups (200 egg each).

One group was left untreated, while the other received a double coating with Aloe vera gel and air dried. Every group was split into two pieces. One half was

stored at 30°C, while the other was stored chilled at 4°C (Fig.1). The coated and the uncoated eggs were stored for six months. Samples were collected at the start of the experiment and at monthly intervals for analysis.

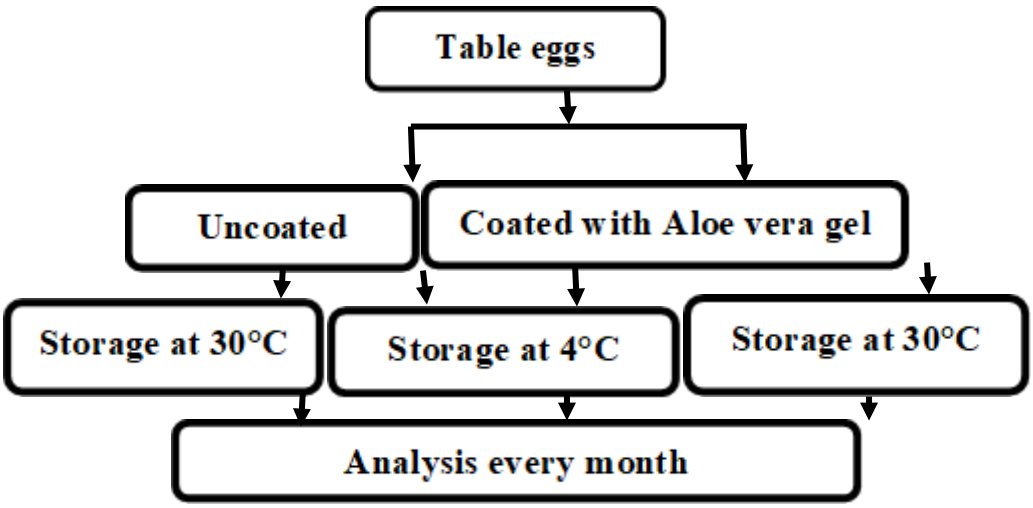

Fig. 1. Flow diagram of the preparation of table eggs for the experiment.

Coating of eggs by Aloe vera gel

Fresh aloe vera gel used for coating eggs was produced from aloe vera plants obtained from the College of Agriculture farm at Minia University in Egypt. Homogeneous leaves were gathered and selected based on size. The epidermis and gel were manually separated after the sample had been cleaned and chilled. The fibrous portion of the gelatinous parenchyma was removed and blended for 5 minutes at 24.500 rpm to form a homogeneous material.

A thin layer of gel was applied to the egg shell right away and kept to dry for 10 minutes, followed by another layer of gel, which was allowed to dry in the open air.

Calculating the % of total weight loss

According to the procedure described by (Wannita *et al*., 2010), a top loading electronic scale (TS400S, Florham Park, NJ, USA), with a readability of 0.001 g, was used to quantify the weight loss of treated and untreated eggs during storage. For each treatment, ten measurements were taken. The estimations for the weight loss (%) of the entire egg during storage are as follows:

$$(\text{Initial weight (g) at day 0} - \text{weight (g) after storage time}) \times 100$$

Where: Initial weight (g) at day 0

Determining the treated eggs' quality parameters

Yolk index and Haugh unit

By breaking eggs onto a glass table with mirrors, albumen length, yolk diameter, and height were measured according to the method of (Keener *et al*., 2006). With a precision of 0.01 mm, a digital tripod micrometer was used to measure the heights of the albumen and yolk. By measuring the portion of the

albumen nearest to the yolk and the height of the yolk from its center, albumen height was calculated.

$$\text{Yolk index (cm)} = \text{yolk height/ yolk breadth}$$

The Haugh unit (HU) is calculated using the following formula:

$$HU = 100 \log (H + 7.5 - 1.7\ W\ 0.35)$$

Where: HU = Haugh unit, H = the height of thick albumen (mm) and W = weight of egg (grams)

Determination of total acidity

The AOAC's (1990) method was used to measure the total acidity of treated and untreated eggs. Percentage of lactic acid is used to describe total acidity.

