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The impact of a sodium alginate-based edible coating mixed with essential oil on the quality and shelf life of chicken breast fillets and fresh sliced apple during storage.

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ABSTRACT

Efficacy of an edible coating based on sodium alginate and mixed up with essential oil 1% of either thyme or cinnamon oil on the quality, shelf life and microbiological safety on chicken breast fillets stored at 4 ºC for 12 days , as well as cinnamon oil on fresh sliced apple throughout the storage period at 4 ºC for 15 days were investigated**.** Data indicated that coating solution based on 3% sodium alginate incorporated with either 1% thyme or cinnamon oil had the maximum antimicrobial action ($P<0.05$) against pathogenic bacteria, yeast, and mold. According to the results coated chicken breast fillets sample showed good quality with lower TBARS, TVBN, weight loss, lower L^* and a^* values and higher WHC until 12 day of storage. Also, adding cinnamon oil to sodium alginate enhanced the sensory quality and increase the shelf life of fresh sliced apple during preservation**.**

Keywords: Sodium alginate, edible coating, essential oil, antimicrobial, quality parameters.

INTRODUCTION:

Due to the short storage period and quality deterioration faced by freshly cut products through storage thus one of the feasible strategies to extend the storage period , edible coatings are used to keeping the quality of freshly cut products. The increasing consumer pressure for healthy, natural and more nutritious researchers were advised to use edible coatings and films as an environmentally friendly technology that provided a semi-permeable membrane difficulty to improve stability, mechanical characteristics of handling, safety, and food quality by supplying carbon dioxide, oxygen, and water vapor between both the food material and the atmosphere of the neighboring environment **(Dhall, 2013 and Liu et al., 2020)**. Edible coatings and films are biopolymers that are broadly being explored for conservation and packaging of food. Films and coatings that are edible have been widely applied due to their many benefits of cost, efficacy and being environmentally friendly edible coatings or edible films have been commonly used in the manufacture of food to preserve food products from corruption and extended shelf life **(Paidari et al., 2021).**

Essential oil applications are still restricted by their strong aroma, low water solubility, and lack of stability in various environmental factors such as temperature, light, and oxygen. **(Maurya et al., 2021; Singh et al., 2021).**

One of the newest methods of food preservation is to apply antibacterial films on the product's surface. Antimicrobial films and coatings have been shown to be effective in different trials which have inhibitory effect against pathogenic bacteria without affecting the properties of films and ensure food safety. **(Sneh Punia Bangar et al., 2021)**.

Chicken meat has major problems of processing and storage issues, In addition to increase the shelf life of fresh items, food manufacturers use synthetic chemicals with antioxidant and antibacterial properties. Other solutions to decrease oxidation of lipid and pathogen growth in foods have increased interest; the use of essential oils in association with Basel seed gum has an antibacterial and antioxidant impact on chickens fillets **(Marjan Majdinasab et al ., 2020).**

These functions improve and increase the quality of food products, resulting in increased shelf life and safety. Antimicrobials are included into edible coatings to prevent food from microbial degradation, increase their shelf life, and improve safety. **(Elham Tavassoli-Kafrani et al ., 2020).**

The goal is to investigate how to make edible films and coatings from natural polysaccharides (alginates) and how to use them to preserve food by focusing on the following points:

- Antimicrobial characteristics of edible coatings made from extracted alginates incorporated with essential oils are studied.
- Evaluation the impact of during refrigerated storage, edible coatings improve some quality parameter and increase the storage period of fresh sliced apple and chicken breast fillets.

MATERIALS AND METHODS

Microorganisms and media

1. Bacteria The bacterial strains used in this study were kindly supplied by the Microbiology Department, Faculty of Agriculture, Cairo University. These strains are *Staphylococcus aureus* ATCC 25923, *E. coli* O157:H7 ATCC 8624, *Listeria monocytogenes* ATCC 7644 *and Salmonella typhimurium* ATCC 14028. Cultures were maintained on nutrient agar slants at 4 ±1^{o}C and sub cultured at 37 ^{o}C in nutrient broth for 24 hours.

2. Fungi *Aspergillus niger* (NRRL 326) was obtained from MIRCEN (Microbiological Resource Center), Ain Shams University, Cairo, Egypt.

3. Yeast *Candida albicans* ATCC 10231 was obtained from MIRCEN (Microbiological Resource Center), Ain Shams University, Cairo Egypt.

2. Food ingredients

Fresh chicken breast fillets were bought from the local market, Cairo city, Egypt, directly after slaughtering. Apple was bought from the local market, Cairo City, Egypt.

Methods

1) Preparation of edible film sod. alginate extracted from brown algae (commercial known as seaweeds) *Turbinaria conoides*

Sodium alginate solutions were prepared from brown algae (commercial known as seaweeds) *Turbinaria conoides* according to **Dina, A. et al ., 2021** at different levels **(**1.5, 2, 2.5 and 3%), (w/v) with distilled water under stirring slowly until a homogenous solution was formed. After that adding 2% CMC or 2% pectin and 1% thyme or cinnamon oil, then the solution was mixed until a homogenous solution was obtained and 1.0% glycerol was added as plasticizer until an edible film solution formed (**Rojas-Graű et al., 2007).**

2) Assessment of antimicrobial activity of extracted sodium alginate

Different concentrations of sodium alginates solutions 2, 2.5 and 3% combined with 2% carboxy methyl cellulose (CMC), 1% essential oil (thyme or cinnamon), were heated at 70°C on a hot plate with stirring. After cooling, 1% glycerol was added as plasticizer. These solutions were used to study the antimicrobial properties. Antimicrobial activity of previous prepared solutions of extracted sodium alginates was detected by the well diffusion method **(Valgas et al., 2007).**

3) Application of edible coating

3**. 1. Fresh chicken breast fillets preparation**

Fresh chicken breast fillets were used in the study coated with the prepared extracted sodium alginates solution and 1% thyme oil by dipping, draining and drying on an expanded stainless steel mesh for 5 to 10 min and then placed in packages. Control sample was dipped in distilled water. All of the control and there were samples packed in polyethylene tere phthalate (PET) and stored at 4±1˚C for 12 days. Samples were withdrawn at 0, 3, 6, 9, 12 days for physical, chemical and microbiology and sensory analyses according to **(Seyhan et al., 2005).**

3. 2. Fresh sliced apple preparation the apple was gently cleaned with tap water and dried. manually. After that, it was halved and sliced into slices. Then, the sliced apple was dipped twice in the fresh coating solution with 1% cinnamon oil for 1 minute to ensure that the coating on the entire surface is consistent. The sliced apple was air dried for 30 min at room temperature. Control sample was dipped in distilled water. After drying, sliced apple was placed in polyethylene tere phthalate (PET) and stored at 4±1˚C for 15 days. The samples were withdrawn at 0, 3, 6, 9, 12, 15 days for analyses.

