Storage properties of figs coated using chemically modified whey proteins and caseins

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Abstract
Edible coatings are a suitable approach to maintaining the quality and shelf life of fig fruits. The effect of chemically modified milk proteins (whey and caseins) as coating materials for fig fruits were evaluated. whey proteins and caseins were modified using formaldehyde treatment, esterification, and deamination, and the modified proteins were used to prepare edible coating solution at 5%. The fruits were dried well after the coating process and it were put down in a plastic box. After that, were stored at 5 °C and relative humidity (RH) 85-90% for three weeks. The results displayed the fresh weight loss in all coated fruits treatments significantly decreased compared with untreated fig fruits. Total soluble solid (TSS) in all coated treatments were less than control fig fruits. While the coated fig fruits with whey proteins (modified and unmodified) had a reduced titratable acidity (TA), carotene content compared with caseins (modified and unmodified) and control. On the other hand, fruits coated with whey proteins had higher polyphenol oxidase activity in comparison with figs coated with caseins and control. Moreover, all coated treatments of fig fruits exhibited higher score of each (color, texture, brightness, and overall acceptability) in comparison with control treatment. Regarding the storage period effects, prolonging storage periods increased weight loss, TSS, TA, carotene, while the polyphenol oxidase activity was decreased. Also, the degrees of sensory evaluation of each (color, taste, texture, brightness, and overall acceptability) were decreased with the increment of storage period.

Keyword: whey and casein protein, chemical modification, edible coating, fig fruits, polyphenol oxidase activity.

INTRODUCTION

Edible coatings or films are used in food manufacture to maintain foods and this application is not a new maintenance method (Skudlarek, 2012). When buying fruits and vegetables, consumers judge the freshness and quality of products based on their appearance (Kader, 2002). Edible films and coats provide barriers to chemical, physical, and biological changes in foods (Sharma et al., 2021). Fruits and vegetables are very perishable and post-harvest losses are important for susceptibility to microorganisms, insects, respiration and sweating, and pathogens. Therefore, huge losses of horticultural products occur each year during handling and transportation. Various pre-harvest and post-harvest treatments are available to mitigate these losses. Of these, the use of edible coatings is an important tool for improving the shelf life of products(Tiwari, 2014).

Most edible coatings are made from natural polymers with film-forming properties such as polysaccharides, proteins, and lipids(Álvarez et al., 2017). The protein-based edible coating is obtained from animal and vegetable sources. Plant-based edible protein coating materials include zein (from corn), gluten (from wheat), and soy protein, etc. The animal-based proteins are milk proteins casein & whey, albumen in egg, collagen, etc (Baldwin et al., 1995). The edible coating applies to the complete and fresh-cut fruits and vegetables, and the fruits which have been coated are lemone, strawberry, fig, mango, cherry, peach orange, apple, grapefruit, papaya, etc., and fresh-cut peach, fresh-cut pear, and fresh-cut apple, etc. Vegetables include: tomato, cucumber, cantaloupe, capsicum, and minimally processed carrot, (Youssef et al., 2015) also edible coats are applied to nuts, such as walnut, pistachio kernel and almond(Farooq et al., 2021, Javanmard, 2008, Grosso et al., 2020).

Fig fruits are usually very sensitive to some physiological and pathological disorders in post-harvest life, including softening and cracking of the skin. The edible coatings (EC) were used in some fruit crops to lessen post-harvest fruit transpiration and preserve the visual quality of the fruit (Allegra et al., 2018). The casein-based coating is used to preserve the quality of guava fruits and extend their shelf life. Based on thorough research, casein was selected for the maintenance of fresh guava fruits because of its availability, safety, and versatility as a shell-forming proteinaceous substance. Various quality parameters were regularly evaluated to understand the qualitative and quantitative alterations in guava fruit at the storage time(Cerqueira et al., 2011). The coated casein protein is due to the barrier to weight loss and helps control the moisture remaining in the fruit for a prolonged time during storage (Beulah et al., 2021).

The edible coating is based on a whey protein concentration which was used to preserve the quality of kiwifruit. Coating with whey proteinconcentrate lessens the fresh weight loss in kiwi fruit compared with uncoated fruits during the storage time (Hassani et al., 2012). On the other hand, edible coating-based whey protein is an additional functional ingredient

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(antioxidants and antibacterial agents) that reduces water loss, limits oxygen intake, reduces respiration, slows the ethylene production, traps volatile flavors, and slows discoloration and microbial growth,…etc (Albert and Mittal, 2002).

Chemical modifications to the primary structure of proteins can be applied to improve their functional properties. This approach has been successfully used to study the relationship between structure and function (enzymatic, biological, physicochemical, and functional properties). Some methods used for chemical modification of proteins consist of formaldehyde modification, esterification, and deamination (ALKaisy and Al-Saadi, 2019).

Due to the lack of studies on the effect of these types of edible coatings on the shelf life of fig fruits and being a highly perishable fruit, this study to investigate the impact of chemical modifications on the properties of milk proteins (whey proteins and casein) as coating materials to prolong the storability of fig fruits and maintain their quality during storage and to determine the appropriate storage period of the "Koija" fig fruits.

Materials and Methods

milk protein sources:

Whey proteins: Whey proteins were obtained from a Greece company called Velcos. A.Alinda and the concentration of whey proteins was 80.7%**Casein protein**: Casein was obtained from Alfasol company -Turkey and the concentration of protein was 86.50%.

Chemical modification of proteins

Formaldehyde modification

Protein modification was conducted by adding Formaldehyde up to 1.20 mol/ 100 g of dispersed proteins under gentle stirring for one hour at room temperature (20°C), after that the proteins solution was dialyzed by 0.001 M HC1for 24 h, and freeze-dried.

Esterification

Esterification of milk proteins were prepared according to the method defined by (Fraenkel-Conrat and Olcott, 1945). Protein was suspended in the cold methanol to yield a 10 % suspension. While the protein-alcohol suspension was stirred, concentrated Hydrochloric acid was gradually adding to obtain 0.7 M HC1. The mixture was stirred on four temperatures at twenty-four hours and diluted 10: l0 by adding cold deionized water, dialyzed upon 0.001 M Hydrochloric acid for 24 h, and freeze-dried.

Deamination

Deamination of milk whey proteins and caseins were implemented utilizing a modified version of the procedure defined by (Mimouni et al., 1994). Proteins were dissolved in 0.5 normality of HCl at value of (1:10) (w\v) and hydrolyzed by heating for two hours at seventy temperatures in a water bath. The reaction was stopped by cooling in an ice bath, accompanied by readjusting the pH at (4.6) and centrifuging for fifteen minutes at 3000g. The pellet was neutralized pH (6.7–7) by one normality of sodium hydroxide and freeze-dried.

Preparation of coating solutions

Dipping solutions were prepared by dissolving 50 g of whey proteins, casein and modified protein in 920ml of distilled water, pH was raised to 8 to dissolve proteins. After the proteins were dissolved completely the pH of solutions were decreased to 7 and 30 ml of glycerol was added as a plasticizer and the volume of solution was completed up to 1L. The solutions were kept in a water bath for 30 minutes at 90 ◦C. Finally, the solutions were homogenized in blender for 5 min and degassing were performed for all of them(Han et al., 2004) .

Fig fruits

Fig fruits harvesting time and orchard location

This study was carried out on the locally cultivar "Koija". Fig fruits was harvested manually from four years old trees at the ripening stage (4 August 2021), from the private orchard in the Zamaqy village of Halabja Governorate in Iraqi Kurdistan region. The fruits were manually harvested at the early morning, the fruits were selected that were uniform as possible in maturity, size, and color, also free from phenotypic defects such as cuts, bruises and diseases at harvest. The harvested fruits were transferred to the laboratory of the Technical College of Applied Sciences in Halabja Governorate on the same day.

Fig fruits coating

Fig fruits samples were dipped for one minute in the coating solutions according to treatments and placed on a flat surface for drying at room temperature (20°C), while, uncoated fig fruits were dipped in distillate water for one minute. The fruits were placed in the plastic (polyethylene) boxes (1kg Capacity) has eight holes with 1cm diameter and stored at the five temperature and relative humidity (RH) 85–90% for three weeks as storage periods.

