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Comparison of Different Edible Coatings Materials For Improvement of Quality And Shelf Life of Perishable Fruits.

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ABSTRACT

Four types of edible coatings; pectin, gluten, starch and soy protein were previously prepared. Coatings were formed directly on the surface of the fruit. The effect of the different edible coatings on refrigerated strawberry quality and shelf life was studied at1,6,12,and 16 days of storage at 10°c.Fruit quality was evaluated by weight loss, firmness retention, visible decay, surface color development, titratable acidity, total soluble solids, reducing sugars and sensory attributes. Also a comparison of the tensile properties (TS) and percentage of the elongation at break (%E) between the four types was determined. The pectin- based coating had a significant effect on the retention of firmness, reduced the weight loss and showed better results from the Physico-chemical analysis compared to the other coatings and to the control fruit. Also had a substantial amount of mechanical properties compared to them. The gluten coating seemed to be the second prefer one for controlling decay and maintained the visual quality of the fruit during the storage time and from the result of TS and %E while starch – based and soy protein-based coating had the third level of beneficial effect which the strawberries covered with these coatings shrank during 16 days of storage and did not maintained their original size. Sensory evaluation of the strawberries showed that the pectin and gluten layers maintained the visual quality of the fruit during the storage time, and the taste of the strawberries with the same treatments was acceptable to consumers.

Key words: strawberry; Edible coating; Pectin; Gluten; Starch; Soy protein; shelf life; Quality.

Introduction

Chemically synthesized polymeric films are widely used for packaging in food industry, petrochemical-based plastics have advantages in their availability in large quantities at a low cost and good functionality such as tensile and tear strength. However, increased use of synthetic packaging films based on petro chemicals has led to serious ecological problems due to their total non-biodegradability (Tharanathan, 2003). Thus consumer demand has shifted to safe and eco-friendly biodegradable materials, especially from renewable agriculture by – products and food processing industry wastes.

Pectin in one of the proportionally largest materials, in a citrus by-products. Pectin is a complex anionic polysaccharide composed of B-1,4- linked D-galacturonic acid residues. Wherein the uronic acid carboxyls are either fully (High methoxy pectin) or partially (low methoxy pectin) methyl esterified. High methoxy pectin forms (Tharanathan, 2003). Plasticized blends of citrus pectin and high amylase starch provide storage,flexible films, which are thermally stable up to 180°c.

Starch is the most important polysaccharide polymer that is used to develop biodegradable films because it has capability of forming a continuous matrix and it is a renewable and abundant resource (Talja *et al.*, 2007). Nevertheless, starch exhibits several disadvantages such as a strong hydrophilic character (water sensitivity) and poor mechanical properties compared to conventional synthetic polymers (Averous and Boquillon, 2004), which make it unsatisfactory. For some applications such as packaging purposes.

Wheat gluten, a mixture of the prolamin and glutelin fractions of wheat proteins, has been studied extensively to produce an edible films (Gennadios *et al.*, 1994; Babak *et al.*, 2011; Claudia *et al.*, 2011). Recent studies have evaluated properties of films from rice bran protein as an edible coating or packaging film for cooked meat and poultry (Claudi *et al.*, 2011). They found that; mechanical and gas barriesproperties, and its permeability to moisture are suitable but water vapor barriers properties is poor. Wheat gluten coating reduced moisture loss from Sharon fruit and cherry tomatoes (Tanada – Palmu *et al.*, 2000).

Edible films and coating from the globulin protein fractions of soy beans have been reviewed (Gennadios *et al.*, 1994). Functionality of soy protein – based edible coatings on different food products has yet to be explored. A process was described where dehydrated meat was stabilized with soy protein coatings Preferably made from mixtures of soy protein isolate and egg albumen (Ghorpade *et el.*, 1995). Stuchell and Krochta (1994) treated soy protein isolate films with another protein cross – linking enzyme, horseradish peroxidase,whichcatalyses oxidation of tyrosine residues leading to formation of di-,tri-,and tetra-tyrosine. Horseradish peroxidase did not affect water vapor permeability of soy protein films but increased film tensile strength.