Determination of pH

Using a pH meter (IQ150, IQ Scientific Instruments, San Diego, Calif., U.S.A.) and buffer solutions of 4.0, 7.0, and 10.0, the pH of egg yolk, albumen, and entire eggs was measured (at zero time and monthly for treated and untreated eggs during storage). Using a homogenizer, the samples were homogenized (10,000 r/min, 30 s) (Scott and Silversides, 2001).

Foaming characteristics

The foaming characteristics of treated and untreated eggs were examined by the method of (Ferreira *et al*., 1995). 20 mL of 5% v/v whole egg were put in 250 mL graduated cylinders and homogenized twice for 30 s at 12000 rpm to create foam. The initial volume of foam and the liquid phase were measured 30 seconds after the second shaking. After 30 minutes, the liquid phase and foam's volume were re-measured.

$$\text{Foaming capacity (\%)} = (V0/Vi) \times 100$$

Where: Vi is the initial volume of liquid, and V0 is the volume of foam at 0 min.

By keeping the foam for 30 minutes and comparing the final foam volume to the initial foam volume at 0 minutes, the stability of the foam was tested as follows.

$$\text{Foam stability (\%)} = (V30/V0) \times 100$$

Where: V30 the foam volume after 30 minutes, and V0 is the volume of foam at zero time.

Microbial analysis

Throughout the storage period for the treated and untreated eggs, the total bacterial count (TPC) was examined monthly accordance to the methods of (AOAC 2000).

Results and Discussion

Due to their outstanding protein quality and great nutritional value, eggs are among the top sources of animal protein. This is in addition to having a wide range of other nutrients, such fats and sufficient amounts of vitamins and minerals, which

can greatly enhance our diet on a regular basis. Food products are wrapped primarily and crucially in order to prevent rotting caused by factors including oxygen, moisture, temperature, and bacteria while being transported and stored. Packaging protects food from the chemicals used in its preparation, processing, and transportation. Food products typically use edible coatings to extend shelf life, prevent weight loss during storage and transport, and protect the environment. Aloe vera gel is one of the many materials that can be utilized to create edible packaging.

Eggs' quality, attributes, and weight deteriorate when they are stored under inadvertent temperature and relative humidity circumstances, which results in financial losses for those working in the egg production and marketing industries. Table eggs' weight loss was shown in (Fig. 2) as a function of time, storage temperature (30°C & 4°C), and edible coating (Aloe vera gel).

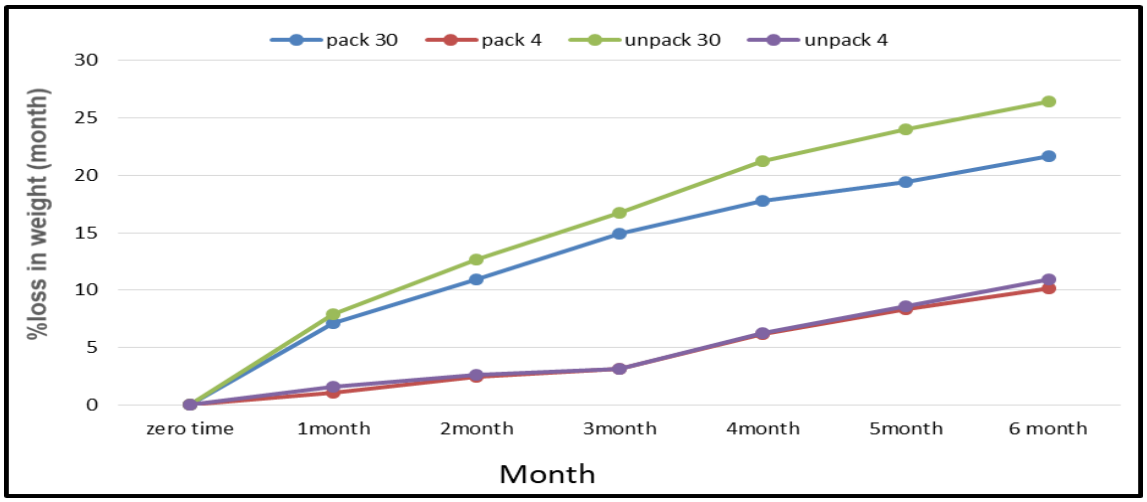

Fig. 2. effect of edible coating (Aloe vera gel), and storage temperature on the weight loss of table eggs stored for 6 months