Factors immersing (treatments) of fig fruit

Nine treatments were investigated in the present experiment including:

Fruits were immersed in distilled water for 1 min as (control treatment).

Fig fruits were immersed in 5% of unmodified whey proteins for one minute (unm. whey).

Fig fruits were immersed in 5% of formaldehyde whey proteins for one minute (for. whey).

Fig fruits were immersed in 5% of esterified whey proteins for one minute (est. whey).

Fig fruits were immersed in 5% of deaminated whey proteins for one minute (dea. whey).

Fig fruits were immersed in 5% of unmodified casein protein for one minute (unm. casein).

Fig fruits were immersed in 5% of formaldehyde treated casein for one minute (for. casein).

Fig fruits were immersed in 5% of esterified casein for one minute (est. casein).

Fig fruits were immersed in 5% of deaminated casein for one minute (dea. casein).

Storage periods

Fig fruits were stored for one or three weeks as storage periods.

Storage characteristics of fig fruit:

Fresh Weight loss (%): It was estimated by taking the weight of the fig fruit at the starting of storage and at the final of each storage period.

Total soluble solids (TSS)%: It was measured by a hand refractometer the name model, and manufacturer country is ATAGO/ Japan as described in (Horwitz, 2002).

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Titratable acidity (TA) %: It was measured using the way described by (Sinha et al., 2015).

Carotene content (mg/100 ml): The carotene pigment was extracted according to the method (Goodwin, 1965).

Determination of polyphenol oxidase (PPO) activity: The method mentioned by (Shi et al., 2002)was used to estimate the enzyme's activity.

Sensory evaluation:

The sensory evaluation was confirmed by 5 staff members of the Food Science and quality control Department at the Technical College of Applied Sciences in Halabja at zero time and after each storage period. The major sensory parameters were selected: fruit color (25 scores), texture (25scores), taste (25 scores), brightness (25 scores) and overall acceptability (100 scores) (Amerine et al., 1965).

Design and Statistical Analysis:

The factorial experiment (9 (Treatments) *2 (Storage Periods)) within complete randomized design (CRD) was used with three replicates and 10 fig fruits for each experimental unit (54 experimental units in total). Collected data were analyzed by using SAS v8.2 and Duncan's test at the level of 5% was utilized for comparing the mean of treatments.

RESULTS AND DISCUSSION

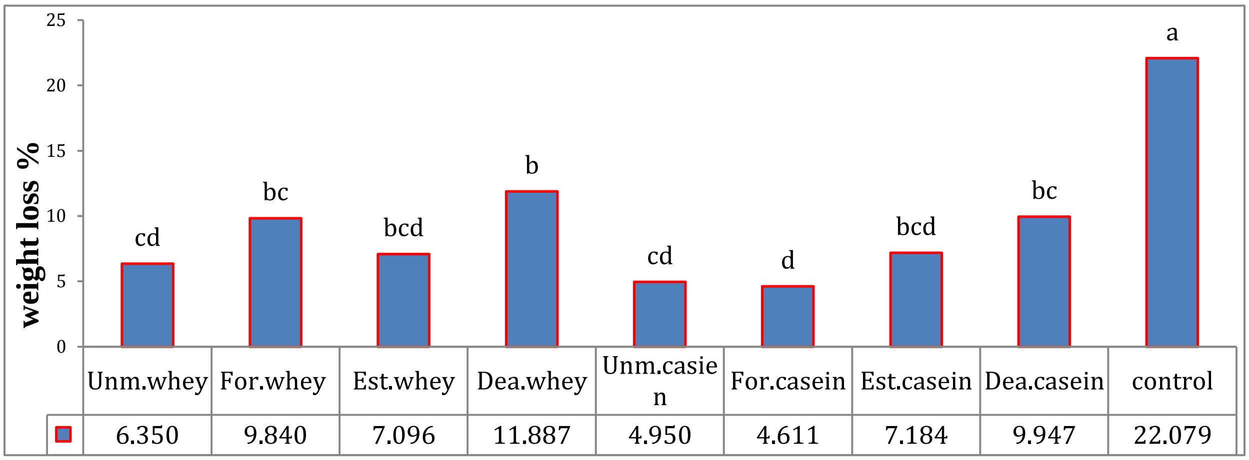
Fresh Weight loss (%)

According to (Fig.1), the percentage of fresh weight loss in each coated fruits was significantly less than control treatment (uncoated). The highest percentage of weight loss was recorded in uncoated fruits, while among the all coated treatments; the lowest score of fresh weight loss was achieved in (for-casein) (4.611) %.

According to (Beulah et al., 2021) these results were agreed with the result study conducted on guava coated with 5% and 10% composite casein protein. All of the treatments coatings with casein protein in each concentration have roles to the reduced weight loss in guava fruits compared with control (untreated). While the best results of coated fruits were obtained in 5% of casein protein. Whey protein concentrates and bee wax less fresh weight loss was observed in fresh-cut apple coated compared to uncoated sample was found according to the researcher (Perez-Gago et al., 2006) . This may be due to the coating characteristics as a good barrier for coating substance made from whey proteins isolate. In addition, these coatings result in an improved atmosphere around the surface of the fruit and a reduction in fruit weight loss by the transpiration of the surroundings. Mass loss occurs based on the water vapor pressure gradient between the fruit and the environment air. Epidermal and cuticle layers help reduce transpiration (Ruelas-Chacon et al., 2017). Likewise, the fruit coating decrease transpiration due to the formation of a coating on the surface of the fruit and whole or partially coats the stomata, lenticels, and micropores. Formation of a semipermeable barrier for gas exchange and ultimately reduced transpiration (Kumar and Saini, 2021).

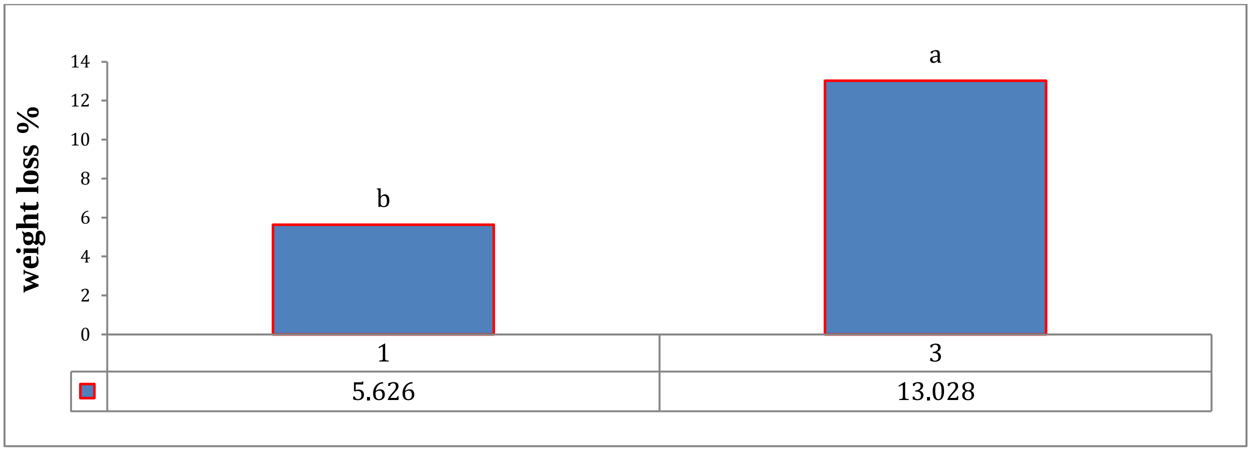
The postharvest weight alters in fruits and vegetables are usually due to the evaporation of water by transpiration. Weight loss as a function of storage time in soybean protein isolate- chitosan coated apricots compared with the uncoated fruits, apricots with soybean protein isolate- chitosan coating displayed the effect of weight loss

(Zhang et al., 2018), the results appear that the soybean protein isolate--chitosan coating prohibits fresh weight loss of apricots markedly. Reduce of weight in fresh fruit and vegetables is fundamentally due to the reduce of water from transpiration and respiration (Zhu et al., 2008). Protein coatings are excellent at preventing the loss of carbon dioxide and oxygen and water, so coating with protein in combination with other ingredients such as (chitosan) can very well protect the quality of the fruit, and the coating effect can be characterized as better water evaporation prevention properties (Yousuf et al., 2018).