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Highly perishable berries and tropical fruits are products most likely to benefit economically from coatings. Strawberries are a soft fruit with high respiration and softening rates, making the availability of high quality strawberries challenging .Due to its high metabolism, strawberries must be kept at 4-5°c, which can extend its high quality for 6 or 7 days. The use of coating or edible film envolving strawberries can also be an alternative to improve their shelf life (Santos, 1997).

The objectives of this work were to study the influence of different types of edible coatings from polysaccharides and proteins such as pectin, gluten, starch and soy protein, on extending the shelf life of strawberries, and make a comparison between the influence of the four types of edible coatings on the quality attributes of strawberries, such as weight loss, firmness retention, surface color development, titratable acidity, soluble solids, reducing sugar content, sensoy attributes and also a comparison between the tensile properties of each one of these coatings, or films.

Materials And Methods

Pectin coating formulation and film preparation:

Pectin: (5.0%, w/v; from citrus fruits, Sigma – Aldrich co., St. Louis, Mo, USA). Polyvinyl alcohol (PVA,1.25 %, w/v, 98% hydrolyzed, Sigma – Aldrich Co., St. Louis, MO,USA), and glycerol (2.5%,w/v, Junsei Chemical Co.) were suspended in distilled water (100 ml) at 90°c after stirring for 30 min. The PVA was used as a crosslink reagent and the glycerol used as a plasticizer. After degassing the solution,The coating was formed directly on the surface of the fruit by dipping the fruit into the pectin formulation and allowed it to dry. To cast the film, about 25 ml of the sample was spread into ateflon casting tray and air deied for 48h at room temperature, (Method of Cheorun Jo *et al*., 2005)

Starch coating formulation and film preparation:

Five grams of starch were mixed with distilled water (100 ml) polyvinyl alcohol(1.25 % w/v) and 2 ml. glycerol (40%, w/v) and 10 % citric acid w/w starch at room temperature (25°c) for 5 min. This suspension was transferred to a water bath at 90°c for 30 min, and agitated by magnetic stirrer (500 rpm). After cooling the coating was formed directly on the surface of the fruit as mentioned previously. To cast the film, about 70 ml of the sample was powered into a teflon casting tray, and dried at 60°c in an oven (Method of Babak *et al*., 2011).

Soy protein formulation and film preparation:

Slowly dissolving 5 % isolated soy protein (w/v) in distilled water while stirring Polyvinyl alcohol (1.25 w/v) and glycerol (3.5% w/v) was added as a plasticizer and pH was adjusted to 10.0 with 0.1 NaOH. The coating solutions were heated to 90°c in a water bath for 30 min followed by cooling to 40°c, and then filtering through four layers of cheese cloth by a vacuum pump. The coating was formed directly on the surface of the fruit as mentioned previously. To cast the film, about 15 ml .of the sample was poured into a Teflon casting tray, followed by oven drying at 30 °c for 72 h. Films were peeled and stored in a vacuum desicator for further use. (Method of Zehra *et al.,* 2010).

Gluten coating formulation and film preparation:

Gluten (9.og /100 ml solution) polyvinyl alcohol (1.25% w/v 98%) and glycerol (1.5 g/100ml solution), ammonium hydroxide to adjust the pH to 10 and distilled water. All components were mixed under magnetic stirring until the temperature of the mixture reached 70c and the solution centrifuged at 5000xg for 6 min at room temperature.The coating was formed directly on the surface of the fruit as mentioned previously. To cast the film, 50ml of the sample, spreading evently over a Teflon covered glass surface and drying at room temperature for 24h. (modifiedmethod of Gontard *et al*., 1993). All films used for the experiments were equilibrated at 52% RH (relative humidity) and 25°c for 48h before being tested.

The quantity of solutions (vol.) poured on the Teflon covered glass were calculated to obtain a constant thickness of the dried films for all the four different samples under investigation. The thickness of the films prepared was 0.17 + 0.01 um with no difference among the films.