4. Quality parameters

a. Moisture content & pH value

The moisture content and was determined using the **AOAC technique (2016)**. A digital pH meter was used to determine the pH of the samples (Genway-Germany) **(AOAC, 2016)**.

b. Titratable acidity

The AOAC (2016) method for fruits was used to determine titratable acidity (TA) by titrating 10 mL of fresh sliced apple juice with 0.1 M NaOH and using phenolphthalein as an indicator. On both coated and uncoated samples, assays were performed in triplicate. The results are given in malic acid (%).

$$\% \, T.A = \frac{V \times M \times E \times 100}{W \times 1000}$$

The volume of titrant (NaOH) used is V, the molarities of NaOH are M, the equivalent molecular weight factor for malic acid is E (67,045), and the weight of the sample is W. (in grams).

c. Total soluble solids (ºBrix)

The concentration of soluble solids in the samples was determined using a refractometer and given in°Brix scale (**Gol et al., 2013).**

d. Thiobarbituric acid value (TBA) The TBA as an indicator for lipid oxidation was determined according to the method of **Pearson (1970).**

f. Total volatile basic nitrogen (TVBN)

Winton and Winton's (1958) method for determining total volatile basic nitrogen was used.

g. Water holding capacity

The filter press method **Wierbicki and Deatherage (1958)** was used to determine the water holding capacity (WHC) of fresh chicken breast fillet samples.

h. Weight loss

Before being placed at 4^{o}C and at intervals of time, each apple slice was weighed (0, 3, 6, 9, 12, 15 days). At various periods, chicken breast fillet samples were weighed (0, 3, 6, 9, 12 days). The difference between the original weight and the weight of the samples after storage was used to calculate weight loss, and the results were reported as a weight loss percentage. Weight loss (%) = $[(m1 - m2) / m1] \times 100$

Where m1 was initial weight (g) and m2 was time point weight (g).

i. Texture (firmness) determination

The force–deformation curve was used to measure the hardness and distortion of fruit samples. Using the methods given by **(Maftoonazad and Ramaswamy 2005).**

j. Color analysis

Samples were analyzed using CR-40 (Konica Minolta Sensing Inc, Sakai, Japan) colorimeter. Readings of L*, a* and b* were recorded for control and coated samples **(Ali et al., 2011 and Song et al., 2013).**

k. Microbiological analysis

1. Coated fresh chicken breast fillets

Fresh and coated chicken breast fillets were analyzed for yeast and mold count, total coliform bacteria counts and *Staphylococcus aureus* were determined according to **FAO/WHO (1995).** Dishes are incubated at 37^{o}C for 24 to 48 h. Proteolytic and lipolytic bacteria counts were detected by using 10% skim milk agar and 10% oil, respectively, added on nutrient agar before poured in dishes and incubated at 37°C for 24-48 hours **(Cappuccino and Sherman 1999).**

2. Coated fresh sliced apple

Coated and uncoated fresh sliced apple were analyzed for total bacterial and yeasts and molds count and total coliform bacterial count according to procedures of **FAO/WHO, (1995)**.

5. Sensory evaluation

Sensory evaluation of uncoated (control) and coated fresh chicken breast fillets

Samples were breaded with Seasoned Coater and fried. Frying was done at 175-180°C for 1.5: 2 min. Each treatment was replicated three times. Samples were withdrawn at 0, 3, 6, 9 and 12 days for evaluation **(Seyhan et al., 2005**). Fresh sliced apple were done like ten panelists for coated and uncoated fresh sliced apple (**Ramadhan et al., 2011).**

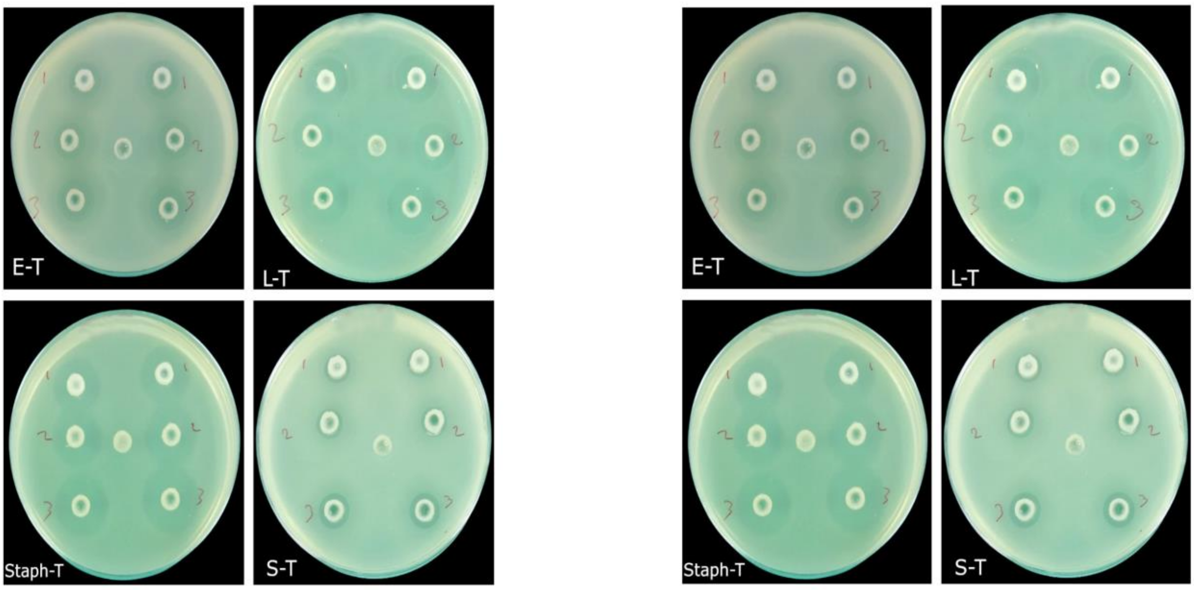
6. Statistical analysis

SPSS software was used for all statistical analysis (version 20.0, IBM SPSS Statistics, USA). The experiments were carried out in three different methods. The Dunken multiple comparison test was employed after the analysis of variance (ANOVA) to look for differences between treatments. Differences of a statistical significance of ($p < 0.05$) were determined to be significant. **(Maftoonazad et al., 2008).**

RESULTS AND DISCUSSION

1. Antimicrobial activity of coating solutions (sodium alginate-essential oil) in vitro.

Food-borne infections and food quality deterioration are considered the main cause mostly by pathogenic and food spoilage microorganisms including both developed and emerging nations. This results in decreased storage duration and the spread of foodborne infections, and financial losses in the food industry. For example, *Staphylococcus aureus* is the most common cause of food poisoning **(Hennekinne et al., 2012).** Artificial additives have been regularly used for centuries, on the other hand, is more complicated due to their toxicity. As a result, there has been a rise in interest in utilizing natural compounds as a food preservation alternative. Essential oils have been popular in recent years due to their wide range of bioactivities, including antibacterial, antifungal, antiviral, antioxidant, and insecticidal properties **(Böhme et al., 2014).**



A **B**

Fig. (1): Images of inhibition zones of sodium alginate, CMC films incorporated with A:Cinnamon oil , B :Thymus oil agaist (E) *Escherichia coli* (L) *Listeria monocytogenes* (S) *Salmonella typhimurium*, (S-T) and Staphylococcus aureus

In Table 1 and Fig. 1 the results showed that control coating (coating consists of extracted sodium alginates+2% CMC+1% glycerol without essential oil) There was no evidence of antimicrobial action. The diameters of the inhibition zone indicated that coating with 3% sodium alginates incorporated with 1% of either thyme OR cinnamon had strongly effect than coating with other concentration of sodium alginates (2 and 2.5%) which inhibited species of pathogenic bacteria including *Listeria monocytogenes* and *Staphylococcus aureus* (gram-positive) but *Salmonella typhimurium* and *Escherichia coli* (gram-negative), *Candida albicans* and *Aspergillus niger.*

It was showed that *Candida albicans* was more sensitive to sodium alginate-thyme oil at different concentrations (2, 2.5 and 3%) of sodium alginates followed by sodium alginate-cinnamon oil coating. The diameters of inhibition zone of sodium alginate incorporated with thyme oil coating were 13.16, 13.50, and 14.00 mm at concentration of 2, 2.5 and 3% sodium alginates, respectively.