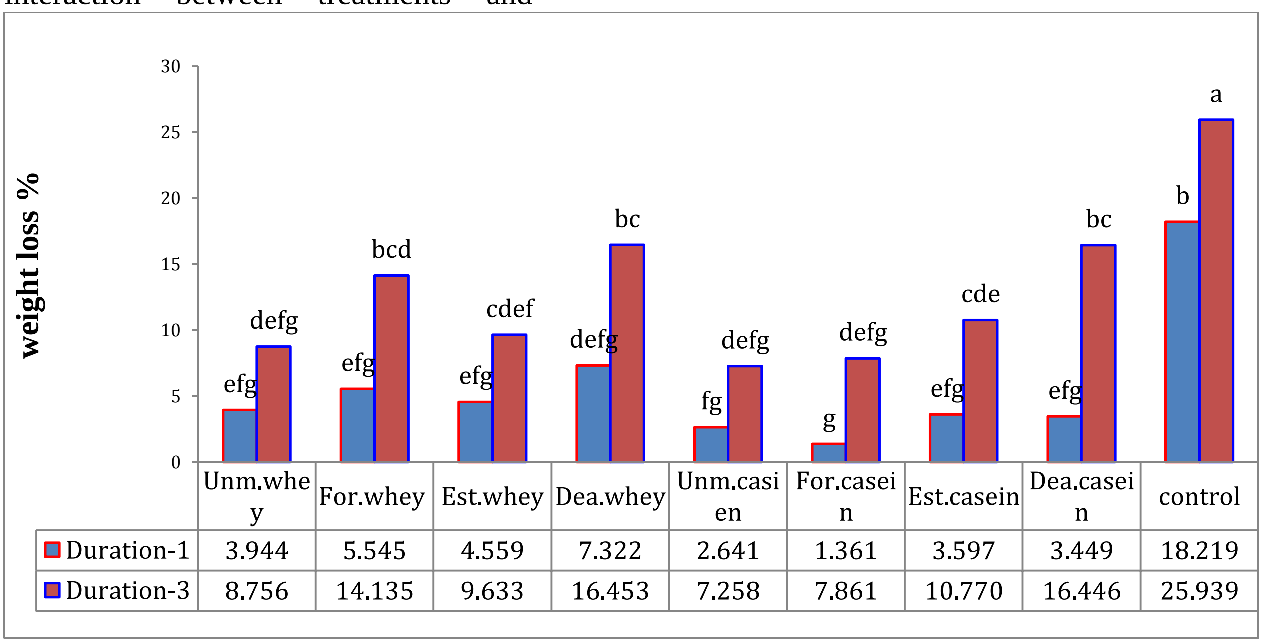
Figuer.1: Effect of treatments on fig fruits weight loss (%). Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

Fig.2 demonstrated that with prolong the storage period the weight loss percentage was increased gradually and significantly. In the first week of storage the fresh weight loss reached to 5.626%, and increased gradually up to 13.028 % in the third week of storage. Weight loss usually occurs during fruit storage due to respiratory processes, water transfer, and some oxidative processes (Ayranci and Tunc, 2003). Moreover, weight loss is a major selected of quality during storage. Fruit weight loss occurs when moisture level evaporates from the surface of the fruit to the surrounding atmosphere (Khan et al., 2019).



Figuer.2: Effect of storage periods on weight loss (%) of fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

The results in (Fig.3) shows the significant differences impact of the interaction between treatments and storage duration, which appeared the lowest weight loss percentage was 1.361% in fruits coated with for-casein at the first week, but the maximum rate of fresh weight loss was 25.939% occurred in uncoated fruits at the third week.



Figuer.3: Effect of the interactions between the treatments and the storage periods on weight loss (%) of fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

Total soluble solids (TSS) %

Figure.4 shows that the TSS was significantly reduced in most of the coated fig fruits than the control

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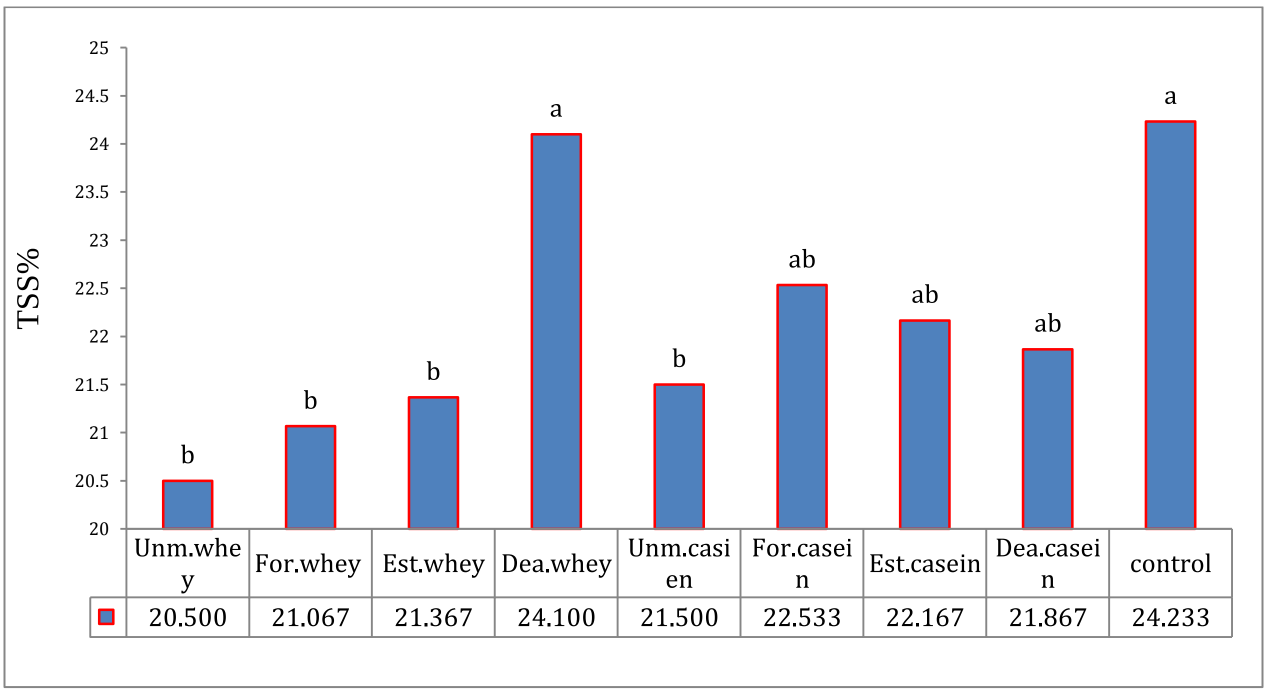
treatment, moreover, the highest rate (24.233%) was obtained in fruits untreated (control) compared with the lowest range of total soluble solid up to 20.500% was obtained in fruits coated with unmodified whey proteins. Our results come harmony with finding of(Beulah et al., 2021) when they used casein protein for coating guava fruit at 26ºC for 4,8,12 and 16 days at two concentrations 5and 10% casein, which they reported that in uncoated fruits total soluble solid was 17.44 % while in coated fruits with casein concentrations were (15.31 15.29 Brix%) respectively. The total soluble solids were greater in uncoated fruits, this is a well index of fruits ripeness. The explanation for this might be due to in coated fruits controlled ripening was achieved by inhibiting/slowing the generation of ethylene within the fruit tissues (Bashir and Abu-Goukh, 2003, Krishna and Rao, 2014).

On the other side with the use of whey protein isolate for coating tomato, there was a progressive rise in TSS, the highest degree maintains of the TSS was achieved in uncoated (control) fruits. This may be to occur due to the rising quantity of fresh water loss and increment TSS concentration was recorded in untreated fruits (Hassani et al., 2012).