Eggs stored at high temperatures (30°C) lost weight more quickly overall, whereas eggs kept in refrigerators lost weight much more slowly. The uncoated eggs showed the same pattern. Table eggs covered with Aloe Vera gel lost less weight than those that weren't. This could be as a result of the shell spores helping the eggs expel moisture and gases. The egg white's carbonic acid decomposes into carbon dioxide and water. The egg white thins and becomes more watery as the carbon dioxide escapes through the egg shell pores, which causes the egg to lose weight. The eggs' shell pores may open up at a high temperature of 30°C, making it easier for moisture and carbon dioxide to escape from the eggs.

The results support those made by (Kamel et al., 1980, Waimaleongora *et al*., 2009, and Eke *et al*., 2013).

The Haugh unit and yolk index are the two primary indicators of egg quality. As egg deterioration increases, the vitelline membrane's fiber structure progressively loosens and the membrane strength decreases, lowering the yolk index score. An indication of how recently an egg was deposited is provided by the yolk index. If the yolk index is greater than 0.38, eggs are considered to be very

fresh. Regular are those that fall below 0.28, whereas fresh are those that fall between 0.28 and 0.38. When an egg is broken onto a flat surface, the albumin's height to width ratio is measured to determine how fresh or high-quality the egg is. As the egg deteriorates, the albumin distributes more broadly, lowering the albumin index.

The Haugh unit score rapidly drops during storage, allowing for precise measurement of egg degeneration as soon as it starts to happen after being deposited. Even in eggs that are past their prime, changes in quality can be detected since the yolk index score gradually declines over the length of the storage period.

Figures (3&4) showed how the yolk index and Haugh unit of table eggs stored for six months were affected by the edible coating (Aloe vera gel) and storage temperature (30°C & 4°C). The obtained information demonstrated that every sample under examination decreased in yolk index over the course of storage. In comparison to samples stored at (4 °C), the rate of reduction was much higher in samples stored at high temperature (30°C). The yolk index value was 0.45 at the beginning of storage, indicating that the eggs were of a very high level of freshness.

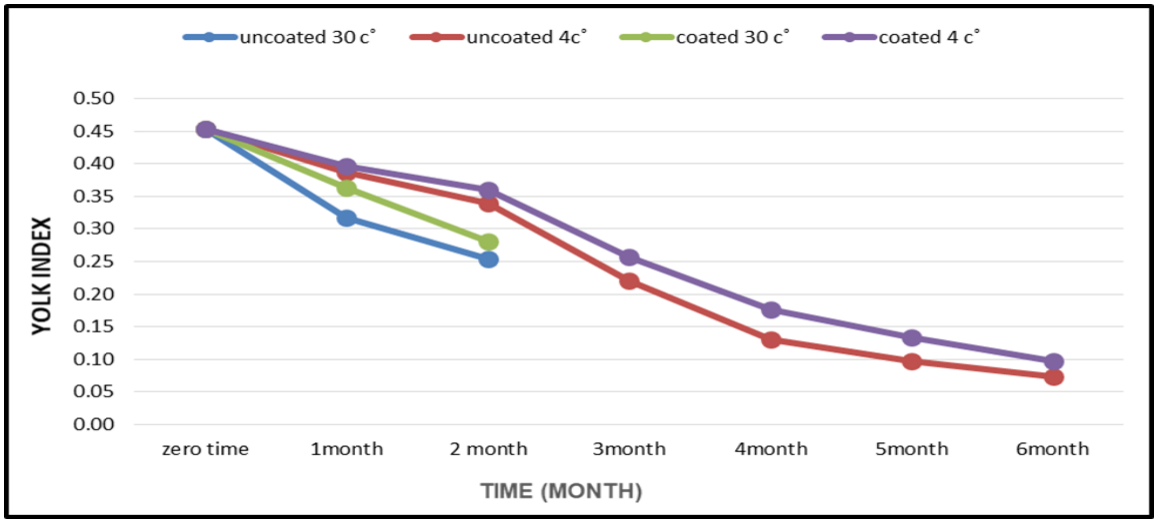

Fig. 3. effect of edible coating (Aloe vera gel), and storage temperature on the yolk index of table eggs stored for 6 months

