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Novel in Nano-Edible Films Applications in the Production of High-Quality Dates Al Hulwah and Soukari for Export

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Abstract

The aim of this study was to improve the quality of Al Hulwah" and Soukari dates by using edible coatings and films that have a high potential to carry active ingredients such as nano materials. The substances used in this experiment were: control: without treatment, T1: $AgNO_3$/ZnONPs at 0.5% (0.015%) and 0.03 wt% of chitosan/gelatin, T2: 0.5% (0.015%)/(0.03) wt% chitosan/gelatin chitosan/gelatin combined with phenolic compound active Luria leaves extract LLE (0.15%). T3: $AgNO_3$/ZnONPs 0.5% (0.015%)/0.03 wt% chitosan/gelatin combined with active phenolic compound Thyme Leaves Extract TLE (0.15%). T4: $AgNO_3$/ZnONPs 0.5% (0.015%) or (0.03) chitosan/gelatin weight percent combined with phenolic compound active Green Coffee Extract GCE, 5% (0.15%). The effect of edible coating on fruit quality attributes, including alhulwuh and soukari dates, was investigated during storage at 2 - 4°C and 70 - 75% relative humidity. The rheological properties of edible solutions and suspensions were studied. Mechanical properties, particle size distribution, zeta potential emulsions, and scanning electron microscopy films were also measured. The results observed that the best samples were edible coatings with nanosuspensions (T2), followed by samples (T3 and T4 as nano materials on quality of Al Hulwah" and Soukari dates. The effect of edible coating on quality attributes of fruits, including alhulwuh and soukari dates, was studied during storage at 2 - 4°C. The rheological properties of edible solutions and suspensions were studied. Different analyses period were determined on coated dates, such as weight loss, total soluble solids, total acidity, microbiological testing, and sensory evaluation tests. In contrast, the nanocoated Al Hulwah and Soukari dates were found to be of high quality when compared to the control and T1. Al Hulwah and Soukari dates dipped in (T2, T3, and T4) solutions reduced weight loss percentage and fruit quality for 6 weeks of storage.

Keywords: *Edible Coating; Physical and Mechanical Properties; Al Hulwah" and Soukari Dates; Nano Materials and Sensory Evaluation*

Introduction

Date palms (*Phoenix dactylifera* L., family Arecaceae) are plants of enormous nutritional, medicinal, and economic value. They are one of the most important crops in arid and semiarid regions of the world, mainly in the Arabian Peninsula, Middle East, and North Africa, where Al Hulwah and Soukari dates are two of the most important date cultivars Peninsula, Middle East, and North Africa, where Al Hulwah and Soukari dates are two of the most important date cultivars. In 2012, cumulative world date fruit production amounted to

7,548,918 metric tonnes (mt). Egypt (1,470,000), Iran (1,066,000), Saudi Arabia (1,050,000), Algeria (789,357), and Iraq (650,000), with Medjool, Deglet Noor, Ajwa, and Barhi varieties leading the international market and already being marketed at higher prices due to their unique qualities [1]. In this study, chitosan and gelatin nanofibers were produced using the electrospinning method, which is a promising method for large-scale manufacturing. Nanoemulsions are colloidal systems that consist of an oil phase dispersed in an aqueous phase, such that each drop of oil is surrounded by a thin interfacial layer made up of emulsifying molecules. The particle size of nanoemulsions ranges from 50 to 500 nm. Two kinds of nanoemulsions are available, depending on the phases: oil/water (o/w) or water/oil (w/o). However, o/w systems are preferred for producing edible coatings since they allow the incorporation of different lipophilic substances with antioxidant and antimicrobial effects into a hydrophilic polymeric matrix. Nanoemulsions are thermodynamically unstable but kinetically stable [2]. Chitosan (CS), a polysaccharide generated by the deacetylation of chitin due to its good film formation, antibacterial activity, antioxidant activity, and degradability, is widely used in food packaging. However, as the production process needs to add acetic acid to dissolve chitosan, the cost of such packaging materials becomes high, leading to a low practical application value. Therefore, we can modify chitosan using carboxymethyl. Carboxymethyl chitosan (CMCS) is a water-soluble chitosan derivative. It can compensate for the poor water solubility of chitosan. CMCS is also an amphoteric polysaccharide due to its good solubility in acidic or alkaline environments. CMCS has been widely studied in biomedicine, food packaging, cosmetics, and other fields due to its film-forming properties, water solubility, and antibacterial [3]. However, better water solubility is not conducive to its application in the field of food packaging. It is necessary to improve the water insolubility of CMCS in specific potential applications to expand its application fields. Nanoencapsulation technology is currently being studied extensively. Compared with traditional packaging, nano-packaging technology can improve the stability of materials in terms of such things as thermal stability, specific surface area, and mechanical properties. It also has a high specific surface area, good chemical stability, and is nontoxic. by adding nanometer-sized zinc oxide to biopolymeric materials. The water insolubility and mechanical properties of the composite film can be improved. Therefore, nanozinc oxide has been widely used to prepare new, effective, and affordable nano-packaging materials with biological polymers such as chitosan and fish skin gelatin [4]. Because of their ability to survive in harsh environments, zinc particles, particularly zinc oxide (ZnO), are being widely proposed to be used as antimicrobial agents with a broad range of other applications due to their broad spectrum of other uses. The antimicrobial activity of zinc oxide (ZnO) particles was proposed due to the emission of zinc ions (Zn^{2+}), which are able to penetrate the bacteria's cell wall and affect the cytoplasmic content in the cell, leading to the death of bacteria. The incorporation of zinc oxide nanoparticles into gelatin was observed by [5]. which revealed that the film showed a higher inhibitory effect against gram-negative bacteria (*Pseudomonas aeruginosa*) than gram-positive (*Enterococcus faecalis*) bacteria. The findings supported the hypothesis that ZnO induced a photocatalytic mechanism due to its semi-conductive properties, resulting in the formation of reactive oxygen species (ROS) and H_2O_2, which damage the cell wall structure of bacteria [6]. The objectives of this study were: Study the applications of nano edibles films to improve quality attribute to prolong shelf life of some varieties of date palm Al Hulwah and Soukari by use of treatments control, T1, T2, T3 and T4 have been done to them the as an edible film of prepared chitosan/gelatin- nano edible coating and films in retardation of deterioration of date palm Al Hulwah and Soukari by extending postharvest life. Examine the change in weight loss, total soluble solids (TSS%), acidity, total sugars, reducing sugars, sensory evaluation, microbial count of coated Al Hulwah and Soukari with storage time. Develop a mathematical model for moisture of Al Hulwah and Soukari during storage.