There were no significant variations between the effect of different concentrations of sodium alginates (2, 2.5 and 3%) incorporated with 1% of either thyme or cinnamon essential oil against *Aspergillus niger* The zone diameters of inhibition of sodium alginate-thyme oil coating were 18.16, 18.38, and 18.66 mm at different concentrations 2, 2.5 and 3% of sodium alginates, respectively. These results are in harmony with those of **Rohaim ,(2020)** who reported that starch-high propyl cellulose composite edible coating incorporated with 2% rosemary extract showed antimicrobial activity against *E. coli* 0157:H7, *S. aureus*, *B. subtilis*, coliforms, yeasts and molds in all samples (apple slices, strawberry fruits and potato strips) during storage at 4ºC for 28 days.

In another study conducted by **Solís-Contreras et al., (2021)** in which authors examined the impact of three bioactive coating types (chitosan-based coating, guar gum-based coating, and composite guar gum-starch-based coating) on microbiological analyses of low-processed golden delicious apple slices over a 25-day period at 4°C. Authors found that all coating containing cinnamon essential oil (10%) late the growth of bacteria, slow rate of the growth of yeast and mold. .

From the obtained results in **Table (1)** the concentration 3% of sodium alginates incorporated with 1% thyme or cinnamon oil has a good potential to be a natural antimicrobial agent on the application of chicken breast fillets and apple slices, respectively, during refrigerated storage.

Table (1): Antimicrobial activity of sodium alginate-based coating incorporated with 1 % of either thyme or cinnamon essential oil on pathogenic bacteria, yeast and mold in vitro.

Organism	Concentration (%) of extracted sodium alginate	Inhibition diameter (mm)	
		Thyme	Cinnamon
Listeria monocytogenes.	control	0.00	0.00
	2%	17.00 ± 1.7 Ba	14.00 ± 0 .00 Bb
	2.50%	17.33 ± 0 .57 Bb	18.33 ± 0.57 ABa
	3%	18.66 ± 0 .57 Aab	19.16± 0 .57 Aa
Staphylococcus aureus.	control	0.00	0.00
	2%	19.50 ± 1 .15 Ab	21.50 ± 0 .7 ABa
	2.50%	20.33 ± 0 .57 Ab	22.00 ± 0 .00 Aa
	3%	20.66 ± 0 .57 Ab	22.66 ± 0 .57 Aa
Salmonella typhimurium.	control	0.00	0.00
	2%	11.16 ± 0 .28 Ba	9.30 ± 0 .00 Cb
	2.50%	11.33 ± 0 .57 Ba	11.33 ± 0 .57 Ba
	3%	12.00 ± 0 .57 Aa	12.00 ± 0 .00 Aa
Escherichia coli	control	0.00	0.00
	2%	11.33 ± 0 .50 Ba	11.16 ± 0 .28 Ba
	2.50%	11.50 ± 0 .57 Bb	11.83 ± 0 .25 Bb
	3%	13.00 ± 0 .00 Aa	13.00 ± 0 .28 Aa
Candida albicans	control	0.00	0.00
	2%	13.16 ± 0 .28 Ba	11.16 ± 0 .28 Bb
	2.50%	13.50 ± 0 .00 Ba	11.33 ± 0 .57 Bb
	3%	14.00 ± 0 .50 Aa	12.16 ± 0 .28 Ab
Aspergillus niger	control	0.00	0.00
	2%	18.16 ± 0 .28 Aa	11.10 ± 0 .10 Ac
	2.50%	18.38± 0 .57 Aa	11.16 ± 0 .15 Ac
	3%	18.66 ± 0 .57 Aa	11.33 ± 0 .26 Ac

* Means of 3 replicates ± SD,
* Means with the different letters in the same column (capital letters) or in the same row (small letters) differed significantly ($p<0.05$)
* Control: the coating consists of extracted sodium alginates + 2% CMC + 1% glycerol without essential oils.

2. Quality and shelf- life of coated chicken breast fillets during cold storage.

2. 1. Lipid oxidation

The main source of food oxidation is oxidation. It is one of the primary causes of quality degradation during storage **(Pouzo et al., 2016)**. Based on our results revealed in **Table (2)** and **Fig (2),** TBARS values of control as well as coated sample noted a significant ($P<0.05$) increasing toward the storage time. In the coated sample, the rate of increase in TBARS values was slower than in the control sample. demonstrating that coated chicken breast fillets are more oxidatively stable There was significant ($P<0.05$) decrease in TBARS values in coated sample at 6th day of storage compared to control sample. The similar results were presented in fresh chicken sausages treated with essential oils **(Sharma et al. 2017).** Lower TBA values of coated chicken breast fillets because alginate and thyme oil have a synergism on lipid peroxidation. According to the study **(ES1694 / 2005),** coated chicken breast fillets sample suggests acceptable quality with lower TBARS until 12 days at 4 ^{o}C, as illustrated by their lower TBARS (less than 0.9 mg MDA KG-1 meat).

Table (2): Assessment of sodium alginate – based edible coating incorporated with thyme oil on thiobarbituric acid value as mg/kg and Total volatile basic nitrogen (TVBN) (mg N/100g sample) of chicken breast fillets during storage at 4ºC for 12 days.

Storage time (days)	TBA (mg. MDA / kg)		Total volatile basic nitrogen (TVBN)	
	control	coated	control	coated
0	0.32 ± 0.01^{Aa}	0.20 ± 0.01^{Aa}	12.46 ± 0.11^{Aa}	11.7 ± 0.17^{Ab}
3	0.46 ± 0.01^{Aa}	0.37 ± 0.01^{Aa}	18.48 ± 0.03^{Ba}	15.42 ± 0.03Bb
6	1.3± 0.44^{Ba}	0.54 ± 0.01^{ABb}	23.41± 0.02^{Ca}	17.24 ± 0.09^{Cb}
9	NE	0.63 ± 0.02^{ABb}	NE	19.62 ± 0.32^{Db}
12	NE	0.83 ± 0.01^{Bb}	NE	20.45 ± 0.06^{Eb}

Data represent mean of 3 replicate ± SD *

* Means with different letters in the same column (capital letters) or in the same row (small letters) are significantly difference (p< 0.05)
NE= not examined since the product has spoiled Control sample = no treatment, coated sample = 3% sodium alginate and 2% CMC, 1%, thyme oil.

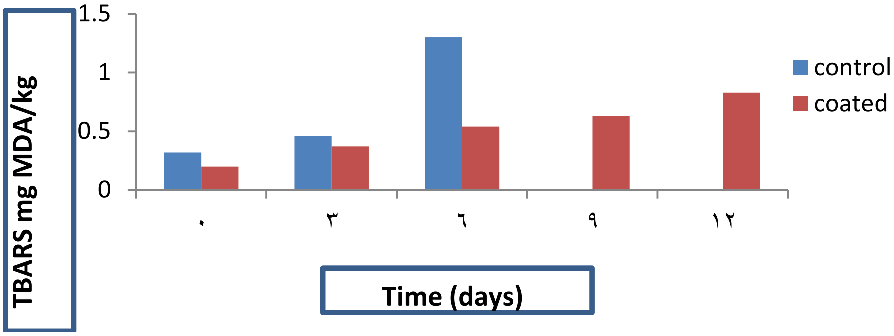


Fig. (2): Effect of sodium alginate incorporated with thyme oil 1% on TBARS values (mg MDA/kg) of chicken breast fillets during storage at 4 °C for 12 days.