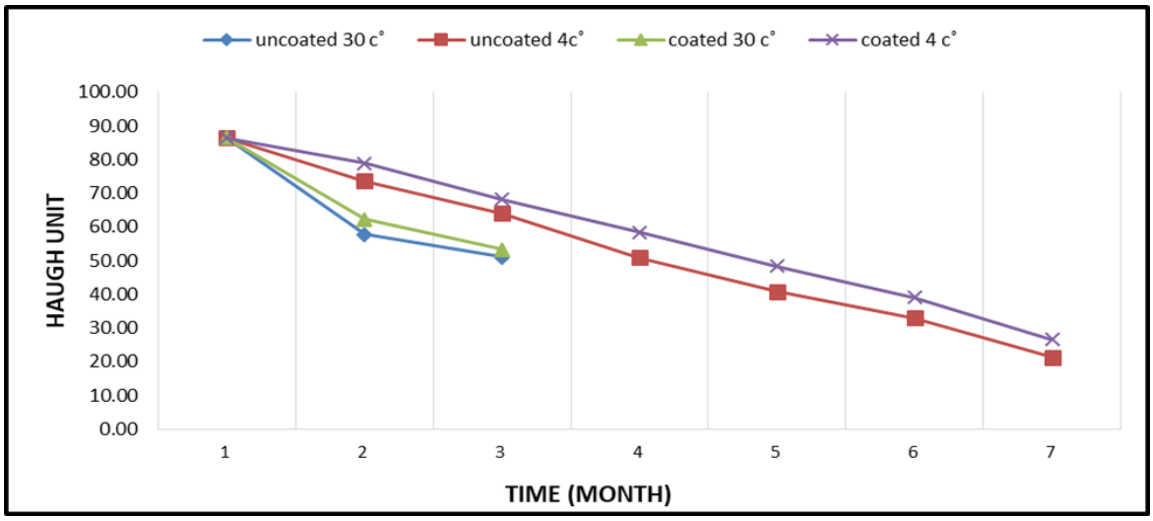

Fig. 4. effect of edible coating (Aloe vera gel), and storage temperature on the Haugh unit of table eggs stored for 6 months

The yolk index for the Aloe vera uncoated and coated samples decreased to 0.25 and 0.28 after two months at (30°C). While the samples kept at (4 °C) had yolk index values of 0.34 and 0.36, respectively, over the same storage time. The yolk index values for the uncoated and coated samples stored at (4 °C) at the end of 6 months of storage were 0.07 and 0.1, respectively, indicating that the eggs were too old and their quality had declined. The data also showed that Haugh value for all samples declined along with the progressing in the storage period. The rate of reduction was much higher for the samples (coated and uncoated) stored at high temperature which reached 51.13 and 53.35 after two months of storage. Whereas the samples stored at low temperature had Haugh unit values of 64.09 and 68.20 for the same treatment respectively.

According to the aforementioned studies, table eggs' yolk index value and Haugh unit value were positively impacted by both Aloe vera gel treatment and low-temperature storage. This is consistent with the findings of (Akarka *et al*., 2021), who discovered that after cleaning and storing encapsulated chicken eggs for 60 days at 4 and 22 °C, the Haugh index will be reduced in aged egg yolks and the Haugh value fell throughout this time.

Because it is not a sufficient indicator to evaluate food quality on its own, the pH value can be used as a guideline to control the quality of food products. Many people are becoming more conscious of the pH levels in their bodies and how acidic their foods are. People with certain kidney and digestive issues can maintain their health and wellbeing by avoiding acidic meals.