Materials and Methods

Materials

This study was conducted during the growing season of 2021, where a comparison was made between two local Arab date palm cultivars, "Al Hulwah" and "Soukari," which were obtained from the Tabuk market in the Kingdom of Saudi Arabia. These date palms were physicochemically analysed by the researchers of the Department of Nutrition and Food Sciences, College of Home Economics, University of Tabuk, Kingdom of Saudi Arabia. The effect of different post-harvest treatments on the quality of fruits was studied. Preparation of Thyme Leaf Extract TLE, Green Coffee Bean Extract GCE, and Laurea Leaf Extract: The plant material (20g for each sample) was soaked for 6 hours in solvents (ethanol and methanol: water, 80:20 v/v) (200 mL) with tropical shaking in a separate water bath, then Filter the residue through Whitman No. 1 filter paper and re-extract the residue twice with the same fresh solvent and compound extracts. Solvents were removed under reduced pressure at 45°C using a rotary evaporator. (0.5 ml) is extracted from the crude phenolic compound extract and mixed with (4.5%) glacial acetic acid before being soaked for an hour at room temperature in a dark place at [7]. The substances used in this experiment were chitosan and calcium hypochlorite, obtained from El Nasr Pharmaceutical Chemical Company, Cairo, Egypt. Glycerol, glacial acetic acid gelatin, ZnONPs, and $AgNO_3$NPs were obtained from Arkan Development Co., Ltd., Riyadh, Kingdom of Saudi Arabia.

Preparation of different treatments

Al Hulwah and Soukari date palms were stored overnight at 2 - 4°C and 70 - 75% RH. On the next day, the fruits of date palms Al Hulwah and Soukari were washed with tap water and then immersed for 1 minute in a disinfectant solution of calcium hypochlorite (0.25 g/L distilled water) and air dried. The fruits were divided into five treatments as follows:

- Control: Without treatment.
- T1: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin.
- T2: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin combined with phenolic compound active Luria leaves extract LLE (0.15%).
- T3: $AgNO_3$/ZnONPs 0.5% (0.015%)/0.03 wt% of chitosan/gelatin combined with phenolic compound active Thyme Leaves Extract TLE (0.15%).
- T4: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin combined with phenolic compound active Green Coffee Extract GCE, 5% (0.15%).

The dipping period for each treatment was one minute. Date palm Al Hulwah and Soukari were dried after dipping and packaged in plastic trays, with approximately 1 kg of Al Hulwah and Soukari per tray. Each treatment contained 8 trays, and each tray was considered one replicate. Each treatment (500 gram/ trays) was packed in one cartoon box. After that, all boxes were stored at 2 - 4°C and 70 - 75% RH for 45 days and kept in carton boxes, where all samples were kept after packaging. The cooled storage was carried out in the post-harvest at the Department of Nutrition and Food Sciences-College of Home Economics-University of Tabuk, Kingdom of Saudi Arabia. During the storage period, samples of the investigated fruit date palms, Al Hulwah and Soukari, were periodically withheld for analysis.