2. 2. Total volatile basic nitrogen (TVBN)

At the beginning of storage (zero time), uncoated and coated chicken breast fillets samples exhibit 12.46 and 11.70 mg N/100g sample respectively. These values are similar to previous results by **EL-Desouky et al., (2006)** are related to the high quality of raw materials employed in this experiment. **In Table (2)** and **Fig. (3)**. the coated chicken breast fillets sample shows good quality with lower TVBN till 12 days at 4 ºC. Storage time had a significant effect on TVBN values which tended to increase with storage. Bacterial activity in the deterioration process and endogenous enzymes could be linked to the increase in TVBN value in chicken breast fillet samples **(Gavriilidou et al., 1997 and Lu et al., 2009).**

Also **Table (2)** and **Fig. (3)**. Showed that a sodium alginate edible coating had a significant ($P<0.05$) influence on TVBN chicken samples. At the 6th days, TVBN of uncoated and coated chicken breast fillets reached to 23.41 and 17.24 mg N/ 100g sample respectively.

This could be because thyme oil's antibacterial activities cause a faster decline in bacterial population or a decrease in bacteria's capacity to oxidatively delaminate non-protein nitrogen molecules. When it comes to TVN levels for deterioration meat products, anything over 20 mg N/100g is usually considered ruined meat **(ES 1694, 2005).**

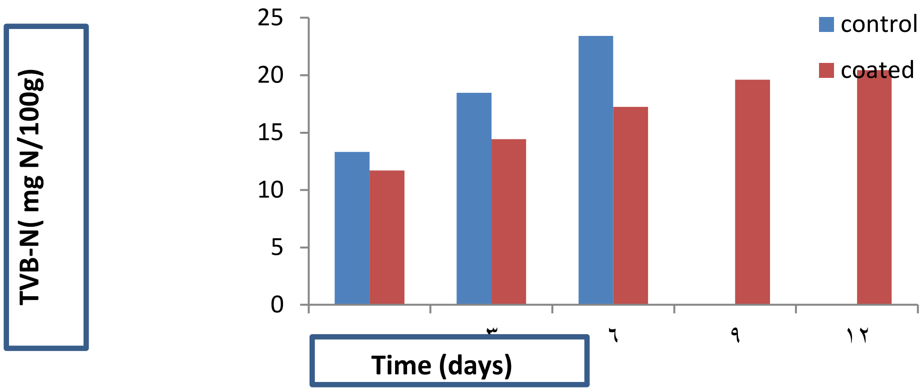


Fig. (3): Effect of sodium alginate incorporated with thyme oil 1% on TVB-N values (mg N/100g) of chicken breast fillets during storage at 4 ºC.

2. 3. pH

During the keeping of poultry and meat, pH is one of the components that change .pH changes in uncoated and coated chicken breast fillets after 12 days of cold storage at 4°C are presented in **Table** (3) and **Fig. (4)** Coated chicken breast fillets had comparatively lower values than control. Freshly prepared control and coated samples had pH values of 6.22 and 6.20, respectively, which arrived to 6.29 and 6.23 at 3rd day of storage. Control samples were not investigated after the 6th day because there is a visible sign of rotting. The pH of coated chicken breast examined fillets increased from 6.32 at 6th day to 6.57 at 12th day of storage; this was related to the ionized carbonate action caused by the coating's release. **Petraccia et al., (2013),** reported that carbonates because they make the ionic strength stronger. And enhance exchanging ions; they significantly raise the pH of meat.

According to research, the pH of foods maintained under aerobic conditions increases throughout storage, alkalinizing substances produced by microbes and ammonia due to amino acids degradation **(Krizek et al., 2004 and Balamatsia et al., 2006).**

Table (3): Assessment of sodium alginate based edible coating incorporated with thyme oil on pH of chicken breast fillets during of storage at 4 ºC for 12 days.

Storage time (days)	pH	
	Control	Coated
0	6.22 ± 0.19	6.20 ± 0.01
3	6.29 ± 0.25	6.23 ± 0.01
6	7.01± 0.01	6.32 ± 0.01
9	NE	6.48 ± 0.01
12	NE	6.57 ± 0.01

Data represent mean of 3 replicate ± SD *
NE= not examined since the product has spoiled Control sample = no treatment, coated sample = 3% sodium alginate and 2% CMC, 1%, thyme oil.

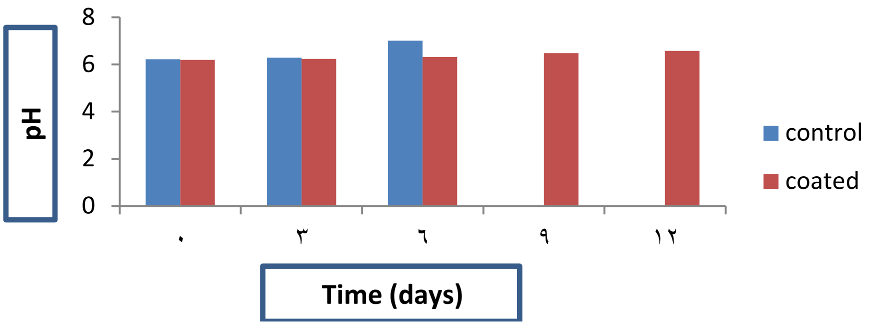


Fig. (4): **Effect of sodium alginate incorporated with thyme oil 1% on pH values of chicken breast fillets during storage at 4 °C for 12 days.**

2.4. Water holding capacity and Weight loss (%)

In **Table 4** There was a significant ($p<0.05$) difference in WHC between storage periods in all of the samples and WHC declined considerably with storage time in all of the samples. When compared to uncoated chicken breast fillets, coated chicken breast fillets showed a greater WHC, which could be attributable to less moisture loss.

Coated chicken breast fillets exhibited higher WHC which could be due to addition of hydrophilic hydrocolloids which prevents moisture loss **(Varela and Fizsman, 2011).** At the end of storage period control had lowest WHC values. This was in agreement with **Jamshidi and Shabanpour, (2013)** who compared different gums coating material on fish fillets and found that alginate gums had highest WHC.

As shown in Table 4, during the refrigerated process, weight loss occurs. Time exhibited significant differences ($P<0.05$) both samples and days of storage .Uncoated control fillets lost more weight during storage. After 6 days of storage, weight loss in the uncoated and coated samples increased to 6.4 and 1.9%, respectively. Of the 12th day of storage at 41°C, weight loss in coated samples reached 2.9 %, whereas the control sample was ruined. Plasticizers like sorbitol, which help to compensate for this by improving the extension and storage capacity of the water lost from the sample by the coating **(Sanyang et al., 2015**).

As shown by **Song et al., (2011),** the application of an alginate-based coating to bream fillets stored at 41°C prevented weight loss. The antibacterial activity of thyme oil and its synergistic impact with alginate, which had moisture reduction or moisture loss, could be related to lower weight losses in coated chicken breast fillets.

Table (4): Assessment of sodium alginate – based edible coating incorporated with thyme oil on water holding capacity (cm^3) and Weight loss (%) of chicken breast fillets during storage at 4 °C for12 days.

Storage time (days)	Water holding capacity (cm^3)		Weight loss (%)	
	Control	Coated	Control	Coated
0	2.21 ± 0.01^{Aa}	1.7 ± 0.02^{Ab}	0.00	0.00
3	2.55 ± 0.05^{Aa}	2.23 ± 0.23^{Ba}	1.3 ± 0.01^{Aa}	1.2 ± 0.01^{Aa}
6	3.22 ± 0.02^{Ba}	2.11 ± 0.01^{Bb}	6.4 ± 0.01^{Bb}	1.9 ± 0.01^{Ba}
9	NE	2.31 ± 0.01^{Bb}	NE	2.4 ± 0.01^{Cb}
12	NE	2.72 ± 0.021^{Cb}	NE	2.9 ± 0.01^{Db}

. Data represent mean of 3 replicate ± SD *
* Means with different letters in the same column (capital letters) or in the same row (small letters) are significantly difference ($p < 0.05$)
NE= not examined since the product has spoiled Control sample = no treatment, coated sample = 3% sodium alginate and 2% CMC, 1%, thyme oil.