Figuer.4: Effect of treatment on the TSS% of the fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

The Fig.5 illustrated the impact of storage duration on the TSS which was incremented gradually and significantly, at the first week TSS was (21.237%) and

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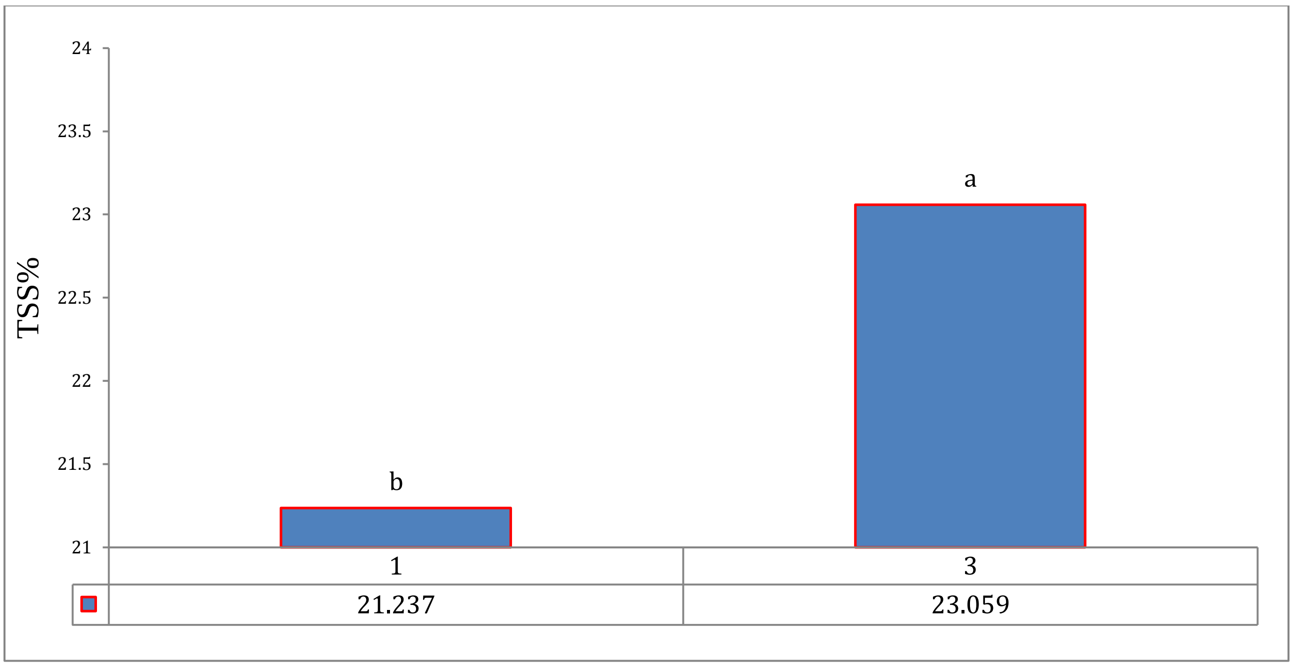
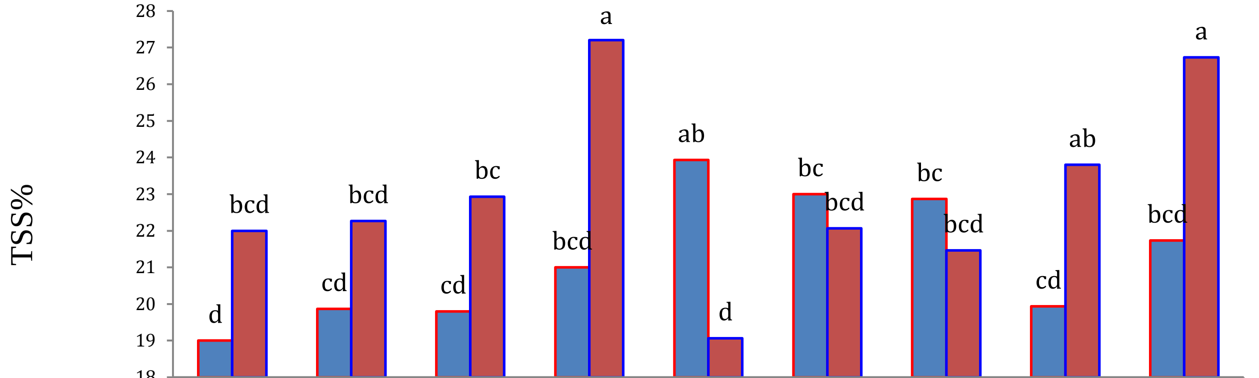
increased gradually at the final of the prolong storage duration to (23.059%). These results are close to the results found by [14] in their study on kiwifruit coated with composite whey proteins at certain temperature (4±1°C) for 4 weeks.

(Yan et al., 2019) reported that of the TSS was incremented in all of the tomatoes fruits storage period, although TSS incremented much less in the coated tomatoes. The coating produced superior results, with a lower rise in total soluble solids over storage life. Although, the coated cherry fruits by sodium caseinate, then the TSS and pH of the treated and untreated (control) fruits increment with prolonged storage period Soluble solids are a rough indicator of the sugar content of cherries, so this value is expected to increase during aging and decrement as a result of respiration. Coated and uncoated cherries lost considerable water during storage, but their soluble solids continued to increase. Although the most successful coatings to prevent weight loss should be also the most successful to prevent the increment of soluble solids with prolong storage duration (Certel et al., 2004) .



Figuer.5: Effect of storage duration on the TSS% of the fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

The results in (Fig.6) were demonstrate the significant difference $P \leq 0.05$ in the interaction among treatments and storage duration on total soluble solids. The coated fig fruits with deamination whey proteins and uncoated fruits had maximum rate of total soluble solid at the third week of storage period, while the coated fig fruits by unmodified whey protein had the lowest value of total soluble solids (19.000%).



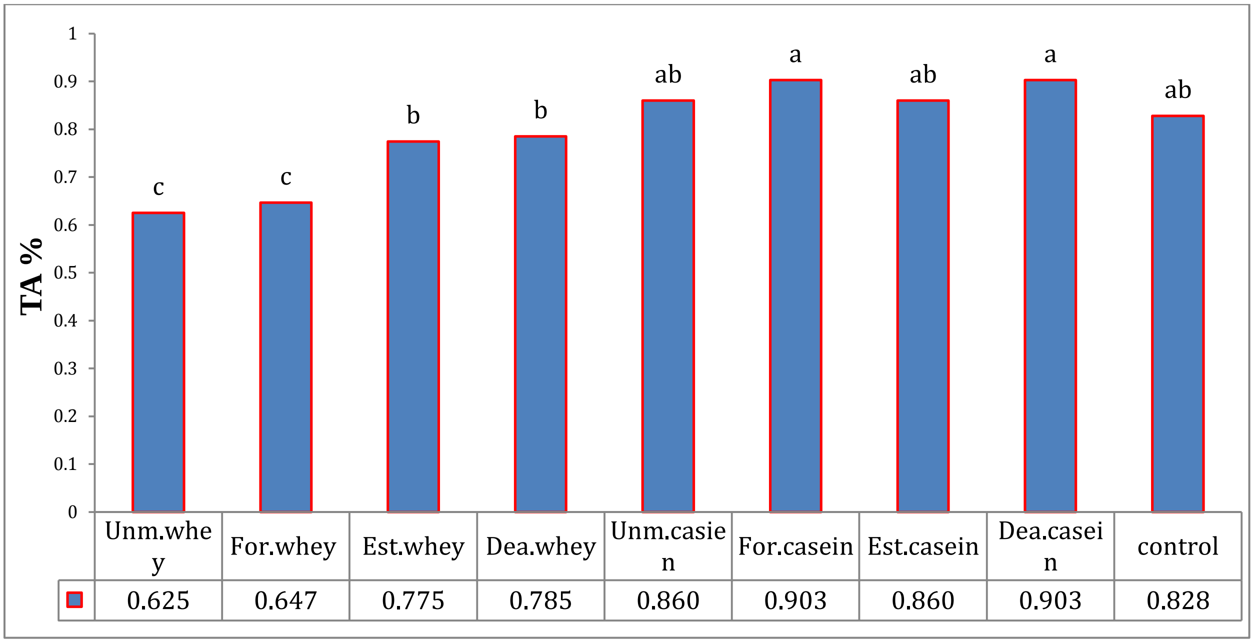
	Unm.whey	For.whey	Est.whey	Dea.whey	Unm.casien	For.casein	Est.casein	Dea.casein	control
Duration-1	19.000	19.867	19.800	21.000	23.933	23.000	22.867	19.933	21.733
Duration-3	22.000	22.267	22.933	27.200	19.067	22.067	21.467	23.800	26.733