Preparation of the edible composite film nanoparticles

Preparation of coating solutions of chitosan and gelatin, respectively. Chitosan powder was added in 1.5%/2% (w/v) acetic acid with constant blending at room temperature to obtain a uniform 1% (w/v) chitosan solution. 1.5% (w/v) gelatin solution was prepared by dissolving gelatin in distilled water. The gelatin solution was allowed to swell completely by blending at 7°C for 15 minutes and warmed to 55°C for 30 minutes. Four groups of coating solutions were formulated. The chitosan and gelatin solutions were blended mixing and homogenizer together with constant agitating at 60°C for 10 minutes. Subsequently, $AgNO_3$/ZnONPs with phenolic compound active Luria leaves Extract LLE, Thyme Leaves Extract TLE, and Green Coffee Extract GCE at a level of 5% (0.15%) (v/v), was added to the cooled coating solution and completely blended. The eventual coating solution was obtained by adjusting its pH to 5.6 ± 0.1 using sodium bicarbonate. The homogenised mixture was ultrasonicated for 20 minutes to remove air bubbles formed during agitation. Film-forming solutions were poured into a plates. All of the films were dried at 50°C [8]. The substances used in this experiment on edible natural films were divided into four groups for the modification of matrix composition of the studied edible natural films: In this trial, the described film formation solution mentioned above was modified by adding and dividing into four equal parts: One part was film-forming on based

T1: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin, second part was film-forming T2: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin combined with phenolic compound active Luria leaves Extract LLE, 5% (0.15%), and the third part was film-forming T3: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/Gelatin combined with phenolic compound active thyme leaves extract TLE, 5% (0.15%), four part was film-forming based on T4: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/Gelatin combined with phenolic compound active green coffee extract GCE, 5% (0.15%).

Films components %					
Film code	**Chitosan/Gelatin**	**Glacial acetic acid**	**Glycerol**	**5% (0.15%)**	**Film cod $AgNO_3$/ZnONPs**
Control:	Without Treatment				
T1	1.5%/1.5%	1.5 ml	0.9	-	0.5% (0.015%)
T2	1.5%/1.5%	1.5 ml	0.9	Luria leaves Extract (0.15%)	0.5% (0.015%)
T3	1.5%/1.5%	1.5 ml	0.9	Thyme Leaves Extract (0.15%)	0.5% (0.015%)
T4	1.5%/1.5%	1.5 ml	0.9	Green Coffee Extract (0.15%)	0.5% (0.015%)

Table 1: *Show up the formulas for nano edible coating & film of prepared chitosan/gelatin combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible coating and films.*

Control: Without treatment.
T1: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin.
T2: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin combined with phenolic compound active Luria leaves extract LLE (0.15%).
T3: $AgNO_3$/ZnONPs 0.5% (0.015%)/0.03 wt% of chitosan/gelatin combined with phenolic compound active Thyme Leaves Extract TLE (0.15%).
T4: $AgNO_3$/ZnONPs 0.5% (0.015%)/(0.03) wt% of chitosan/gelatin combined with phenolic compound active Green Coffee Extract GCE, 5% (0.15%).

Prepared nanotechnology physical, mechanical, and rheological properties on edible films:

1. **Rheological measurements:** The rheological parameters (shear rate and shear stress) of the selected edible natural films were measured using a Brookfield Engineering labs DV-III Rheometer solutions at room temperature. The samples were placed in a small sample adapter and a constant temperature water bath was used to maintain the desired temperature. The viscometer was operated between 10 and 60 rpm. The sc4-25 spindle was selected for the measurement.

2. **Zeta-sizer nano Company name:** Malvern, UK. Zeta Sizer Nano Series (Nano ZS) model. The size range (nm) is 0.6 to 6000 nm. XR-Diffraction. Model:XPERT-PRO-PANalytical-Netherland.

3. **Scanning electron microscopy measurements of prepared edible films by:** INSPECT S- SEM schematic overview-TM 1999-2007 Bwildate, FEL company Euld number D 8571, Machine type inspect S [9].

4. **Film thickness:** The thickness of the prepared edible natural films from chitosan/gelatin nano particles T1, T2, T3 and T4 was measured using a digital micrometer (mitutoyo digimatic indicator corporation, model: pk-1012 E, Japan). Film strips were placed between the micrometer jaws and gap and was slowly reduced until the first contact was noted [10].

5. **% solubility in water:** The film nanoparticles at different treatments T1, T2, T3, and T4 specimens were first dried in a desiccator containing dry calcium chloride. Dry film samples of 500 mg were immersed in beakers containing 50 ml of distilled water at

room temperature for 24 hours with a periodic gentle shaker incubator. Films were removed from the water and placed back in the desiccator until a constant weight was achieved. Loss of weight in water was reported as a percentage of weight loss in water on a dry film basis as follows: According to [11]. % weight loss = initial dry weight - final dry weight *100/initial dry weight. according to Hernandez (2004).

6. **Mechanical properties of prepared nanotechnology on edible films:** Measurement of T1, T2, T3, and T4 nanoparticle films: the tensile properties (tensile strength, elongation) were measured by a texture analyzer CT3. The films' nanoparticles received different treatments (T1, T2, T3, and T4) and were cut into 35-cm-long strips. These were gripped at each end by a jaw, and the jaws were moved at a controlled speed until the young's modulus was automatically recorded, as described in [12].