Sample preparation:

Strawberries (F. ananassacv "Oso Grade") at the commercially ripe stage, grown in a local farm (Giza, Egypt) were harvested and treated in the next day. An amount of 500 fruit of uniform size, free of physical damage and fungal infection, were used. Strawberries were dipped in chlorinated water 0.25 g/L according to

Garcia *et al*., (1998) and dried using tissue paper. Each hundred fruit were individually dipped into one of the four previously coating solutions. All coated fruit after preparation were maintained at about. 20°c over night. After this, all samples were transferred to the refrigerator at 7-10°c and 60-80% RH for 16 days to follow the shelf life coating solutions. The last hundred fruit (control), after strawberries were cleaned and dried, they were again dripped into distilled water for 60s, and then refrigerated after maintained at about 20° over night. The refrigerator used was a home refrigerator, since the objectives of this work was to study the shelf life of pectin – coated, starch-coated, soy protein – coated and gluten- coated refrigerated strawberries after purchase by consumers.

Strawberry visible decay:

Each treatment was inspected after 6,12 and 16 days of storage and the fruit were considered infected when a visible lesion was observed. The visible microbial attack on the fruit was characterized as brown spot and a softening of the injured zone. The results (with LSD mean comparison test) were expressed as the percentage of infected fruit (Garcia *et al*., 1998).

Weight loss:

Three fruit prow each treatment (the same fruit during all the storage time) were weighed at the beginning of the experiment and after 1,6,12 and 16 days of storage. The trays of day 16 were chosen to follow the weight loss, since these trays would only be analyzed on the last day of the experiment. The results (with LSD mean comparison test) were expressed as percentage loss of initial weight.

Firmness:

The compression force of the strawberry flesh was measured using a Texture analyzer TA.XT2 (SMS, Surrey, UK) equipped with a compression cell of 5kg and a cylindrical and flat acrylic probe of 1 cm in diameter, using a 1 mm/s crosshead speed, a 1N force and a 75% strain to penetrate the fruit (Garcia et al., 1998 a).Determinations were performed on strawberries (three fruit from each treatment) after 1,6,12 and 16 days of storage. Strawberries of uniform size from which the calyces had been removed to obtain even surface, were used to determine the compression force. The results (with LSD mean comparison test) were expressed as percentage of firmness retention (compression force during storage time was compared to force on day 1).

Surface color development:

Colorimetric measurements of the fruit surface were carried out with a Hunterlab colorimeter equipped with an optical sensor (Color Quest II, Hunter Associates Laboratory, Fairfax, VA, USA). The chromaticity parametersaand b (from the Hunter scale) were registered on strawberries (three fruit from the tray of each treatment) after 1,6,12 and 16 days of storage. There were two determinations for each strawberry, in each side of the fruit, so the results were expressed as the mean of six determinations for each treatment with LSD mean comparison test. (Claudia *et al.* 2011).

Physico – chemical analyses:

The same samples used for firmness and color determinationsof each treatment was used to obtain homogenates using a blender (Fisatom 7ow, Brazil) for the determinations of titratable acidity, total soluble solids and reducing sugar content after 1,6,12 and 16 days of storage. All the determinations were conducted in triplicate for each day of analysis. The titratable acidity was determined using a 10.0g aliquot of the homogenates made up to 100 ml. with distilled water, which was titrated with 0.1 N NaOH to an end point of PH 8.1 (A.O.A.C, 2000). The titratable acidity was expressed as percentage citric acid. The total soluble solids of the homogenates were determined in a refractometer (Hegerstelit, Germany) and were expressed as percentage.

For the reducing sugar determination, 5 gm aliquot of the homogenates were transferred to a beaker and 50 ml distilled water added. The mixture was heated in a water bath for 5 min and then filtered into a 100ml volumetric flask. The flask was completed to 100 ml. with distilled water. Aliquots of 10 ml. were titrated according to the Fehling method (AOAC, 2000) Sugars were expressed as percentage glucose.

Tensile properties of the films:

Ultimate tensile strength (UTS) and strain at break (SB) of the films were determined at 21 ± 1 °c using a tensile tester (Zwick - Roell model FRolo. Germany) according to ASTM standard method D 882 – 91 (ASTM D882-91, 1996). Three film specimens 8cm x 0.5cm dumbbelly forms, were cut from each of film samples and were mounted between the grips of the machine. The initial grip separation and cross-head speed were set to 50 mm and 5 mm / min, respectively.