2.5. Color measurement

Table (5) show the color that was identified in form of a- value (level of redness or greenness), b*- value (level of yellowness or blueness, L*- value (level of lightness and brightness, of the chicken samples. As seen, the lightness (L*- value) was slightly affected by coating with sodium alginate and thyme oil. Coated chicken breast fillets samples had lower L*- value than uncoated control samples. This was in agreement with **Tyburcy and Kozyra (2010)**, who discovered that carrageenan-coated sausages had a lower L*- value

The L*-value of the coated sample was 57.83 at the start of storage and declined significantly to 51.06 at the end of the storage period (12 days). Between the samples and the storage time, there was a significant variation in redness a*- value ($P<0.05$). Control samples had higher a*- value, which was supported by **Lu et al. (2009)** who also found that control samples (untreated fish fillets) had higher redness than alginate and cinnamon coated samples. The current investigation found that after 12 days of storage, the a* – value in uncoated and coated chicken breast fillets decreased. The addition of thyme oil to the coated chicken breast fillets resulted in greater values than the control.

Table (5): Assessment of sodium alginate – based edible coating incorporated with thyme oil on Color parameters L*, a* and b* values of chicken breast fillets of storage at 4 ºC for 12 days.

samples	Storage time (days)				
	L values*				
	0	3	6	9	12
control	57.83 ± 0 .83 [a]	56.28 ± 0 .26 [a]	54.28 ± 0 .26 [b]	NE	NE
coated	57.83 ± 0 .82[a]	56.46 ± 0 .41[a]	55.38 ± 0 .33 [a]	54.38 ± 0 .33 [b]	51.06 ± 0 .11 [b]
	a * value				
control	32.82 ± 0 .82 [a]	31.96 ± 0 .05 [a]	30.95 ± 0 .05 [b]	NE	NE
coated	32.66 ± 0 .20 [a]	31.20 ± 0 .10 [b]	30.35 ± 0 .30 [b]	28.00 ± 0 .05 [b]	26.98 ± 0 .01[b]
	b* value				
control	26.94 ± 0 .00 [a]	25.40 ± 0 .10 [a]	20.10 ± 0 .10 [b]	NE	NE
coated	28.45 ± 0 .00 [a]	27.00 ± 0 .00 [a]	25.95 ± 0 .94 [b]	25.40 ± 0 .30 [b]	24.10 ± 0 .20 [b]

Data represent mean of 3 replicate ± SD [*]
[*] Means with different letters in the row (small letters) are significantly difference ($p< 0.05$) **NE= not examined since the product has spoiled** Control sample = no treatment, coated sample = 3% sodium alginate and 2% CMC, 1%, thyme oil.

2.6 .Microbiological characteristics

Antimicrobial films improved the microbiological quality characteristics of coated chicken breast fillets during storage, extending their shelf life at refrigerated conditions**.** *Coliform, Salmonellae and Staphylococcus* counts were detected neither in control nor in coated chicken breast fillets samples. It could be because of the additional hygienic methods used during the processing and packaging of chicken breast fillets, as well as the antibacterial properties of essential oil.

Proteolytic and lipolytic bacterial count showed increasing trend in uncoated sample during progression of refrigerated storage period and the absence of essential oil in coated chicken breast fillets could be associated with the influence of the essential oil. Because it includes monoterpenes and phenols, which work against the bacteria membrane and structure, thyme oil has been shown to inhibit gram-negative bacteria. **(Ramos et al. 2010).**

Yeasts and molds count were only noticed after 6 days of storage in uncoated samples and at 9 days in coated samples. Yeasts and molds count indicated that an increase in control as well as in coated samples through refrigerated storage period and showed lower values in coated samples. This could be due to thyme oil's antibacterial properties. The reduction in yeast and molds counts could be due to the coating working as an oxygen barrier, preventing yeast and molds growth. The amount of yeasts and molds in the coating solution was also reduced by adding essential oils. Similar results have been found by **Hosseini et al., (2020)**.

Table (6): Microbiology Assessment of sodium alginate – based edible coating incorporated with thyme oil on chicken breast fillets during of storage at 4 ºC for 12 days.

Sample	Storage Time (days)				
	0	**3**	**6**	**9**	**12**
	lipolytic bacterial count				
control	**ND**	**ND**	**4x10**	**$5x10^2$**	**NE**
coated	**ND**	**ND**	**ND**	**ND**	**ND**
	coliform count				
control	**ND**	**ND**	**ND**	**ND**	**NE**
coated	**ND**	**ND**	**ND**	**ND**	**ND**
	***Salmonellae sp.* count**				
control	**ND**	**ND**	**ND**	**ND**	**NE**
coated	**ND**	**ND**	**ND**	**ND**	**ND**
***Staphylococcus sp*. count**					
control	**ND**	**ND**	**ND**	**ND**	**NE**
coated	**ND**	**ND**	**ND**	**ND**	**ND**
Proteolytic bacterial count					
control	**ND**	**ND**	**2x10**	**$3x10^2$**	**NE**
coated	**ND**	**ND**	**ND**	**ND**	**ND**
Yeast and moulds					
control	**ND**	**ND**	**$5x10^2$**	**$4x10^3$**	**NE**
coated	**ND**	**ND**	**ND**	**6x10**	**$5x10^2$**

Microbiology assessment of chicken breast fillets of chicken breast fillets chicken breast fillets stored at 4 ºC for 12 days.
Data represent mean of 3 replicate ± SD *
NE= not examined since the product has spoiled Control sample = no treatment, coated sample = 3% sodium alginate and 2% CMC, 1%, thyme oil.

2.7. Sensory evaluation

The results showed in **Table (7)** Significant variations ($p < 0.05$) were discovered in sensory characteristics and storage constancy, with the panelists receiving the greatest scores on day 0 and the lowest taste scores after 12 days. During the first and third days of storage, taste assessments were not significant ($P > 0.05$). During the sixth day of storage, however, an extremely significant change was detected. The uncoated samples were removed from the examination after 9 days because they declined below the 6th acceptability standard. Sensory attributes of uncoated samples was evaluated up to 6th day as the product was spoiled. The following report's data indicate coated samples had significantly higher color scores than uncoated sample which might be due to color of meat pigments stabilizing effect of sodium alginate and thyme oil for long period of time. During initial days all the samples had pink color; however at the 9Th day of storage period, uncoated sample had pale yellow color indicating complete spoilage. According to **Gupta et al. (2012)** Changes in optical properties such as color, gloss, and transparency, as well as odour and external texture of the coated product, are all caused by edible coatings. Coated chicken breast fillets exhibited the lowest values on the last day of storage, which could be attributed to a larger microbial load that caused the color to change from pink to light pink. At the third day of storage, odour scores were not significant ($P>0.05$).

At the 3rd day of storage, the texture and overall acceptance scores were not significant ($P>0.05$). However, due to changes in the several sensory properties evaluated, major differences were identified between the coated sample and the control sample starting on day 6 and between the later evaluation days. The results of the sensory panelists agreement with the microbiological quality results. The control sample had a shelf life of 6 days, while the coated sample had a shelf life of 12 days. The data are similar to **Muñoz-Lescano, (2017),** They improved the texture and color of breast fillets coated with a guar gum-based film with a storage period 13 days against 7 days for the control**.** Also **Eldaly et al. (2018)** the shelf life of chicken breast fillets coated with a chitosan edible film and stored at $4 \pm 1\ ^{o}C$ was 12 days, compared to 3 days for the control sample.