7. **Measurements of water vapour permeability (WVP):** The ASTM Method E96-95 was used to determine the gravimetric water vapour transmission rate [g/(s.m^2)] and water vapour permeability through films. A circular test cup was used to determine the WVP of the films' nanoparticles at different treatments (T1, T2, T3, and T4). The film was first cut into a circular shape that was larger than the inner diameter of the cup. The cup was filled with 50% distilled water, and the film was sealed at the top using paraffin oil. Then the cups were placed in a desiccator containing calcium chloride. The weights of the cups were recorded every hour for 10 hours, and specimens of each film were tested. Linear regression was used to estimate the slope of this line in g/h. The water vapour transmission rate (WVTR) and water vapour permeability were determined using the following: WVPR = WVP = WVPR/L Where is the moisture gain weight per time unit (g/s), A is the surface area of the film (m^2), L is the film thickness (mm), and is the difference in relative humidity (ASTM E96-95).

8. **Measurement of gas permeability**: Gas (O_2 and CO_2) permeability at 30°C was measured in a designed stainless cell using a gas testing instrument, the model Witt Oxybaby headspace gas analyzer (O_2/CO_2), following the method described by Garcia., *et al*. (2000). The gas permeability (P) was calculated according to the following equation: P = Q.X/A.t.p. where P is the permeability of gas (m^3/m. day. mmHg), Q is the quantity of gas diffused per m^3, X is the thickness of the film, m2 is the area of the film, t is the time of day, and p is the pressure difference across the film nanoparticles at different treatment levels (T1, T2, T3, and T4).

9. **IR ATR-FTIR measurements:** Were taken with a Bruker VERTEX 80 (Germany) combined Platinum Diamond ATR, which includes a diamond disc as an internal reflector in the range. 4000 - 400 cm^{-1} with a resolution of 4 cm^{-1} and a refractive index of 2.4.

Physical and chemical properties:

1. **Chemical analysis:** Weight loss, total soluble solids (TSS%), acidity, total sugars, and reducing sugars were determined according to the methods of the [13].

2. **Color measurement:** Internal colour measurements L and A value of the film nanoparticles at different Treatments T1, T2, T3, and T4 were measured using a Minolta chroma metre, Model CR - 200. Calibration was done on a white plate before use. Color changes were quantified for the L value, which refers to the lightness, and the A value, which refers to the yellow [14].

3. **Microbial analysis:** The total microbiological count was determined according to [15]. All the microbiological counts were carried out in duplicate:

    1. **Total plate count:** The total colonies of bacteria were estimated using plate count agar medium. The plates were incubated at 37°C for 48 hours.

    2. **Psychrophilic bacterial:** The total colonies of bacteria were estimated using plate count agar medium. The plates were incubated at 4ºC for 5 days.

3. **Moulds and yeasts count:** The mould and yeast were determined using the methods for the microbiological examination of foods described by the American Public Health Association [16] by using malt extract agar medium. The plates were incubated at 25ºC for 5 days.

4. **Sensory evaluation:** Different products of alhulwuh and Soukari dates preserve were sensory evaluation as reported by [17]. The products were presented to well trained ten members of staff from the Department of Nutrition and Food Sciences-College of Home Economics-University of Tabuk, Kingdom of Saudi Arabia for sensory evaluation. The panelists were a skid for their decision concerning, color, texture, taste and overall acceptability. The following scale was applied for samples under investigation 9 - 10 equal excellent, 6 - 8 equal good 3 - 5 equal poor and 0 - 2 equal refused. So the score 6 was considered as the limit of acceptability.

5. **Statistical analysi**s: The collected data were subjected to statistical analysis with the MSTAT statistical software. The mean values were compared using the LSD method at a 5% level. The data were tabulated and statistically analysed using completely random factorial analyses [18].

Results and Discussion

Rheological properties of prepared chitosan/gelatin nanoedible coating and film solutions incorporated with AgNO3/ZnONPs and phenolic compound actives to produce edible coating and films

The study prepared measurements of rheological properties such as shear rate, shear stress, and viscosity of samples on chitosan/gelatin nanoedible films and coatings at different treatments T1, T2, T3, and T4 and different shear rates (13.2, 26.4, 39.6, 52.8,52.8 66.00, and 79.2 1/s. Figure 1 and 2 and table 2). The results show that the forming solution exhibits a trend of non-Newtonian pseudoplastic behaviour at different treatments (T1, T2, T3, and T4) and fits the power law equation $\tau=k\gamma^n$ → (1) Where: τ: shear stress, Pa γ: shear rate 1/sec, k: consistency index n: flow behavior index. The results in the table and figure indicated a relationship between shear rate, apparent viscosity, and shear stress for different samples. Explains why the k (consistency index) for T1, T2, T3, and T4 is the same. With the exception of T4 (0.152), all samples exhibited pseudoplastic behavior. Moreover, it was found that the n 1 flow behaviour index indicated that the fluid had the pseudoplastic behaviour of nanoscale $AgNO_3$/ZnONPs edible films and coatings. Treatments T2, T3, and T4 all produce edible film and coatings to create edible film-forming suspension solutions, and their consistency index is higher than that of sample T1, which had a consistency index of 0.1335. The flow behaviour index increased with increasing concentration, except for the decreased T4 (0.406) of nanoscale $AgNO_3$/ZnONPs edible films and coatings. It shows that all samples behave as non-Newtonian pseudoplastic, and constitutive equations are necessary to provide the required material parameters by controlling the process, rate of shear stress, and properties of mixtures of chitosan components and to determine the relationship between shear time and viscosity for mixing components. Because materials and time depend on mixing, the viscosity decreases continuously over time, which means that when the material is cut, it causes disruption of the collected particles and therefore provides less resistance to flow and decreases the viscosity over time until the values are stable. Occured results worked on data for the decomposition of shear stress in different treatments and with different concentrations of nanomaterials with chitosan, where it was found that the shear stress variation with shear time was fitted [19].