The effects of Aloe vera gel coating, storage temperature (30°C & 4°C), on the total acidity and pH of table eggs (yolk, albumin, and whole eggs) stored for 6 months were shown in Figures (5–6). The information demonstrated that as storage time extended, the pH values for the tested (coated and uncoated) eggs rose. Refrigeration-based storage decreases the pH shift, which also slows the rate at which the thick egg white thins. Eggs' pH is typically steady and has no effect on how food products are made. According to Mudannayaka *et al*. (2016), the

albumin pH can be used as a barometer to measure the quality of egg whites. According to (Li-Chan and Nakai, 1989), who found that, the carbon dioxide leakage through the eggshell pores thins the dense albumen during storage and raises the pH of the albumin from 9.6 to 9.7. Whereas, (Eke *et al*. 2013), found that, the pH of eggs covered with oil dramatically rose during storage. Mudannayaka *et al*. (2019) investigated how different coating materials affected egg albumin's pH. After six weeks of storage, they discovered that the uncoated and Aloe vera gel-coated eggs had much higher pHs than the beeswax, gelatin, and mineral-coated eggs, whose pHs ranged from 8.91 to 8.97 at the beginning of the experiment. According to the findings in (fig. 6), the total acidity of all table eggs (coated and uncoated) increased over the course of the storage period. The rate of increment was higher in the samples stored at high temperature (30°C) during the first two months of storage than in the samples stored under refrigeration. Aloe vera gel was applied to table eggs in the interim, slowing the rate at which the total acidity increased. According to (Xu *et al*., 2018), wrapping eggs with wax or aloe vera inhibits the pH from rising, protects the structure of the albumen and ovomucin-lysozyme complex, and reduces carbon dioxide leakage from the shell. According to Mudannayaka *et al*. (2016), the temperature at which an egg is stored affects how quickly it becomes more alkaline; a cooler egg takes longer to become more alkaline. They also said that the age of the egg, how it was produced, and how it was stored all depend on whether a certain area of the egg is acidic or alkaline.

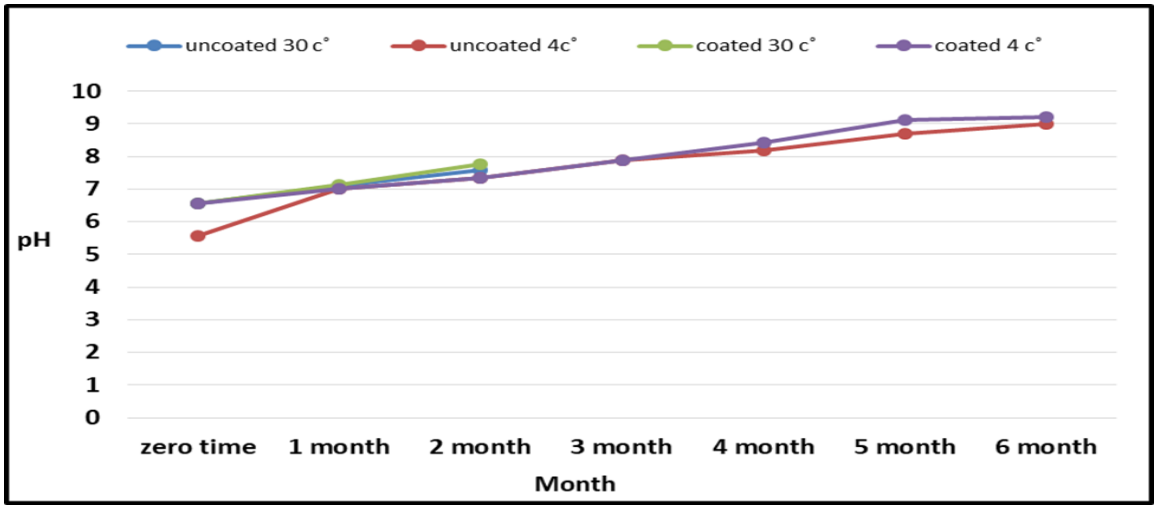

Fig. 5. effect of edible coating (Aloe vera gel), and storage temperature on the pH of table eggs stored for 6 months

Eggs can be regarded as one of the best functional foods because of their role in food manufacturing processes, which includes their distinctive ability to freeze when exposed to heat, the degree of structural change in texture when whipping, the ability of egg yolk to emulsify, its ability to stick things together, and giving some foods like pasta and cakes the yellow color and luster. Egg whites are utilized in the food industry for a number of purposes in addition to being consumed as food, including foaming, emulsification, heat setting, crystallization, and bonding. Egg white can be utilized as a functional component in a wide range of dishes,

including biscuits meringues, meat products, and baked goods, as a result of its special functional qualities. Proteins in egg whites undergo physical stress or compression during whipping, which results in foam. Figures (7 &8) illustrated the effect of edible coating (Aloe vera gel), and storage temperature (30°C & 4°C), on the foaming capacity and foam stability of table eggs stored for 6 months.