Table (7): Assessment of sodium alginate – based edible coating incorporated with thyme oil on sensory evaluation of chicken breast fillets during storage at 4 ºC for 12days.

Item	Refrigerated storage period (Days)	control	coated
Color	0	8.83 ±0.28 ^{Ab}	9.00 ±0.28 ^{Aa}
	3	8.03 ±0.05 ^{Ba}	8.06 ±0.11 ^{ABa}
	6	7.16 ±0.28 ^{Cb}	8.16 ±0.28 ^{BCa}
	9	NE	6.33 ± 0.57 ^{Cb}
	12	NE	5.65 ± 0.05 ^{Db}
Taste	0	8.83 ±0.28 ^{Aa}	8.83 ±0.28 ^{Aa}
	3	8.00 ±0.05 ^{Aa}	8.00 ±0.05 ^{Aba}
	6	5.20 ±0.10 ^{Ba}	7.26 ±0.28 ^{CBb}
	9	NE	6.33 ± 0.57 ^{Db}
	12	NE	4.40 ± 0.17 ^{Eb}
odor	0	8.16 ±0.28 ^{Aa}	8.09 ±0.11 ^{Aa}
	3	8.00 ±0.05 ^{Aa}	8.00 ±0.05 ^{Aa}
	6	5.60 ±0.1^{Bb}	8.30 ±0.26 ^{BCa}
	9	NE	4.83 ± 0.28 ^{Db}
	12	NE	4.96 ± 0.05 ^{EDb}
texture	0	8.06 ±0.11 ^{Aa}	9.00 ±0.11 ^{Aa}
	3	8.00 ±0.05 ^{Ba}	8.00 ±0.05 ^{ABa}
	6	5.76 ±0.05 ^{Cb}	7.23 ±0.25 ^{BCb}
	9	NE	5.16 ± 0.28 ^{Db}
	12	NE	5.01 ± 0.05 ^{DEb}
Overall acceptability	0	9.00±0.28 ^{Aa}	9.00±0.28 ^{Aa}
	3	8.00 ±0.05 ^{Ba}	8.07 ±0.06 ^{Ba}
	6	5.73 ±0.28 ^{Cb}	7.66 ±0.28 ^{Ca}
	9	NE	5.33 ± 0.07 ^{Dab}
	12	NE	5.00 ± 0.00 ^{Eb}

Data represent mean of 10 panelists ± SD *

3. Quality of fresh sliced apple.

3.1 Moisture content and Weight loss percentage

Changes in characteristics such as water loss, texture loss, greater susceptibility to microbial spoilage, formation of unpleasant aromas, flavors, and enzymatic browning reduce the shelf life of ready-to-eat fruits and its quality **(Olivas and Barbosa-Cánovas, 2005).** One method for increasing the shelf life of fresh cut fruits is to treat them with edible coating.

Table (8): Assessment of sodium alginate – based edible coating incorporated with cinnamon oil on moisture content and weight loss % of fresh sliced apple during storage at 4 ºC for 15 days.

Storge time (days)	Moisture %		Weight loss %	
	Control	Coated	Control	Coated
0	85.82 ± 0.56^{Aa}	85.77 ± 0.61^{Aa}	0	0
3	84.49 ± 0.15^{Ba}	84.34 ± 0.14^{Ba}	3.50 ± 0 .43^{Aa}	1.04 ± 0 .04 ^{Ab}
6	83.25± 0.28^{Cb}	84.27 ± 0.2^{Ba}	8.33 ± 0 .30 ^{Ba}	2.09 ± 0 .08 ^{Bb}
9	81.66 ±0.33^{Db}	83.87 ± 0.23^{Ca}	13.22 ± 0.22^{Ca}	3.11 ± 0 .11 ^{Cb}
12	NE	83.71 ± 0.17^{Ca}	NE	4.13 ± 0 .15 ^{Db}
15	NE	82.65 ± 0.3^{Db}	NE	5.61 ± 0 .31 ^{Eb}

*Means with the different letters in the same column (capital letters) or in the same row (small letters) differed significantly ($p<0.05$).
*Control: fresh sliced apple without coating
*Coated: fresh sliced apple coated with 3% sodium alginate +2% CMC + 1% glycerol + 1% cinnamon oil

All samples demonstrated a gradual decrease in moisture content and the reduction in moisture content increased as storage period increased (**Table 8**). Moisture content significantly decreased ($p<0.05$) from 85.82% in the early stages of cold storage to 81.66% after 9 days of cold storage (4.16% decrement) in control (uncoated) samples. While, in coated samples moisture content reached 82.65% at the end of storage period (3.12% decrement). The results in the present study showed that alginate edible coating mixed with 1% cinnamon oil could be used to help preserve fresh sliced apple which providing a good barrier to moisture loss, as a result apple slices-maintained firmness by decreasing water vapor permeability.

Data in **Table (8)** showed that all samples lost weight gradually during cold storage, with the % of weight loss increasing as storage time increased.. Weight loss % increased greatly ($p<0.05$) during cold storage reached values of 13.22 % in control (uncoated) samples after 9 days of cold storage and 5.61 % in alginate coated sliced apple at the end of storage period.

Hussein et al., (2020) found in their research that weight loss % of broccoli florets were gradually increased as the storage period due to the coating barrier, thus, enzymatic activity and metabolism which encourage respiration can be affected thereby resulting in lower water loss.

3. 2. pH measurement and titratable acidity

Because the pH value is responsible for the acid formed components, titratable acidity and pH are key criteria to consider when evaluating the freshness of fruit.

The effect of alginate-based coating mixed with 1% essential oil on pH of fresh sliced apple is illustrated in **Table (9).** The collected data revealed that the pH of fresh sliced apple rose over time, with significant ($p<0.05$) variations between coated and uncoated samples. It should be observed that the pH values of the coated samples gradually increased over time.

Table (9): Assessment of sodium alginate -based edible coating incorporated with cinnamon oil on pH and titratable acidity of fresh sliced apple during storage at 4±1°C for15days

Storge time (days)	pH		T.A (%)	
	Control	coated	Control	coated
0	3.50± 0.025	3.13 ± 0.012	0.40 ± 0.01^{Aa}	0.40 ± 0.01^{Aa}
3	3.76± 0.01	3.18 ± 0.012	0.37 ± 0.01^{Ba}	0.35 ± 0.01^{Ab}
6	3.95± 0.02	3.32 ± 0.029	0.35 ± 0.01^{Ca}	0.30 ± 0.01^{Bb}
9	3.98 ±0.012	3.42 ± 0.046	0.22 ± 0.01^{Da}	0.25 ± 0.01^{Cb}
12	NE	3.69 ± 0.035	NE	0.23 ± 0.01^{Db}
15	NE	3.86 ± 0.012	NE	0.20 ± 0.01^{Eb}

*Means with the different letters in the same column (capital letters) or in the same row (small letters) differed significantly ($p<0.05$) .
*Control: fresh sliced apple without coating
*Coated: fresh sliced apple coated with 3% sodium alginate +2% CMC + 1% glycerol + 1% cinnamon oil

The highest pH value (3.98) was detected in the control (uncoated) samples after 9 days of cold storage. The pH values of uncoated samples increased from 3.5 at the starting of cold storage to 3.98 after 9 days of storage, since after 9 days of storage the uncoated samples became spoiled.

The pH of coated samples increased from 3.13 at the starting of storage to 3.86 at the end of the storage period. This indicated that the uncoated samples recorded higher values of pH compared to the coated samples. The obtained results clear revealed that the use of alginate-based coating mixed with 1% cinnamon oil was effective in the retention of pH at lower levels during cold storage of fresh sliced apple. This could be related to cinnamon oil's antibacterial and preventive properties against spoilage microbes. That secretes extracellular lytic enzymes that break down food components leading to change in pH, color, texture, and odor of microbial contaminated food.