Treatments	Viscosity			Shear stress		
	K	N	R^2	K	N	R^2
Produced edible film of prepared chitosan/gelatin nano edible coating and films solution combined with $AgNO_3$/ZnONPs to produce edible coating and films						
T1	0.1335	0.316	0.8852	0.1076	0.8014	0.9778
T2	0.1398	0.416	0.904	0.1205	0.7288	0.9832
T3	0.175	0.514	0.9859	0.0277	0.9633	0.9941
T4	0.152	0.406	0.8969	0.1205	0.7288	0.9832

Table 2: *Relationship between flow behavior index (n) and consistency index (k) at different treatments preparation of prepared chitosan/gelatin nano films solution combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible film-forming suspension solution.*

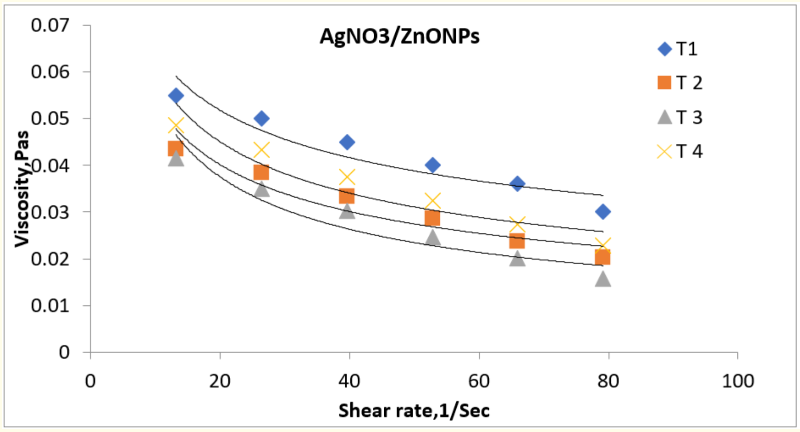


Figure 1: *Shear rate and viscosity of nanoedible film to produce edible film-forming suspension solution at different treatments (T1, T2, T3, and T4). Preparation of prepared chitosan/gelatin nanofilm solutions combined with $AgNO_3$/ZnONPs and phenolic compound actives to produce edible film-forming suspension solution.*

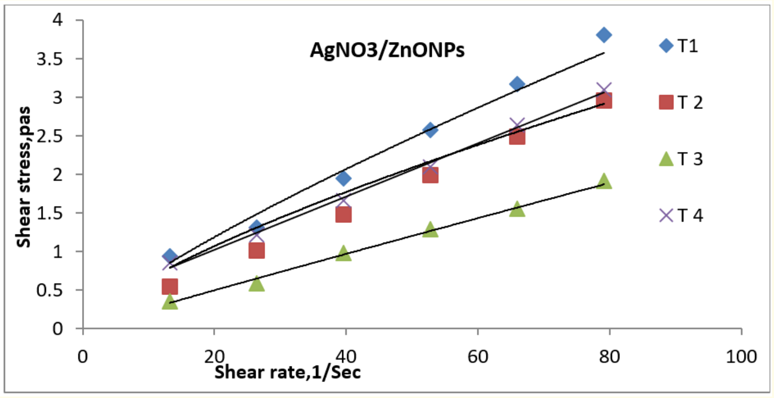


Figure 2: *Shear rate and shear stress of nanoedible film in the production of edible film-forming suspension solution at various treatments (T1, T2, T3, and T4). chitosan/gelatin nanofilm solution combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible film-forming suspension solution.*

Physical and mechanical properties of films

The results shown in table 3 show that the thickness values of chitosan/gelatin nanoedible coatings and films combined with $AgNO_3$/ZnONPs and phenolic compound actives were 174, 125, 129, and 128 um for T1, T2, T3, and T4, respectively. The results indicated that treatment T1 had the highest thickness value, while treatment T4 had the lowest thickness value. Also, it could be observed that the lowest values of tensile strength (58.45 N), elongation (25.62%), oxygen (27.25 $M3/M^2/X^{10-7}$), CO2 (20.12 $M3/M^2/X^{10-8}$), water vapour transmission rate (18.87 $g/hr.m^2$), water vapour permeability (0.159 g/m^2/day.mmHg), and solubility (23.18%) were recorded for treatment T4. It also revealed that the T1, T2, and T3 treatments had the lowest tensile strength (65.43, 61.25, and 54.63 N), elongation (39.25, 28.43, and 24.56%), oxygen (43.22, 33.24, and 30.40 M3.M/M2 X^{10-7}), CO2 (36.45, 31.65, and 27.68 M3.M/M2 X^{10-8}), water vapour transmission rates (High film elongation is always a desirable characteristic if the film is to be used for food applications. All the main factors significantly affected the mechanics of the film, as described below. The chitosan film had an 18% higher elongation than the chitosan film, and in addition to the incorporation of thymol, this reduced the chitosan layer [20,21].