Sensory evaluation of the strawberries:

The sensory evaluation of the strawberries during the shelf life was conducted by 20 consumers. The order of the samples was randomized for each consumer, according to Macfie and Bratchell (1989) to balance the effect of order of presentation and first – order carry-over effects. The strawberries (the same one of each treatment) were visually evaluated after 1,6,12 and 16 days of storage in the refrigerator by the same consumers. The attributes analyzed were appearance, color and brightness. The sensory evaluation of taste and flavor of the strawberries (one of each treatment), also evaluated by 20 consumers , was applied after 5 days of storage, so that the coatings were well adhered and compacted to the fruits, and the attributes were taste, flavor and texture. Scores for appearance, color, brightness, flavor, taste and texture -1: disliked extremely; 2: disliked moderately; 3: disliked slightly; 4: liked/disliked; 5: liked slightly; 6: liked moderately; 7: liked extremely.

Statistical analysis:

Statistics on a completely randomized design were performed with the analysis of variance (ANOVA), the Turkey′s test was used in tables and LSD .mean comparison test was used in .Figures to determine significant differences of all the properties at a 95 % confidence interval.

Results and Discussion

Strawberry visible decay:

Visible decay of strawberries coating expressed as percentage of infected fruit (Fig1). All the coatings adhered well to the strawberry surfaces and were transparent. All of the strawberries shrank during 16 days of storage, especially the control fruit compared with the other treatments with the exception of the strawberries coated with pectin and / or gluten layers. The strawberries covered with pectin or gluten coatings maintained good visual quality up to day 16 which the infected percentage not exceed 5 and 8% respectively. Strawberry is a highly perishable fruit and the shelf life usually ends due to fungal infection (Maas, 1981) in this work, the maximum storage life was defined as the time elapsed between the application of the coating and the visualization of fungal injury. The pectin and the gluten coatings significantly ($P<0.05$) reduced the number of infected fruit in comparison with the control fruit at the end of the experiment (Fig 1). The coating were significantly ($P<0.05$) more effective in reducing the number of infected strawberries except starch and soy protein coatings. The coatings can reduce decay by delaying senescence, which makes the commodity more vulnerable to pathogenic infection as a result of loss of cellular or tissue integrity (Risse *et al*., 1987).

Weight loss:

Weight loss during storage due to transpiration was observed for all treatments (Fig2). Compared to the control, all treatments showed significantly ($P<0.05$) lower values, with pectin treatment showing the lowest value.

Comparing all treatments, pectin and gluten coatings had a significant effect ($P<0.05$) on weight loss, presenting the lowest values, showing a weight loss lower than 10% during the shelf life study. A similar effect was observed by cheorun Jo *et al*, (2005) for strawberries coated with pectin and/or gluten. They evinced that the thickness of 1mm of pectin or gluten layer was very adequate for minimize the weight loss during the storage time and explain the best effect of this coating in reducing the weight loss of the strawberries.