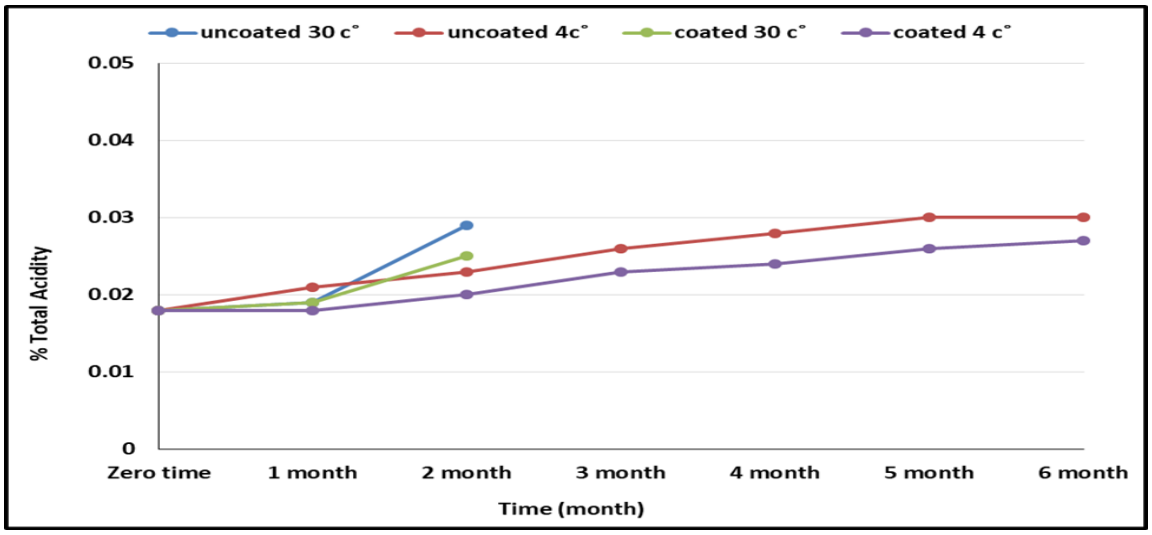

Fig. 6. effect of edible coating (Aloe vera gel), and storage temperature on the total acidity of table eggs stored for 6 months

When comparing storage at high temperature (30° C) to chilled storage (4° C), the same trend was seen. According to the data, egg albumen's ability to foam and the stability of its foam are both negatively impacted by the rise in pH values that arises from storage duration and temperature. The data showed that at the beginning of storage period the foaming capacity was 62.1% but after 2 months of storage it reached 57.85% , 52.23% for the uncoated eggs stored at (4°C &30°C) respectively, and 57.95, 53.76% for the coated eggs stored at (4°C &30°C) respectively. After 6 months of storage the foaming capacity for the coated table eggs reached 36.28%, 26.59% for the samples stored at (4°C &30°C) respectively. Same trend for foaming stability, the data showed that by the progressing of the storage time, the foaming stability declined. The reduction was much higher in the uncoated samples compared with the Aloe vera gel coated ones. The findings demonstrated that albumen foaming capacity and foam stability are significantly impacted by storage duration, temperature of storage and packaging treatment. This comes in agreement with was found by (Hmidet *et al*., 2011).