Treatments	Thickness Um	Tensile strength N	Elongation %	O_2 M³.M/M²×10⁻⁷day.mmHg	Co_2 M³.M/M²×10⁻⁸day.mmHg	Water vapors Transmission rate, g/hr.m²	Water vapors g.mm/m².day.mmHg	Solubility in water %
T1	174	65.43	39.25	43.22	36.45	39.65	0.167	35.30
T2	125	61.25	28.43	33.24	31.65	27.64	0.139	30.23
T3	129	54.63	24.56	30.40	27.68	22.67	0.149	28.34
T4	128	58.45	25.62	27.25	20.12	18.87	0.159	23.18

Table 3: *Mechanical properties, permeability and thickness of prepared chitosan/gelatin nano edible coating and films solution combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible coating and films.*

Determination of particles size and zeta potential of nanotechnology of prepared chitosan/gelatin nano edible coating and films solution combined with AgNO3/ZnONPs and phenolic compound active to produce edible coating and films solution formed from it:

1. **Partical size distribution:** The obtained results are presented in table 4 and figure 3. It is shown that the addition of $AgNO_3$ nanomaterials, ZnONPs, and phenolic compounds has an effective effect on the dispersion properties of the film and coating emulsions, which were evaluated based on the change in the size distribution of the nanoparticles with respect to the coating and film emulsion sample. These values were 0.756, 0.758, and 0.360 for T2, T3, and T4 based on the change in the polydispersion index (suspended particles with zeta potentials higher than +30 or less than -30 mV repel each other because they are considered stable, but if the potential zeta is between +30 and -30 mV, they tend to attract each other [22,23].

2. **Zeta potential:** From the results of the analysis in table 4 and figure 4, In the treatments T1, T2, T3, and T4 of the zeta potential of nanotechnology of prepared chitosan/gelatin nano edible coating and films solution combined with $AgNO_3$/ZnONPs and phenolic compound actives to produce edible coating and films solution, it was discovered that the sizes of the active phenolic compounds, the oil distribution, and the deviation of the extracted oil and nanoparticles depend on the size of the plant nanoparticles. The zeta potential distribution and zeta deviation (mV) for the treatment at the peak were 50.70, 7.64, 6.98, and 6.42, 2.90, and 4.13, respectively, when compared to the initial control samples Tl, 1 zeta potential of 57.7 and zeta deviation (mV) of 5.48 (mV).The zeta potential is an important indicator of surface charges because it measures the electric charge at the colloidal particle boundary. The higher the zeta potential, the better the dispersion stability. Desirable zeta potentials can be obtained by [24,25].

Treatments	Particle size distribution(nm)		Zeta potential(mv)	
	Poly Dispersity indexs Pdi	Hydrodynamic Diameter nm	Z-Potential	Z- Devition
Produced edible film of prepared chitosan/gelatin nano edible coating and films solution combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible coating and films				
T1	0.417	1123	57.7	5.48
T2	0.756	12.52	50.70	6.42
T3	0.758	49.19	7.64	2.90
T4	0. 360	191.5	6.98	4.13

Table 4: *Measured particles size and zeta potential of nanotechnology of prepared chitosan/gelatin nano edible coating and films solution combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible coating and films solution formed from it.*

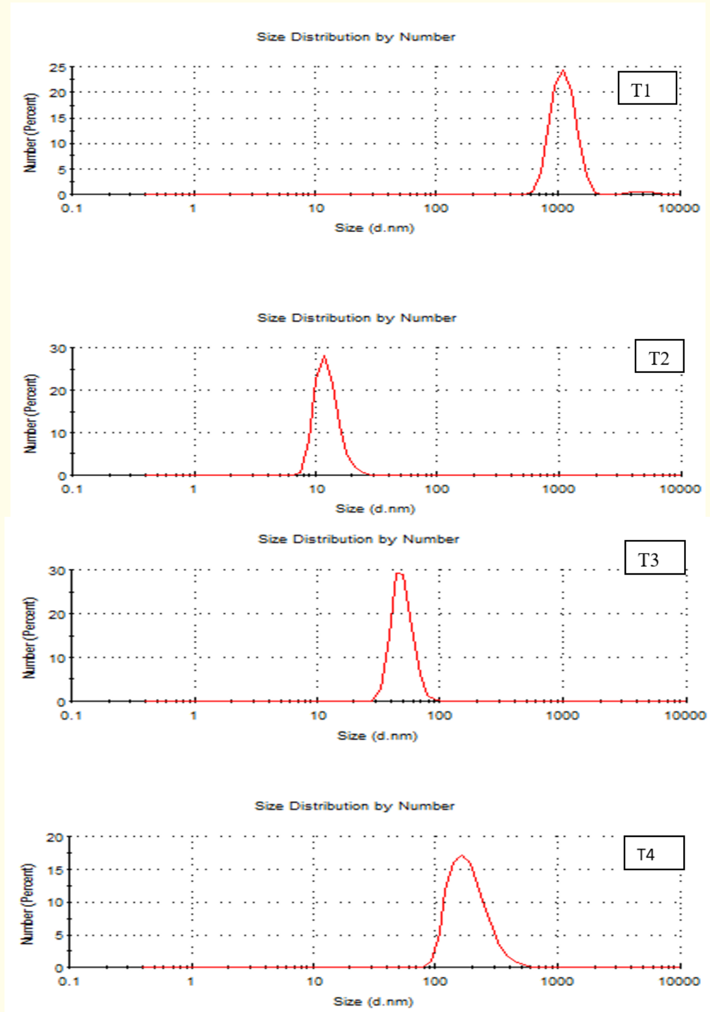
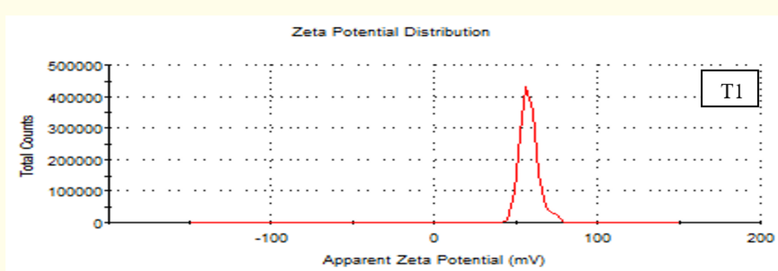