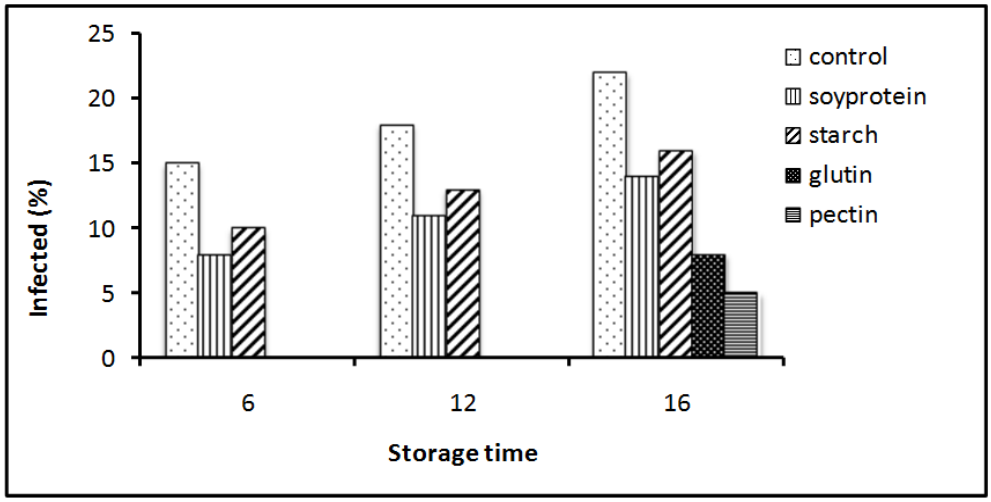

Fig. 1: Visible decay of strawberries coatings during storage. Bars indicate standard error; $LSD_{0.05}$=5

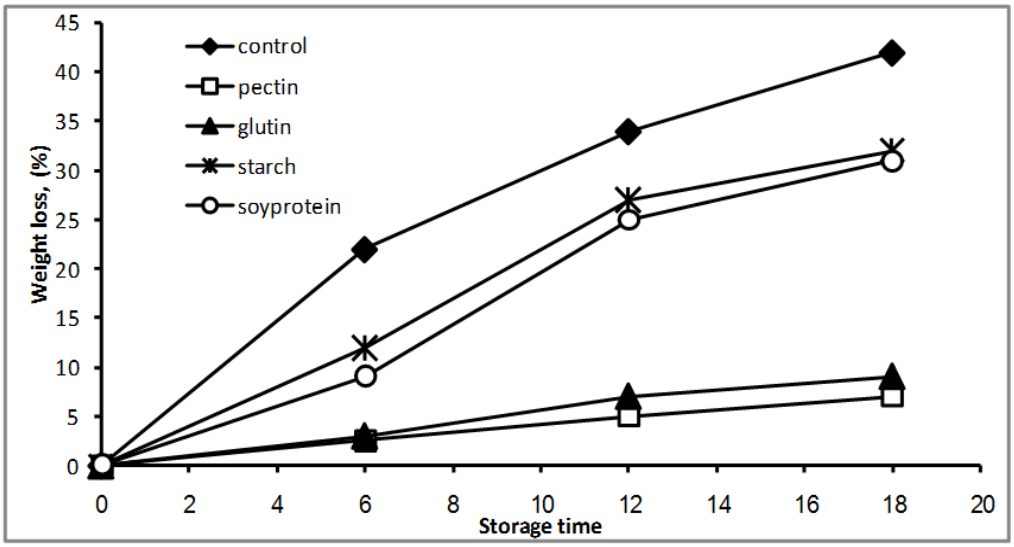

Fig. 2: Effect of pectin, starch, soy protein and gluten coatings on weight loss of strawberries during storage. Bars indicate standard error; LSD0.05=4.28%

Firmness:

One of the main factors used to determine fruit quality and postharvest shelf life is the rate and extent or amount of loss of firmness during the storage of soft fruit, such as strawberries. According to Manning (1993), fruit softening is attributed to the degradation of cell wall components, mainly pectins, due to action of specific enzymes such as polygalactu-ronase.

Firmness retention was calculated as (Ft/Fo) x100, with Ft as the break force at time t and Fo as the break force at the beginning of the experiment. For all control and coated fruit break force decreased as a function of storage time, as shown in Fig (3). All coating showed statistically ($P<0.05$) a beneficial effect on firmness retention compared to the control fruit. At the end of the experiment (16 days),firmness retention of the pectin treatment showed a good result probably because this treatment slowed down metabolism and prolonged the storage life. On the other hand starch treatment showed a little effect on firmness retention, an effect observed by Garcia *et al*., (1998) using starch- coated strawberries.