Figuer.6: Effect of the interactions between the treatments and the storage periods on total soluble solid % of fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

Titratable acidity (TA) %

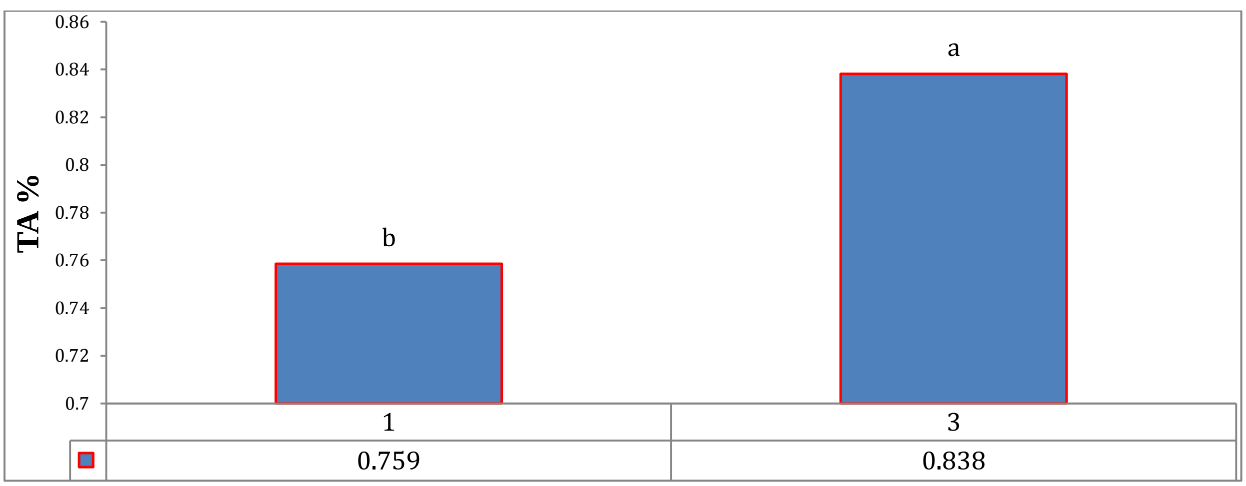
Data in (Fig.7) demonstrates that there are significant differences between treatments in the TA%. Generally, most of coated treatments reduced the TA% than uncoated fruits. While, the highest range of TA was found in formaldehyde and deamination casein protein 0.903% compare to the lowest percentage appeared in coated fruits with unmodified Whey 0.625%.

According to (Han et al., 2004) the different concentrations of casein can effectively maintain and control the acidity of guava fruits. The amount of titratable acids in the fruits is dependent on their maturity and gives them a sour flavor. The quantity of organic acids in the fruit diminishes as it ripens. The rate of organic acid dissolution as the fruit ripens is determined by the rate of fruit respiration. Coating kiwifruit delayed the loss of titratable acidity, and coating with whey proteins at various concentrations was found to be beneficial in retaining TA when compared to other treatments and untreated (control) samples (Hassani et al., 2012). The kind of coating, cultivars, and storage stipulations all influence on TA (Sharma et al., 2019). Casein edible coating, on the other hand, can help retain and manage the acidity of guava fruits. Although, the acidity alteration in coated samples were not substantially different from the control, although severe acidity changes were seen when compared to the control. According to the findings, casein edible coatings can postpone the development and ripening of fruits as much as possible, which is necessary for maintaining fruit quality during storage (Han et al., 2004).



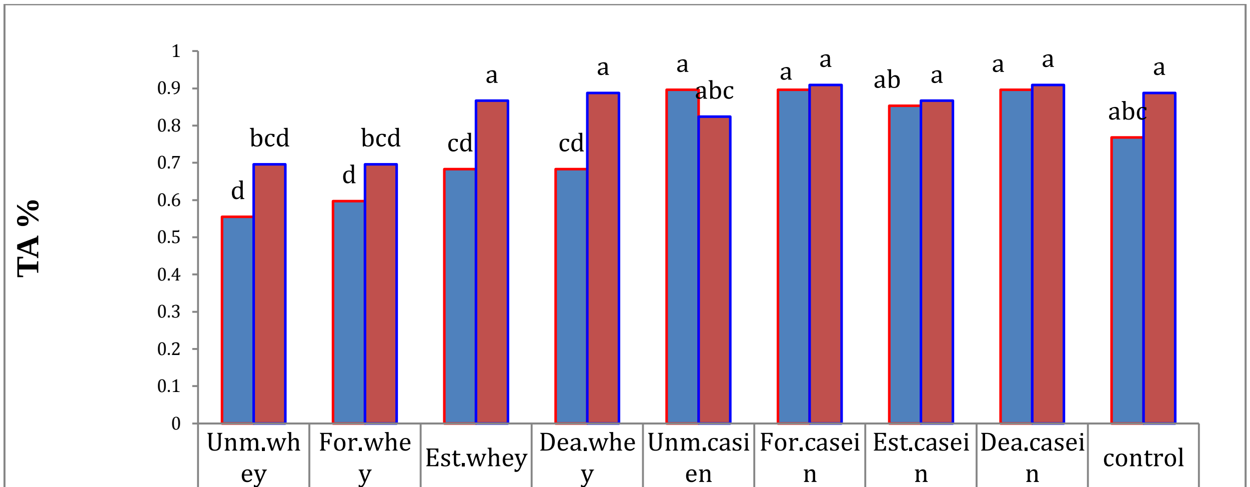
Figuer.7: Effect of treatment on the TA% of the fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

Data in (Fig.8) demonstrated that the significant differences between storage periods in the titratable acidity percentage. The lowest range of TA was reached to 0.759% in the fruits of first week of storage. Whereas, the highest TA percentage was found in fruits at third week of storage (0.838%). The use of coatings on kiwifruit delayed the development of TA. Whey protein coatings in 10% (w/w) concentrations were found to be effective in retaining titratable acidity compared to other untreated samples (controls) storage during 28 days at 4ºC (Hassani et al., 2012).



Figuer.8: Effect of storage duration on the TA% of the fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

The results in (Fig.9) shows that there are significant differences in the interaction between the treatments and storage durations on the titratable acidity. Whereas the highest percentage in titratable acidity (0.909%) were obtained in fruits coated with both of (for. Casein and dea. Casein) which stored for three weeks. Whilst, the lowest range of titratable acidity (0.555%) obtained in fruits coated with unmodified whey protein at the first week.



	Unm.whey	For.whey	Est.whey	Dea.whey	Unm.casien	For.casein	Est.casein	Dea.casein	control
Duration-1	0.555	0.597	0.683	0.683	0.896	0.896	0.853	0.896	0.768
Duration-3	0.696	0.696	0.867	0.888	0.824	0.909	0.867	0.909	0.888