Moraes et al., (2012) and **Elabd and Gomma (2018)** demonstrated that control samples had a higher pH increase than coated samples, suggesting that the application of coating slowed down pH changes in the fruit. . The titratable acidity of control (uncoated) samples significantly decreased ($p < 0.05$) from 0.40 % at the starting of storage to 0.22% after 9 days of cold storage. When compared to the control samples, the decreasing of titratable acidity in the coated samples was the slowest. The obtained data revealed that coating process resulting in significantly reduction ($p<0.05$) of titratable acidity during cold storage. In coating samples, the titratable acidity decreased from 0.40% at the beginning of cold storage to 0.20% at the finish of storage period.

These results are in parallel with those of **Gol et al., (2013)** who found that strawberries coated with carboxy methyl cellulose 1% + chitosan 1% or hydroxy propyl methyl cellulose 1% + chitosan 1% resulted in keeping higher levels of titratable acidity compared to control samples after 12 days in storage. Similar results were also obtained by **Elabd and Gomma (2018) and Farina et al., (2020).**

3.3. Total soluble solids (TSS) (ºBrix) and Texture determination.

With increasing storage time, the TSS of control and coated samples declined considerably. There was a significant difference in TSS between control (uncoated) and coated samples in this investigation, with coated samples showing a small drop in TSS when compared to control samples. **Table (10).**The higher decrease of TSS was observed in the control samples (8.8%) after 9 days of storage (5.7% reduction), while coated samples showed a smaller drop (9.8%) (3.7 % reduction) at the finish of the storage period.

Table (10): Assessment of sodium alginate – based edible coating incorporated with cinnamon oil on total soluble solids and firmness of fresh sliced apple during storage at 4 ºC for 15 days.

Storage time (days)	TSS (%)		Firmness (N)	
	Control*	coated	Control*	coated
0	14.50 ± 0.05^{Aa}	13.50± 0.06^{Aa}	10.33 ± 0.01^{Aa}	10.10± 0.02^{Aa}
3	11.04 ± 0.06^{Bb}	12.06 ± 0.017^{Ba}	8.50 ± 0.02^{Bb}	9.20 ± 0.01^{Ba}
6	10.70± 0.01^{Cb}	11.01± 0.012^{Ca}	7.50± 0.02^{Cb}	8.90± 0.01^{Ca}
9	8.80 ±0.01^{Db}	10.30 ± 0.017^{Da}	6.50 ±0.05^{Db}	7.64 ± 0.00^{Da}
12	NE	10.05 ± 0.029^{Db}	NE	7. 70 ± 0.01^{Eb}
15	NE	9.80 ± 0.029^{Eb}	NE	7.02 ± 0.01^{Eb}

*Means of three replicates ±SD
*Means with the different letters in the same column (capital letters) or in the same row (small letters) differed significantly ($p<0.05$).
*Control: fresh sliced apple without coating
*Coated: fresh sliced apple coated with 3% sodium alginate +2% CMC + 1% glycerol + 1% cinnamon oil.

These data are in parallel with those of **Farina et al., (2020)** who coated the fresh cut apple with Aloe vera gel mix with hydroxy propyl methyl cellulose, or Aloe vera gel with 1% lemon essential oil. The authors observe that as the cold storage period increased, the soluble solids content dropped. They concluded that Aloe vera with lemon oil treatment might prevent the loss of soluble solids content during cold storage for 9 days. The conversion of sugar into malic acid, which is consumed by the fruit as a respiratory substrate and for the synthesis of new molecules during storage, could decrease in sugar concentration **(Hussain et al., 2012).**

The firmness values decreased in all tested samples during cold storage at 4±1ºC for 15 days **Table (10).** Firmness values in the control (uncoated) samples indicate a significant decrease ($p<0.05$) from 10.33 N at the starting of the storage period to 6.5 N after 9 days of storage (37.07% reduction), while firmness values of coated samples ranged from 10.1 N to 7.02 N during cold storage for 15 days (30.49% reduction). Coating treatment resulted in maintain higher firmness values during cold storage for 15 days. These results showed that coating with sodium alginate-cinnamon oil effectively delay the tissue softening in the fresh sliced samples during cold storage for 15 days. These results are in consistent with those of **Sarengaowa et al., (2017) and Shyu et al., (2019).**

3.4. Color measurement.

The examination of color variations is critical for the storage stability of fresh cut apples. **(Cakmak et al., 2017).** Concerning colorimetric measurements**, (Table (11))** show the values of lightness (L*), redness (a*) and yellowness (b*) of uncoated (control) and coated fresh sliced apple during cold storage at 4±1ºC for 15 days.

The results indicated that the lightness values (L*) of both uncoated and coated samples were significantly decreased ($p<0.05$) during storage period. The reduction in the (L*) values of coated fresh sliced apple was decreased than that of the uncoated samples. In control samples (L*) values decreased from (67.56) at the start of storage to (62.57) after 9 days of storage, while (L*) values of coated samples recorded (61.57) at the end of storage period. Concerning yellowness, for coated and uncoated sliced apple, there were no significant differences found in the (b*) values as can be observed in **Table (11).** The redness (a*) values of uncoated and coated samples tend to increase during storage period.

However, the increase in redness values (a*) of fresh sliced apple coated with alginate-cinnamon oil was lower than that of the uncoated samples. The obtained results indicated that treatment with alginate-cinnamon oil coating was effectively in delaying color loss of fresh sliced apple during cold storage for 15 days.

The results indicated that the browning index values increased significantly during storage period. However, the increase in browning index values of fresh sliced apple coated with alginate-cinnamon oil was decreased than that of the uncoated samples. In control samples browning index values increased from (87.22) at the start of storage to (93.48) after 9 days of storage, while browning index values of coated samples recorded (91.62) at the end of storage period.

Shyu et al., (2019). Cut apple cubes covered with fish-gelatin-chitosan coating were the most effective in preventing browning of apple cubes during cold storage when compared to other treatments.

Table (11): Assessment of sodium alginate – based edible coating incorporated with cinnamon oil on color parameters L*, a*, b* values and browning index of fresh sliced apple during storage at 4 ºC for 15days.

samples	Storage time (days)					
	0	3	6	9	12	15
	L^* value					
control	67.56 ± 0 .26^{a}	64.57 ± 0 .00 ^{b}	63.52 ± 0 .52 ^{b}	62.57 ± 0 .54 ^{b}	NE	NE
coated	67.55 ± 0 .57 ^{a}	65.52± 0 .03 ^{a}	64.57 ± 0 .57 ^{a}	63.57 ± 0 .28 ^{b}	62.56 ± 0 .20 ^{b}	61.57 ± 0 .18 ^{b}
	a^* value					
control	20.45 ± 0 .10 ^{a}	23.67 ± 0 .05 ^{b}	26.50 ± 0 .12 ^{a}	28.80 ± 0 .06 ^{a}	NE	NE
coated	18.75 ± 0 .41 ^{a}	20.40 ± 0 .08 ^{b}	22.39 ± 0 .20 ^{bc}	23.43 ± 0 .23^{c}	25. 53 ± 0 .15 ^{d}	27.60 ± 0 .03 ^{e}
	b^* value					
control	28.16 ± 0 .28^{a}	26.16 ± 0 .29 ^{a}	23.23 ±0 .28 ^{b}	20.18 ± 0.25^{b}	NE	NE
coated	25.49 ± 0 .49 ^{Aa}	24.16 ± 0 .29 ^{a}	23.16 ± 0 .29 ^{b}	20.16 ± 0.28^{b}	17.16 ± 0.27^{b}	15.18 ± 0.26^{b}
	Browning indx					
control	87.22 ± 0 .33^{a}	88.46 ± 0 .00^{a}	91.22 ± 0 .13 ^{b}	93.48 ± 0 .11 ^{b}	NE	NE
coated	85.72 ± 0 .22 ^{a}	87.88± 0 .03 ^{b}	87.90 ± 0 .09 ^{b}	87.99 ± 0 .05 ^{b}	90.47 ± 0 .02 ^{c}	91.62 ± 0 .15 ^{d}

*Means of three replicates ±SD *Means with the different letters in the same row (small letters) differed significantly ($p<0.05$).