Figure 3: *Particle size of prepared nano edible coating and films combined with $AgNO_3$/ZnONPs, and phenolic compound active to produce edible film-forming suspension solution of different treatments.*



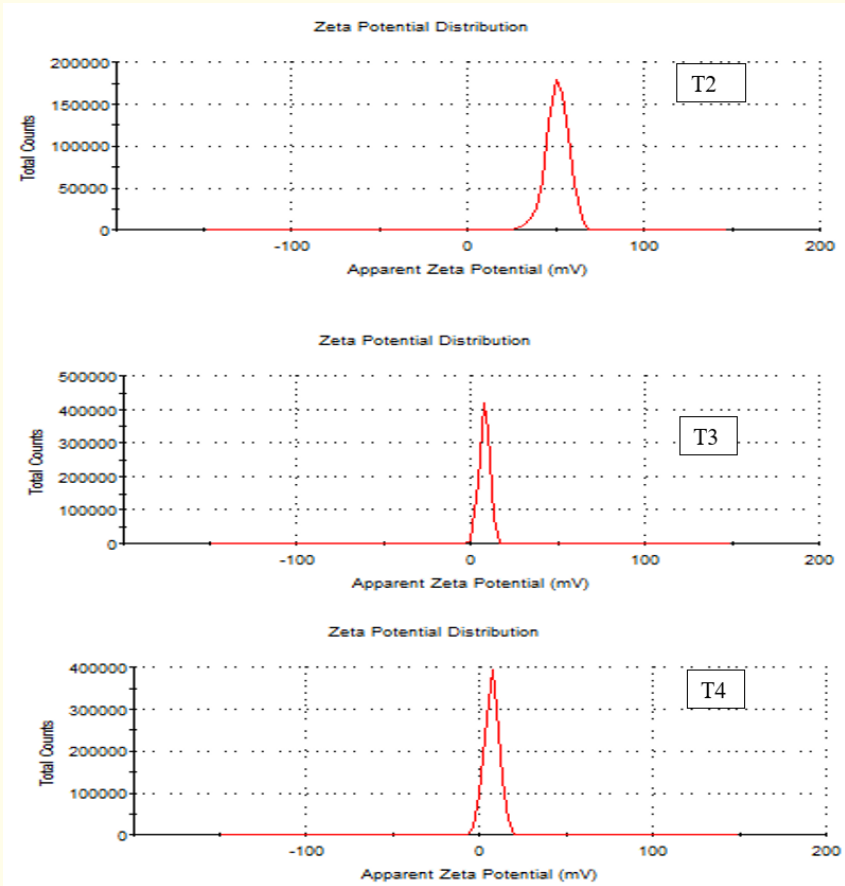


Figure 4: *Zeta potential of prepared nano edible coating and films combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible film-forming suspension solution of different treatments.*

Determination of color apparent and transmittance light transmittance of prepared chitosan/gelatin nano edible coating and films combined with AgNO3/ZnONPs and phenolic compound active to produce edible films

The results obtained are presented in table 5 and figure 5 and 6. From the curves illustrated in figure 1, it is clear that the apparent colour decreased with increasing concentration (exception b) at different treatments (T1, T2, T3, and T4). It was also observed that treatment T2 was higher than the following treatments, T3 and T4. The treatments also had higher apparent colour values: T1 was 81.48, 8.75, 12.75, and 3.31 for L, a, b, and E, respectively, while T3 was 79.11, 2.90, 17.34, and 3.39 for L, a, b, and E, respectively, as compared to T1 for L, a, b, and E of 83.20, 0.74, 7.02, and 9.23.On the other hand, the barrier and transparency of the films were evaluated by measuring the percent light transmittance at T550, 430, and 395 nm, respectively. Light transmittance at 550 nm was found to be higher in T2 (86.1), followed by T4 (85.1), when compared to T1. While it was found that the light transmittance measured at 430nm was higher in T4 (79.5), followed by T177.9, as compared to T1, it was lower at 64.5. It was also observed that the light transmittance measured at 395nm was higher in T3 (72.3), followed by T2 (67.7), compared to T1. according to [9,26-28].