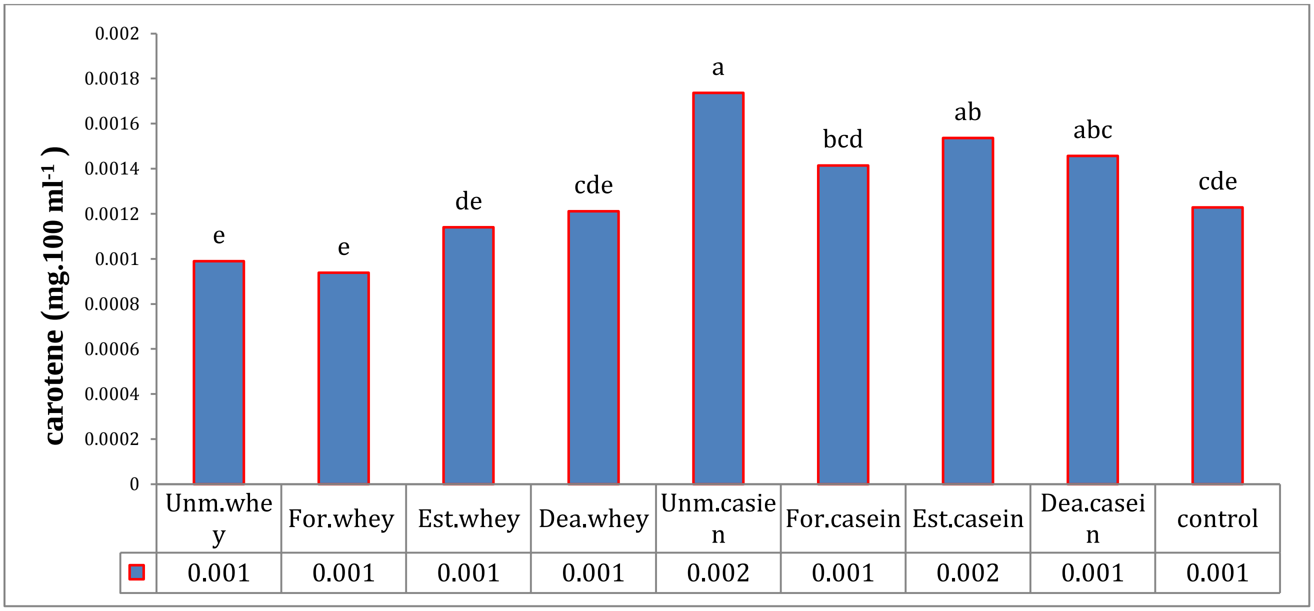
Figuer.9: Effect of the interactions between the treatments and the storage periods on TA % of fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

Carotene content (mg.100 ml^{-1})

Data in figure (10) illustrates that the coated fig fruits by unmodified casein protein were significantly superior on most of the other treatments which recorded the highest carotene content reached 0.0017mg.100 ml^{-1} whereas, the fig coated with formaldehyde modified whey proteins recorded the lowest range in carotene content of fig fruit 0.0009 mg.100 ml^{-1} in each of them

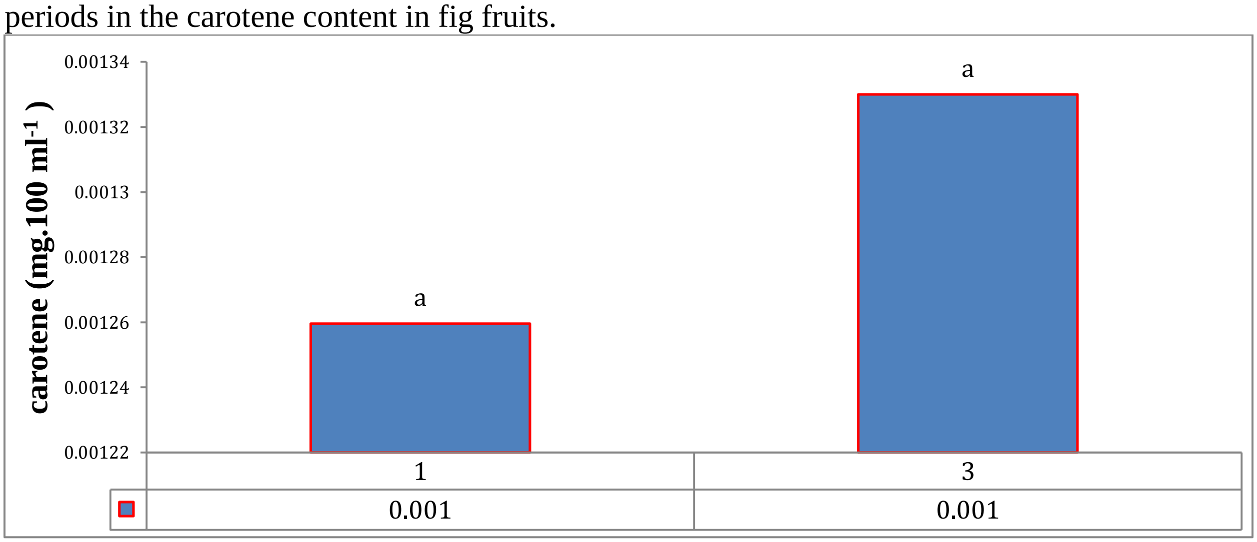
The decrement in carotene content may be due to the decomposition of carotene by the oxygen oxidation process from the surrounding air and the activity of microbial that remove the characteristic orange color of carotene by the decomposition process. The content of colorants in the material (anthocyanins, carotenoids) can result from decomposition (heating, storage, process), aging, and decomposition by the aging of product (Ruswanto et al., 2021). Or may be due to the coatings can reduce the numerous metabolic processes during storage because they generate an interior modified atmosphere that helps to delay fruit ripening thus decreasing the carotene content in coated fruits with whey proteins.

The increase in carotene may be due to the appearance of carotenoids after chlorophyll degradation during maturation. B-carotene concentration increases in proportion to maturity with the rapid accumulation of red pigment (Olaleye et al.2020).



Figuer.10: Effect of treatment on the Carotene content mg.100 ml^{-1} of the fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

Data in (Figure.11) showed that non-significant differences were found among storage periods in the carotene content in fig fruits.



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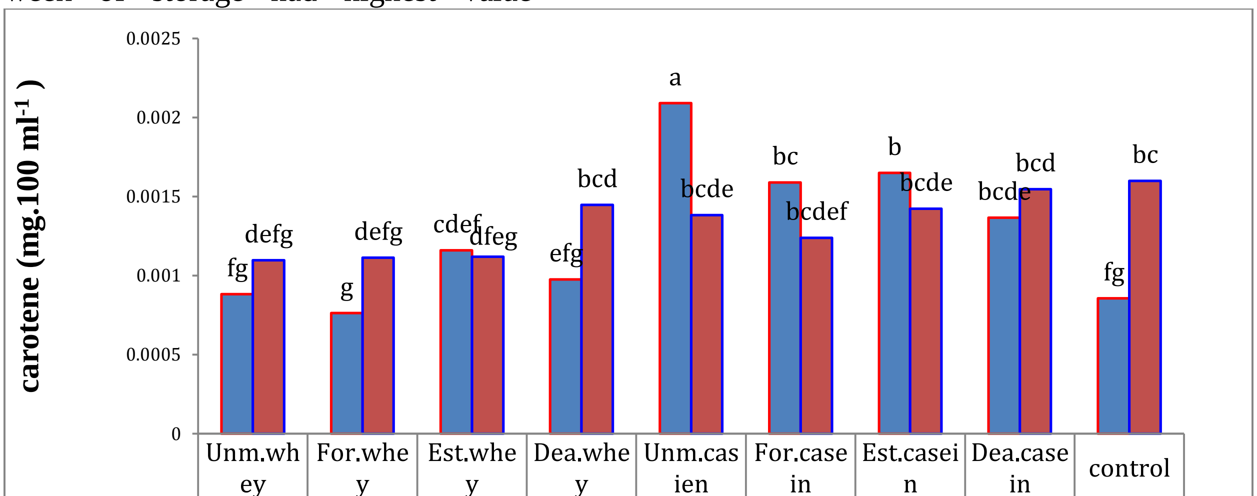
Figuer11: Effect of storage duration on the Carotene content mg.100 ml^{-1} of the fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

Figure in (12) demonstrates that the significant differences in the interaction among the treatments and storage period on the carotene content of fig fruits. The coated fig fruit with unmodified casein protein at concentration 5% at the first week of storage had highest value (0.002% mg.100 ml^{-1}). while the lowest value 0.00071 mg.100 ml^{-1} was in coated fig fruits with formaldehyde whey proteins at the first week of storage period.