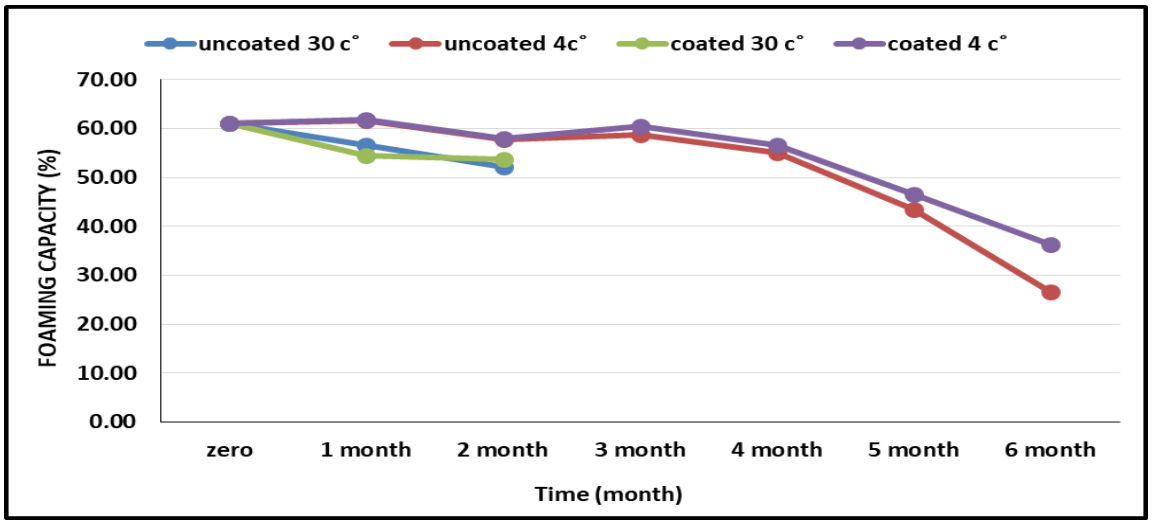

Fig. 7. effect of edible coating (Aloe vera gel), and storage temperature on the foaming capacity of table eggs stored for 6 months

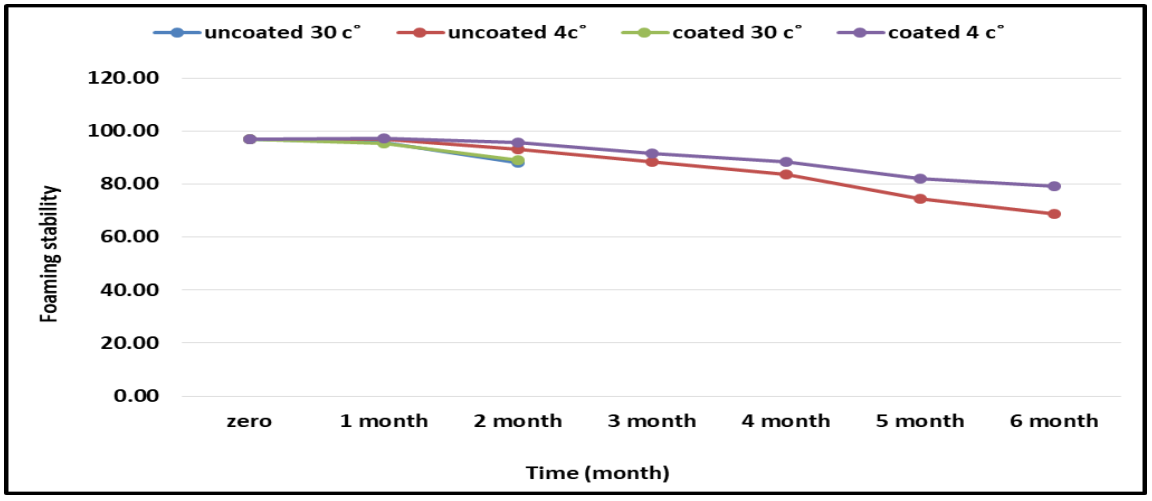

Fig. 8. effect of edible coating (Aloe vera gel), and storage temperature on the foaming stability of table eggs stored for 6 months