3.5 Microbiological characteristics

In **Table , 12** the control samples the population of total bacterial counts was not detected during 3 days of storage and then increased to 8 x 10^2 CFU/g after 9 days of storage and after that the control samples became spoiled. While incorporating 1% cinnamon oil in alginate-based edible coating delayed the growth of aerobic bacteria until the 12 days of cold storage which recorded 6 x 10^1 CFU/g and 2 x 10^1 CFU/g after 12 and 15 days of storage, respectively, in coating samples.

Yeast and mold counts began to appear in uncoated samples on the ninth day of cold storage and recorded 3 x 10^1 CFU/g, while at 12 and 15 days the control samples became spoiled. In coated fresh sliced apple incorporated with 1% cinnamon oil yeast and mold began to appear on the last day of storage period which reached 4 x 10^1 CFU/g. On the other hand, data also indicated that inhibit coliform bacteria was detected either in coated or uncoated sliced apple during the storage period for 15 days. **Azarakhsha et al., (2014)**, an alginate-based edible coating blended with lemongrass oil significantly reduced the total microorganisms in coated fresh cut pineapple during storage. On the other hand, data showed that no coliform bacteria growth was observed in either coated or untreated sliced apple during the 15-day storage period. **Benitez et al., (2015)** showed a inhibition of yeast and mold counts during storage as a result of antimicrobial effects of Aloe vera coating in kiwi fruit slices.

According to the HACCP rules, food with less than 4 log10 CFU/g of microorganisms is considered "excellent," while food with more than 8 log10 CFU/g is considered "spoiled." The overall bacterial count at the end of the storage period in this investigation was 2×10^1 CFU/g, which is within the HACCP guidelines' acceptable limits **(Chong-Hae et al., 2008).**

Table (12): Assessment of sodium alginate-based edible coating incorporated with 1% cinnamon oil on total bacterial, yeast and mold and coliform counts as CFU/g in fresh sliced apple during cold storage at 4±1ºC for 15 days

samples	**Storage time (days)**					
	Total bacterial count					
	0	**3**	**6**	**9**	**12**	**15**
control	ND	ND	6x10	$8x10^2$	$5x10^4$	$4x10^6$
coated	ND	ND	ND	ND	6x10	2x10
	yeast mold					
control	ND	ND	ND	3x10	$6\ x10^2$	$2\ x10^3$
coated	ND	ND	ND	ND	ND	4x10

Control: fresh sliced apple without coating,
Coated: fresh sliced apple with 3% sodium alginates + 2% CMC +1% glycerol + 1% cinnamon oil

3. 6. Sensory evaluation

The sensory evaluations of uncoated and coated sliced apples stored at 41^{o}C for 15 days are demonstrated. (**Table 12).**

At the start of the storage all tested samples recorded the high ranking in all sensory attributes, whereas throughout the storage period, all sensory attributes showed a decreasing trend.

In coated samples the resulted revealed that all sensory attributes were maintained good even after 12 days of cold storage compared to the control samples which showed decayed after 9 days of storage. The color score was higher dropped from 8.43 to 4.06 after 9 days of storage in uncoated samples than in coater samples which may be due to the uncoated samples started to decompose.

The texture scores of coated sliced apple stored at 4ºC for 12 days were considered more acceptable than those of the control samples. Coated samples attained texture scores ranged from 9.23 at the starting of cold storage to 6.04 after 12 days of storage and dropped to 4.6 after 15 days of cold storage. These higher texture scores of alginate coated sliced apple were correlated positively with lower decrease in firmness during cold storage as previously found in coated sliced apple (**Table 12).**

Similar results were reported in a study of **Maqbool et al., (2011)** they discovered that banana samples coated with a mixed coating of gum Arabic and chitosan had the highest overall acceptance.

The sensory assessment showed that the coating significantly (p0.05) improved shelf life while preserving overall acceptance at greater levels scores during 12 days of cold storage, so while uncoated (control) samples exhibited lower quality in terms of color, taste, odour, texture, and overall acceptability decayed and became unacceptable after 9 days of storage.

Table (12): Assessment of sodium alginate – based edible coating incorporated with cinnamon oil on sensory evaluation of fresh sliced apple during of storage at 4 ºC for 15 days.

Item	Refrigerated storage period (Days)	control	coated
Color	0	8.43 ±0.10 Ab	9.45 ±0.10 Aa
	3	8.26 ±0.05 Aa	8.76 ±0.05 Ba
	6	6.36 ±0.15 Bb	8.36 ±0.04 Ca
	9	4.06 ±0.03 Cb	6.26 ±0.05 Db
	12	NE	6.26 ± 0.20 Db
	15	NE	5.00 ±0.05 Eb
Taste	0	8.40 ±0.17 Aa	8.65 ±0.28 Aa
	3	8.20 ±0.10 Aa	8.03 ±0.05 Aa
	6	7.16 ±0.05 Bb	8.16 ±0.05 Ba
	9	5.13 ±0.02 Cb	7.43 ±0.02 Ca
	12	NE	6.06 ± 0.01 Db
	15	NE	5.13 ±0.05 Eb
Odor	0	8.50 ±0.10 Aa	8.70 ±0.11 Aa
	3	7.60 ±0.05 Bb	8.76 ±0.11 Aa
	6	7.23 ±0.11 Bc	8.43 ±0.05 Aa
	9	5.26 ±0.05 Cd	7.36 ±0.05 Bb
	12	NE	6.15 ± 0.05 Cb
	15	NE	5.18 ±0.02 Db
texture	0	8.20±0.10 Ab	9.23 ±0.11 Aa
	3	8.10 ±0.05 Ba	9.10 ±0.10 Aa
	6	7.13 ±0.10 Cb	8.56 ±0.05 Ba
	9	5.15 ±0.02 Db	6.83 ±0.05 Cb
	12	NE	6.04 ± 0.00 Db
	15	NE	4.60±0.17 Eb
Overall acceptability	0	8.60 ±0.10 Ab	9.02 ±0.28 Aa
	3	8.26 ±0.05 Ba	8.07 ±0.06 ABa
	6	7.10 ±0.28 Cb	8.46 ±0.05 BCa
	9	4.923 ±0.01 Dc	7.01 ±0.43 Cb
	12	NE	6.20 ± 0.00 Db
	15	NE	5.00 ±0.05 Eb

* Means of 10 panelists ± SD
* Means with the different letters in the same column (small letters) or in the same row (capital letters) differed significantly ($p<0.05$).
* Control: the coating consists of 3% sodium alginates + 2% CMC + 1% glycerol + 1% cinnamon oil

CONCLUSION

Using edible coatings made from sodium alginate and carboxy methyl cellulose (CMC) and incorporating1% thymus oil during storage at 4 ° c. for 12 days and 1 % cinnamon oil with fresh apple slices during storage at 4 ° c for 15 minutes days can increase the availability and preserve the quality of chicken breast fillets. The Coating decreased the rates of deterioration and prolonged the shelf life of the product.

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