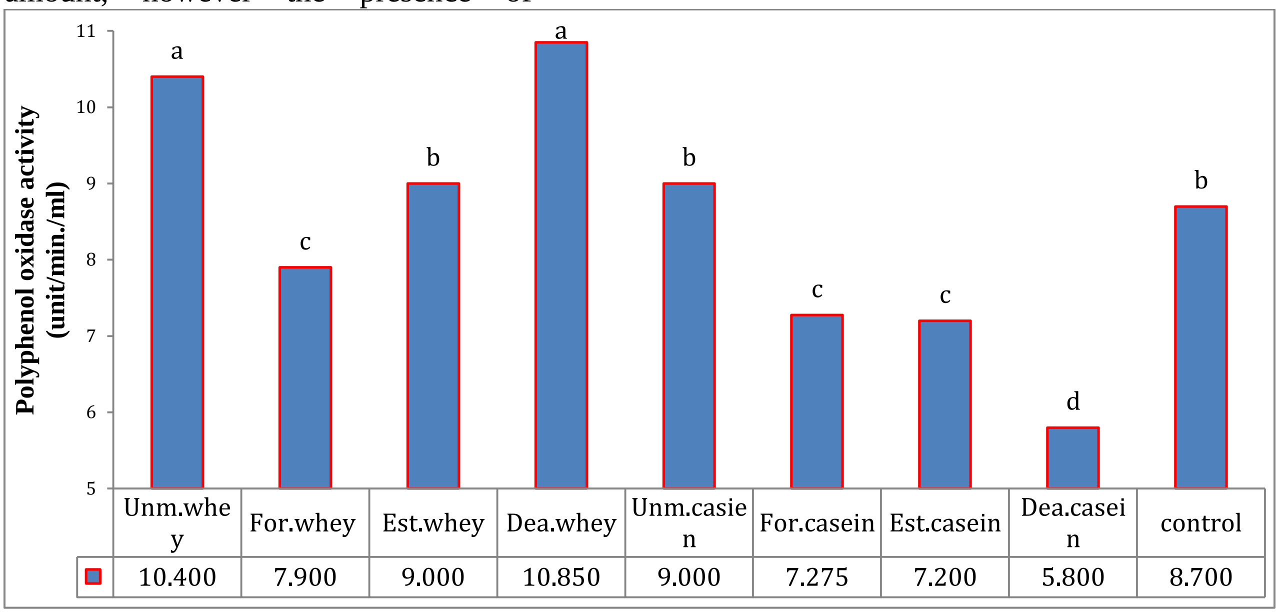
	Unm.whey	For.whey	Est.whey	Dea.whey	Unm.casien	For.casein	Est.casein	Dea.casein	control
Duration-1	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001
Duration-3	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002

Figuer.12: Effect of interactions between the treatments and the storage periods on Carotene content mg.100 ml-1 of fig fruits. Different letters indicate presence of statistical differences at the level of $P \leq 0.05$.

Polyphenol oxidase activity (unit/min./ml)

The results in (Fig.13) show that fruits coated with some of studied treatments significantly superior than control fruits for reducing polyphenol oxidase activity, the fruits coated with unmodified and deamination whey proteins gave the maximum activity of polyphenol oxidase, which superior on the other treatments, while the minimum activity was found in fruits coated with deamination casein protein.

Although, that there are factors that are closely linked to phenolic content and polyphenol oxidase activity this suggests that polyphenol oxidase is more active in fruits with greater phenolic content in most samples, since these molecules are better suited to engage the enzyme and function as its substrate. Polyphenol oxidase catalysis, moreover, causes enzymatic browning, which is plainly visible and quantifiable as a reduction in enzyme activity. Total phenols were identified in papaya and mango analogues, which might be polyphenol oxidase substrates. Due to the low phenolic content of papaya, polyphenol oxidase activity may be reduced. Mango, on the other hand, had the greatest amount, however the presence of endogenous Polyphenol oxidase inhibitors in this fruit may restrict enzymatic browning. PPO induces color changes in fruit pulps, which may be easily measured by observing the brightness of the fruits (Falguera et al., 2012).



Figuer.13: Effect of treatment on the polyphenol oxidase activity (unit/min./ml) of the fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

Date in (Fig.14) demonstrated that non-significant differences were found among storage periods in the polyphenol oxidase activity in fig fruits

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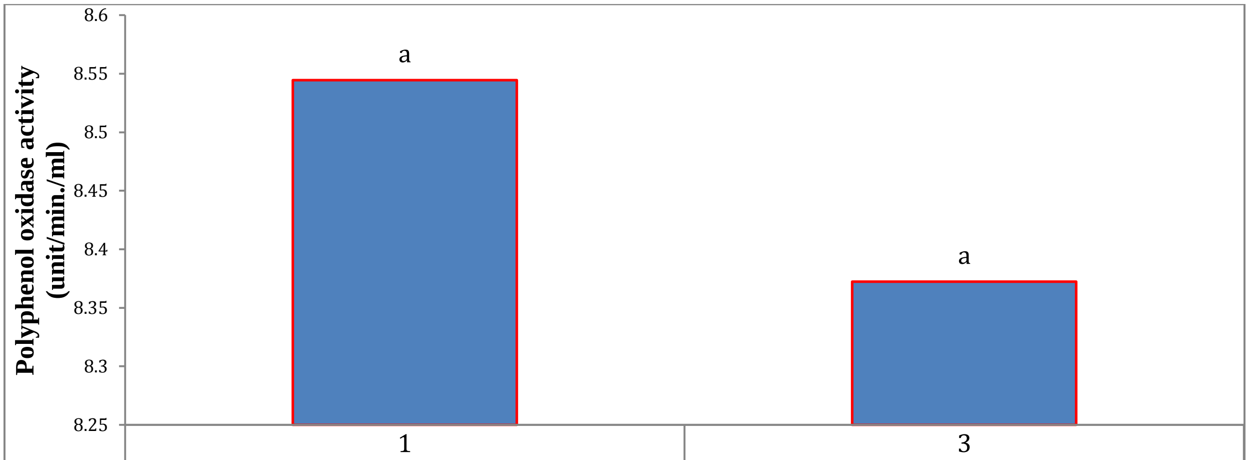
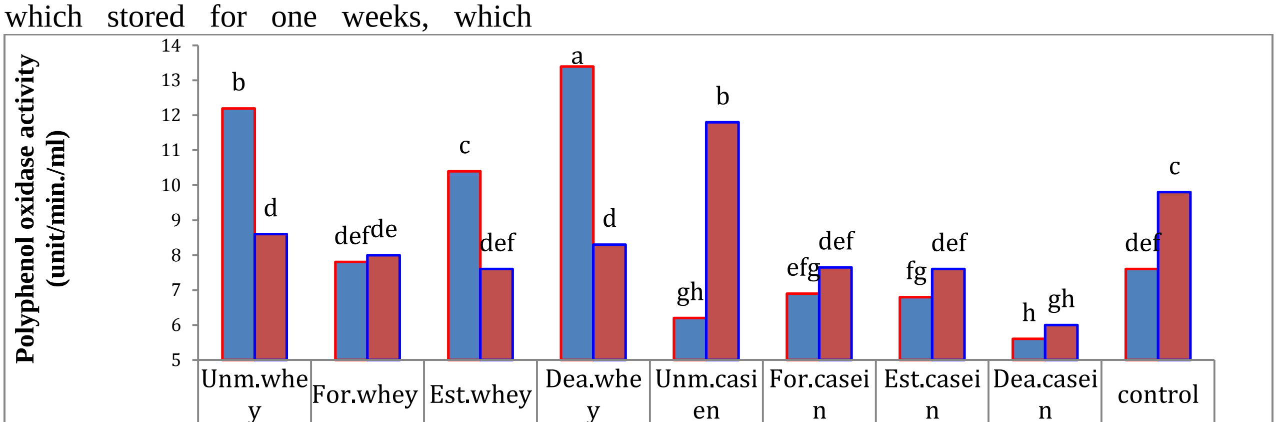


	1	3
	8.544	8.372

Figuer.14: Effect of storage duration on the polyphenol oxidase activity (unit/min./ml) of the fig fruits. Different letters indicate presence of statistical differences at the level of P ≤ 0.05.

Our results indicated that there are significant differences among the interaction between the treatments and storage periods, while the highest activity of PPO was found in fruits coated with deamination whey proteins which stored for one weeks, which superior on the other intraction treatments, but the lowest activity was found in fruits coated with deaminated casein protein which stored for one weeks (Fig.15).



	Unm.whey	For.whey	Est.whey	Dea.whey	Unm.casien	For.casein	Est.casein	Dea.casein	control
Duration-1	12.200	7.800	10.400	13.400	6.200	6.900	6.800	5.600	7.600
Duration-3	8.600	8.000	7.600	8.300	11.800	7.650	7.600	6.000	9.800

Figuer.15: The effect of interactions between the treatments and the storage periods on polyphenol oxidase activity (unit/min./ml) of fig fruits. Different letters indicate the presence of statistical differences at the level of P ≤ 0.05.