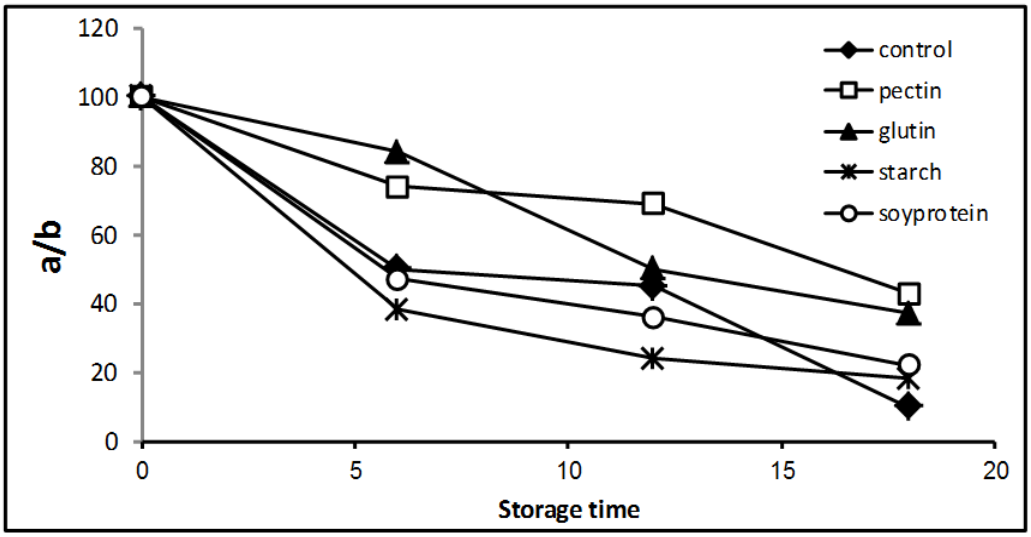

Fig. 3: Effect of different coatings on firmness retention of strawberries during storage. Bars indicate standard error; $LSD_{0.05}$=4.946.

Surface color development:

Color changes during postharvest storage were observed by an increase in the alb ratio with an increase in redness (a) and a decrease in yellowness (b). As shown in Fig (4), the a/b ratios increased with storage time in all treatments. Control fruit with the highest a / b values showed significant differences ($P<0.05$) in comparison with fruit in pectin & gluten coatings. Thus these coatings were effective to promote a small delay of surface color development compared with the control treatment, as documented by the smaller increase in a/b ratio.

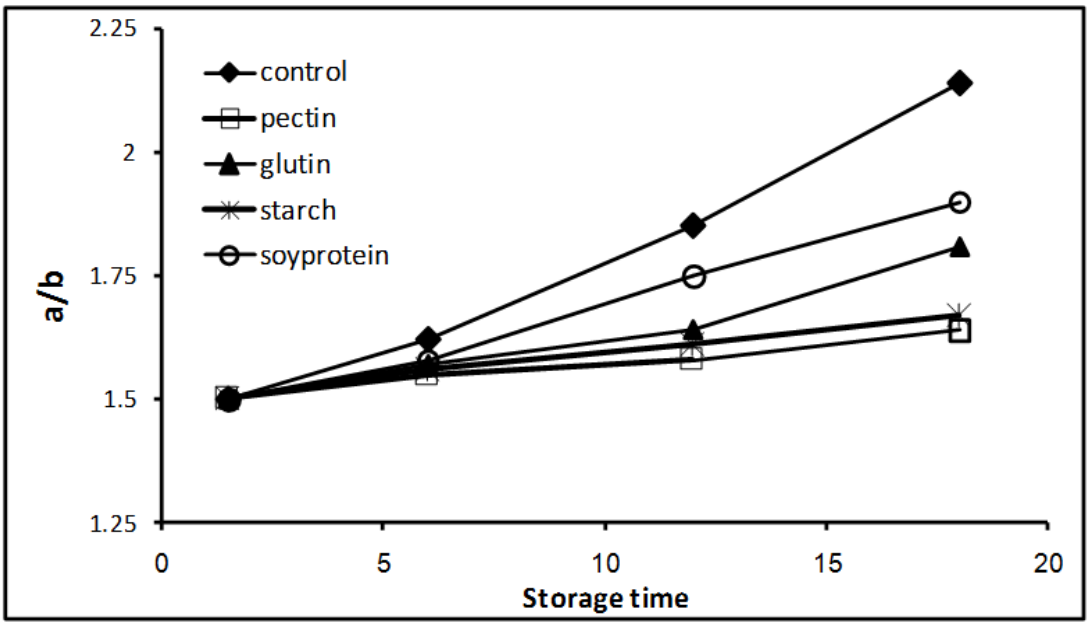

Fig. 4: Surface color changes of coated strawberries during storage. Bars indicate standard error ; $LSD_{0.05}$=0.301