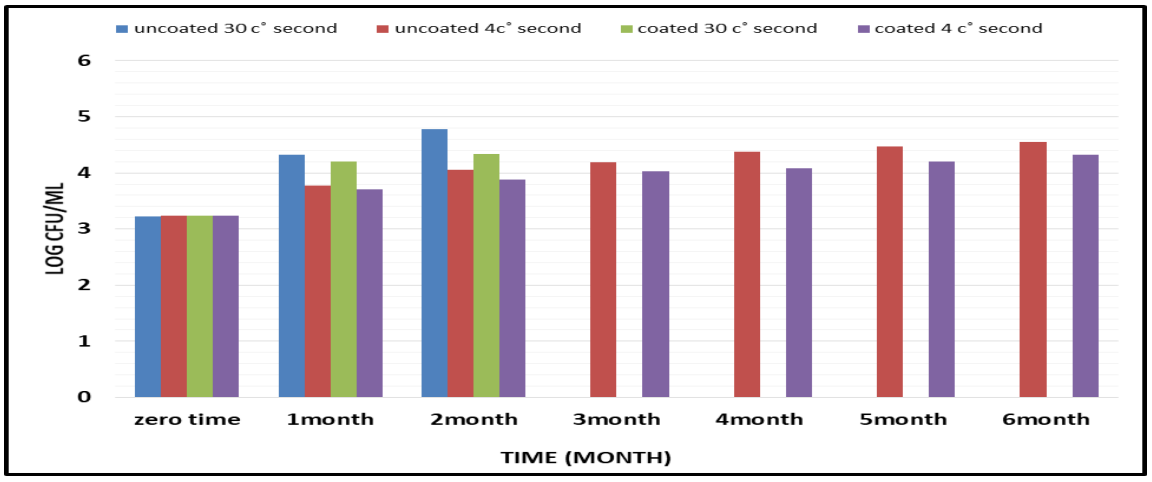

Fig. 9. effect of edible coating (Aloe vera gel), and storage temperature on the total bacterial count of table eggs stored for 6 months

Eggshells are normally covered in microorganisms, and the quantity depends on how hygienic the egg-laying facility is. Eggs' defense mechanisms deteriorate as they age in storage, allowing bacteria and fungi to enter through the membranes of the shell and subshell (Tomczyk *et al*., 2018). The most frequent sources of food-borne diseases are these bacteria. The egg microflora contains microorganisms that lead to degradation, unfavorable alterations in albumen and yolk color, and a foul smell. Figure (9) illustrated the effect of edible coating (Aloe vera gel), and storage temperature (30°C & 4°C), on the total bacterial count of table eggs stored for 6 months. The data showed that all the samples experienced increase in the total bacterial count along with the progressing of the storage period. The increment was much higher for the samples stored at high temperature (30°C) than the ones stored at refrigerated temperature (4°C), Uncoated and coated samples that were stored at high temperatures (30°C), suffered from spoilage and unacceptable changes in smell, color and texture were occurred, which necessitated their disposal. From all of the above, it is clear that storage temperature has greater effect than coating treatment on the viability of table eggs.

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تأثير الغلاف الصالح للأكل ودرجة حرارة التخزين على جودة بيض المائدة

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الملخص

تمت دراسة درجة حرارة التخزين (30 درجة مئوية و4 درجات مئوية) والطلاء بواسطة عبوات صالحة للأكل وقت التخزين لمعرفة تأثيرها على جودة بيض المائدة. أظهرت البيانات أن البيض المخزن في درجات حرارة عالية (30 درجة مئوية) يفقد الوزن بسرعة أكبر من البيض المخزن عند (4 درجات مئوية). أظهر البيض غير المطلي نفس النمط. انخفضت كل عينة قيد الفحص في مؤشر صفار البيض، قيمة Haugh على مدار فترة التخزين. كان معدل الانخفاض أعلى بكثير في العينات المخزنة عند درجة حرارة عالية (30 درجة مئوية). أظهرت البيانات أنه مع تمديد وقت التخزين، ارتفعت قيم الأس الهيدروجيني للبيض المختبَر (المطلي وغير المطلي). تتأثر قدرة زلال البيض على الرغوة واستقرار الرغوة على حد سواء سلبًا من خلال ارتفاع قيم الأس الهيدروجيني الناتج عن مدة التخزين ودرجة الحرارة. شهدت جميع العينات زيادة في العدد الإجمالي للبكتيريا جنبًا إلى جنب مع تقدم فترة التخزين. كانت الزيادة أعلى بكثير للعينات المخزنة عند درجة حرارة عالية (30 درجة مئوية).