Sensory evaluation:

All coated and uncoated (Control) fig fruits were subjected to sensory evaluation in terms of color, taste, texture, brightness, and overall acceptability in each storage period. Fig was positively affected by edible coating solutions based on modified whey proteins and caseins at the concentration of (% 5 w/v) prolong storage period (one, and three) weeks at 5 °C under (85-90) % relative humidity.

The data in the table (1) showed that there was significant difference in sensory evaluation of all coated treatments for fig fruits according to color, taste, texture, brightness and overall acceptability. The coated fig fruits with 5% esterificated casein protein exhibited the highest score of each (color, texture, brightness and overall acceptability) which reached to 22.467, 22.800, 22.300, 89.500 respectively, but the coted fig fruits with formaldehyde casein protein recorded the maximum value in taste reached 22.533. While, the lowest scores were recorded in control (uncoated) fig fruitof all (color, taste, texture, brightness, and overall acceptability) which recorded 15.100, 19.100, 17.833, 16.000 and 68.033 respectively. The result of the figure (4.10) shows the increasing the carotene content in fig fruits which have the role of color evaluation acceptably. In the same time, the TSS% and TA% effect the taste, while increased TSS cause to rise of percentage in total sugar and decreased TA was joined to the taste was desired by the panelist evaluation (figure.4). On the other hand, maybe the decreasing of the fresh weight loss and preserving the moisture content of fig fruits coated compared with uncoated has the role in the panelist decision (figure 1), especially the texture and brightness that affected by the fresh weight loss and the moisture content. Moreover, related to the overall acceptable all the parameters were described above have an impact on the overall acceptability of fig fruits (figures 1, 4, 7, 10). Thus, the coated fig fruits were more acceptable than uncoated fruits.

Moreover, the result of (Table 1) demonstrates that there is a significant effect among storage periods of each (color, taste, texture, brightness, and overall acceptability) for fig fruits, whereas the highest value found in fig fruits which stored for one week in all (color, taste, texture, brightness and overall acceptability), which superior on the lowest value was found in fig fruits which stored for three weeks. This may be owing to increase all of the weight loss, TSS, TA, and carotene content of fig fruits with prolonged storage duration which affected the panelist's decision of each color, taste, texture, brightness, and overall acceptability (figure 2, 5, 8, 11).

Table (1) the impact of treatments and storage duration on the sensory evaluation of the fig fruits

Treatments	Color (25)	Taste (25)	Texture (25)	Brightness (25)	Overall Acceptability (100)
unm. whey	21.867abc	22.300 ab	22.767 ab	21.900 ab	88.633 a
for. whey	21.567 abc	22.033 abc	21.567 bc	21.367 ab	86.533 ab
est. whey	21.00 bc	21.433 bcd	21.700 bc	20.933 b	85.067 bc
dea. whey	21.00 bc	21.033 cd	21.633 bc	21.367 ab	85.033 bc
unm. casein	21.767 abc	21.333 bcd	21.767 bc	22.033 a	86.900 ab
for. casein	22.167 ab	22.533 a	22.433 ab	21.567 ab	88.700 a
est. casein	22.467 a	21.933 abcd	22.800 a	22.300 a	89.500 a
dea. casein	20.633 c	21.000 d	20.933 c	19.667 c	82.233 c
Control	15.100 d	19.100 e	17.833 d	16.000 d	68.033 d
First week	21.852 a	22.970 a	22.600 a	21.756 a	89.178 a
Third week	19.830 b	19.852 b	20.341 b	19.830 b	79.852 b

Different letters in the same column within each factor indicate presence of statistical differences at the level of $P \leq 0.05$.

The significant differences were found among the interaction between treatments and storage duration on the sensory evaluation of fig fruits dependent on (color, taste, texture, brightness and overall acceptability) that displayed in (Table2). The maximum score of color, texture, brightness and overall acceptability was obtained in coated fig fruits with deamination whey proteins which stored for one week compared with all other interaction treatments (23.667, 23.933, 23.667, 95.067) respectively, but the coated fig fruits with formaldehyde whey proteins recorded the maximum value recorded in taste (24.467) at first week of storage period. Whereas, the control fig fruits (uncoated fruits) at the first week was obtained the minimum degree of color, texture, brightness and overall acceptability which were (14.267, 17.733, 15.667, 66.933) respectively, on the other hand the minimum score of taste was recorded in fig fruits coated with deamination whey proteins

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(18.267) at third week of storage duration.

Table (2) Effect of the interactions between the treatments and the storage periods on the sensory evaluation of fig fruits

	Treatments	Color (25)	Taste (25)	Texture (25)	Brightness (25)	Overall Acceptability (100)
First week	unm. whey	22.867 ab	23.400 ab	23.600 ab	23.333 ab	93.200 ab
	for. whey	23.267 ab	24.467 a	23.800 ab	23.133 ab	94.667 a
	est. whey	23.400 ab	23.133 ab	23.000 abcd	23.000 ab	92.533 abc
	dea. whey	23.667 a	23.800 bc	23.933 a	23.667 a	95.067 a
	unm . casein	21.933 bcde	23.067 ab	22.067 cde	21.933 bc	89.000 bcde
	for. casein	22.800 abc	23.467 ab	23.267 abc	22.133 bc	91.667 abcd
	est. casein	22.467 abc	23.600 ab	23.200 abc	22.000 bc	91.267 abcd
	dea. casein	22.000 abc	22.533 bc	22.800 abcde	20.933 cd	88.267 cdef
	Control	14.267 m	19.267 ef	17.733 i	15.667 f	66.933 h
Third week	unm . whey	20.867 cde	21.200 ab	21.533 def	20.467 d	84.067 f
	for. whey	19.867 ef	19.600 ef	19.333 gh	19.600 de	78.400 g
	est. whey	18.600 f	19.733 ef	20.400 fg	18.867 e	77.600 g
	dea. whey	18.333 f	18.267 f	19.333 gh	19.067 e	75.000 g
	unm . casein	21.600	19.600 ef	21.467 ef	22.133 bc	84.800 ef

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		bcd				
	for. casein	21.533 bcd	21.600 cd	21.600 def	21.000 cd	85.733 ef
	est. casein	22.467 abc	20.267 cd	22.400 bcde	22.600 ab	87.733 def
	dea. casein	19.267 ef	19.467 ef	19.067 ghi	18.400 e	76.200 g
	Control	15.933 g	18.933 ef	17.933 hi	16.333 f	69.133 h

Different letters in the same column indicate presence of statistical differences at the level of $P \leq 0.05$.

Conclusion

This study used chemically modified milk proteins to coat fig fruits to increase the shelf-life and maintain the quality of fig fruit during storage.This study is based on the chemical modification of whey proteins and casein using (formaldehyde, esterification, and deamination) for each of them which leads to change the natural properties of these proteins and using them to coat fig. Generally, the results showed that weight loss and total soluble solid (TSS) in all coating treatments were significantly decreased compared with untreated fig fruits. While the coated fig fruits with whey proteins (modified and unmodified) reduced titratable acidity (TA), carotene content compared with casein (modified and unmodified) and control. On the other hand, polyphenol oxidase activity increased in the fruits coated with whey proteins in comparison with casein and control. This means that coating with whey proteins (modified and unmodified) caused delay the ripening of fig fruits better than other treatments. Moreover, all coated treatments of fig fruits exhibited higher sensory evaluation score of each (color, texture, brightness, and overall acceptability) in comparison with control treatment. Regarding the storage period “Koija” fig fruits, prolonging storage periods increased weight loss, TSS, TA, carotene, while the polyphenol oxidase activity was decreased. Also, the sensory evaluation of each (color, taste, texture, brightness, and overall acceptability) decreased with an increased storage period.

Recommendation

Using edible natural materials as a coating material instead of chemicals in fruit packaging to extend the shelf life of fruits. Studying the effect of coating using a chemical modification of milk

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proteins on the microbiological properties of fruits. Studying the effect of the coating materials prepared in this study on the properties of different fruits, and vegetables. Modification of milk proteins with cross-linking enzymes like Transglutaminase and studying their properties as coating materials for other kinds of food products.

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