Physico-chemical evaluation:

Titratable acidity decreased as a function of storage time for all treatments studied(Table 1), with the exception of the fruit covered with pectin layer which showed no significant change with time. The decrease in acidity demonstrates maturity development. On the first day of the experiment, there were significant differences in titratable acidity between the treatments, especially in the treatment with the soy protein samples, which had the lowest value. This may be attributed to small differences in maturity between the strawberries or

they were caused by the treatment. These differences have continued during the storage time and on day 16, fruit with the starch coating layer had the lower titratable acidity. These results were agreement with those of El Gaouth *et al*., (1991) in strawberries coated with starch – based coatings.

Total soluble solids increased with storage time in all treatments and control with the exception also of fruit covered with pectin film, which had no significant change with time (Table 1).

The samples coated with gluten layer showed a small increase in total soluble solids on day 6 and no significant change with time after that,on each day of analysis. There were significant differences between the treatments on day 1; the starch fruit samples had the lowest total soluble solids and on the other days of analysis, the pectin samples had the lowest value.

The reducing sugar content of all treatments and control increased with storage time. The reducing sugar content of fruit coated with pectin and / or with gluten was much lower increase than the others treatments (Table1), suggesting that in these two treatments the fruit synthesized reducing sugars at a slower rate than that the control ,as observed before for banana and mango coated with polysaccharide – based coatings (Kittur *et al*., 2001). This results demonstrates that the pectin and gluten films slowed down the metabolism to give prolonged storage life to the fruit (Kittur *et al*., 2001). Evident differences in reducing sugar content between some treatments on each day of analysis were observed; on days 1,6, pectin & gluten samples had the lowest content and on days 12 and 16, pectin samples had the lowest value. The pectin treatment delayed ripening of the strawberries during the storage time as indicated by the retention of the loss in titratable acidity, no changes in total soluble solids and slower rate of reducing sugars production followed by gluten coating.

Table.1: Changes in titratable acidity, total soluble solids and reducing sugars in control coated strawberries.

Parameter	Treatments	Storage time (days)			
		1	6	12	16
Titratable acidity	control	1.52	1.00	1.00	0.82
(%)	pectin	1.45	1.29	1.12	0.83
	Gluten	1.00	0.88	0.76	0.69
	Starch	1.25	0.96	0.84	0.34
	Soy protein	0.62	0.59	0.59	0.63
Table soluble solids	Control	8.70	9.60	10.80	11.90
(%)	Pectin	8.37	7.77	8.27	7.78
	Gluten	9.10	10.45	10.69	10.72
	Starch	7.90	9.00	12.00	13.04
	Soy protein	8.70	9.32	12.56	13.88
Reducing sugars	Control	3.85	4.06	5.10	5.90
(%)	Pectin	2.63	2.88	3.19	3.30
	Gluten	2.75	2.97	2.97	2.99
	Starch	4.34	4.24	4.22	6.14
	Soy protein	4.38	3.50	3.65	4.44

Sensory evaluation:

The sensory evaluation of the shelf life of the strawberries (Table 2), it can be seen that the pectin and gluten treatments significantly ($P<0.05$) improved the shelf life of the strawberries, maintaining the visual quality (Appearance, color and brightness, with scores ≥6 indicating the consumers liked the strawberries) during the storage time as compared to control fruit.

Table 2: Mean of the attributes in the sensory evaluation of the shelf life of five samples of strawberry stored at 7-10°c during 16 days

Parameter	Treatments	Storage time			
		1day	6 days	12 days	16days
Appearance	Control	7.2a	6.7a	2.7b	3.0b
	Pectin	7.7a	7.3a	6.4a	6.5a
	Gluten	7.6a	7.0a	6.7a	6.4a
	Starch	6.4a	6.5a	5.9b	5.7b
	Soy protein	4.7b	4.0b	3.5b	3.4b
Color	Control	7.2 a	6.8 a	3.6 b	3.2 c
	Pectin	7.7 a	7.3 a	7.0 a	6.7 a
	Gluten	7.6 a	7.1 a	7.0 a	6.8 a
	Starch	7.4 a	7.2 a	6.7a	6.7 a
	Soy protein	4.7 b	4.8 a	4.9 b	4.8 b
Brightness	Control	6.5 b	6.1 b	2.6 c	2.7 b
	Pectin	7.5 a	7.5 a	7.0 a	6.1 a
	Gluten	7.4 a	7.4 a	7.0 a	6.0 a
	Starch	5.6 b	5.5 b	4.3 b	4.2 b
	Soy protein	5.4 b	5.3 b	4.1 b	4.0

Mean of 40 consumers for each sample. Means with different letters for the same parameter in the same column are significantly different (P<0.05), according to ANOVA and the Tukey's test.

In the sensory evaluation of the strawberries (Table3), the consumers most liked the flavor and texture of control, pectin and gluten treatments, and the taste of control and pectin- samples (with scores ≥6 indicating the consumers liked the strawberries).

From the results of the sensory evaluation for taste of the strawberries (Table3), also the pectin and gluten treatments had no negative effect ($P<0.05$) on the taste, flavor and texture of the strawberries (with scores ≥6). This is an important result because it means that the pectin and gluten coatings can be used to coated strawberries since its taste is not perceptible by the consumers.

Table 3: Mean of the attributes in the sensory evaluation for the taste and flavor of five samples of strawberry after 5 days at 7-10°c

Treatment	Flavor	Taste	Texture
Control	7.1 a	7.1 a	7.1 a
Pectin	6.6 a	6.1 ab	6.9 a
Gluten	6.6 a	6.1 ab	6.9 a
Starch	6.4 b	5.5 b	6.2 a
Soy protein	6.3 b	5.3 b	6.0 a

Mean of 40 consumers for each sample Means with different letters for the same parameter (column) are significantly different (P<0.05) according to ANOVA and the Tukey's test.

Tensile properties:

Mechanical properties resulted from the tensile test of the four films under investigation are shown in Table (4). The UTS is the most important mechanical property for many applications (Park and Chinnan,1995). Polyvinyl alcohol (PVA) was used to improve the mechanical property because the PVA offers good TS, flexibility and barries properties to oxygen and aroma by crosslinking polymers (Babak *et al*., 2011).

The TS of the pectin- based film higher than that of the others films. Elongation at break (%E) had a negative correlation with the TS results. From the comparison of the TS and %E of the prepared pectin, gluten, starch and soy protein- based films indicated that pectin-based film had a substantial amount of mechanical properties compared to the others films.

Table 4: Tensile properties of the different prepared films.

Films	TS (KPa)	E (%)
Pectin	115.7	29.34
Gluten	100.3	31.75
Starch	94.2	32.66
Soy protein	90.5	32.93

Abbreviation: TS, tensile strength; E, elongation at break;

Conclusions:

Four types of edible coatings have been applied on strawberries wrapping. All different coatings under investigation extended the shelf life of strawberries and retarded the senescence process compared with strawberries used as a control treatment but pectin-based coating had a higher TS and a substantial amount of mechanical properties than that of them. Also, the fruit with the pectin coating showed a higher beneficial effect on firmness retention, reduced weight loss of the strawberries and reduced the number of infected fruit in comparison with the other treatments. Moreover, from the physico-chemical analysis of the strawberries, the pectin-based coating showed better results. The sensory evaluation of the strawberries showed that the fruit with pectin and gluten coatings maintained visual quality during shelf life and the consumers approved the taste and flavor of the pectin and gluten samples. Therefore ,this investigate evident the preference of using pectin-based layer in fruit coating especially perishable ones such as strawberry which extend its shelf life than that the coatings prepared from gluten, starch and/or soy protein which exhibited certain shortcomings and have not received substantial commercial acceptance.

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