Films	L	a	b	ΔE	T550 nm	T430 nm	T395 nm
T1	83.20	0.74	7.02	9.23	77.3	64.5	56.4
T2	81.48	8.75	12.75	3.31	86.1	77.9	67.7
T3	81.12	1.68	12.65	2.31	79.3	72.9	66.1
T4	79.11	2.90	17.34	3.39	85.1	79.5	72.3

***Table 5**: Measured of color apparent and transmittance light transmittance of prepared chitosan/gelatin nano edible coating and films combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible films.*

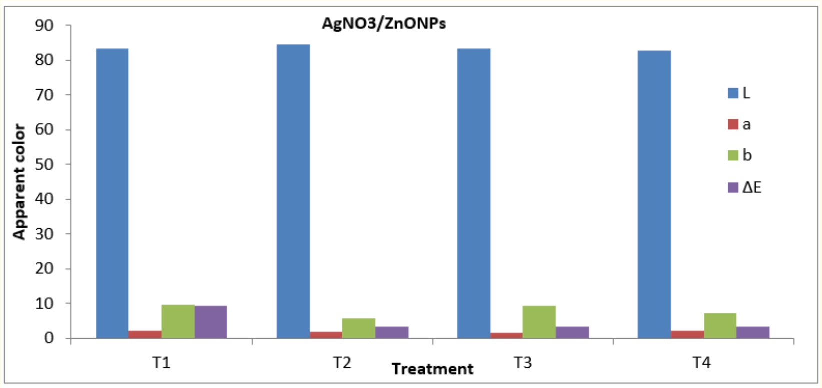


***Figure 5:** Measured of apparent color (Minolta Chroma) of the edible films prepared nano edible coating and films solution combined with $AgNO_3$/ZnONPs and phenolic compound active on edible films at different treatments.*

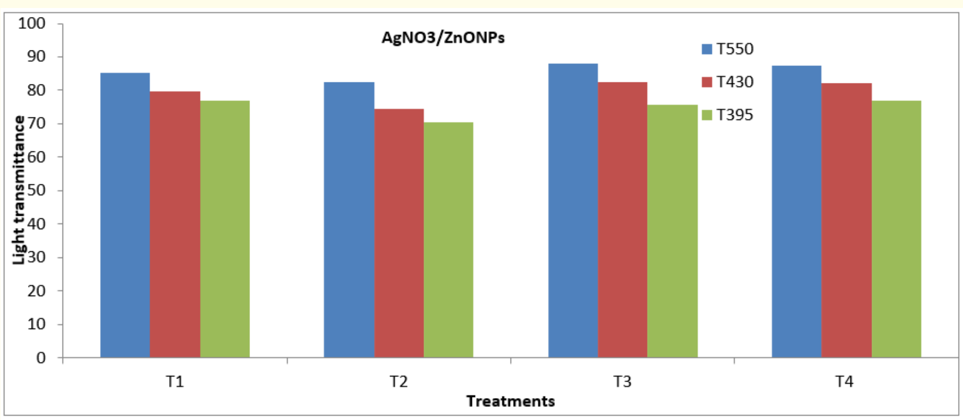


***Figure 6:** Measured of Light transmittance of the edible films prepared nano edible coating and films solution combined with $AgNO_3$/ ZnONPs and phenolic compound active on edible films at different treatments.*

Scanning electron microscopy (SEM) microstructure of prepared nano edible coatings and films combined with AgNO3/ZnONPs and phenolic compound active to produce edible films

There are four microscopic images of nanoedible coatings and films combined with $AgNO_3$/ZnONPs and phenolic compound actives to produce edible films. After taking the cross-section, the morphology of the surface was investigated using SEM images (Figure 7), and the surface roughness was estimated using nanoedible coatings and films. The SEM images showed that the edible films were intact and smooth without any noticeable delamination on the surface, which was found to rise with increasing concentration upon different treatments. In the figure, prepared nano-edible coatings and films combined with $AgNO_3$/ZnONPs/GCE to produce edible films (T1, T2, T3, and T4) are shown. It was found that T1, a 0% treatment, has cracks in the edible film due to poor treatment that does not contain $AgNO_3$/ZnONPs. In general, the edible film is composed of a homogeneous solution with some compact fine grains and an intact smooth crystal morphology in a continuous matrix. It can be concluded that these studies are useful for learning about the microstructure and membrane morphology, which can help in selecting the edible nanofilm formulas for coating and packing. Our results are in agreement with those obtained by [29]. SEM images found that the elegant CMC film was smooth and intact without any deformation, and the surface was clear. The surface roughness of the films supplemented with grape seed extract was slightly increased, as confirmed by the higher surface roughness of the CMC/grape seed extract film compared to the elegant CMC film [3,9].

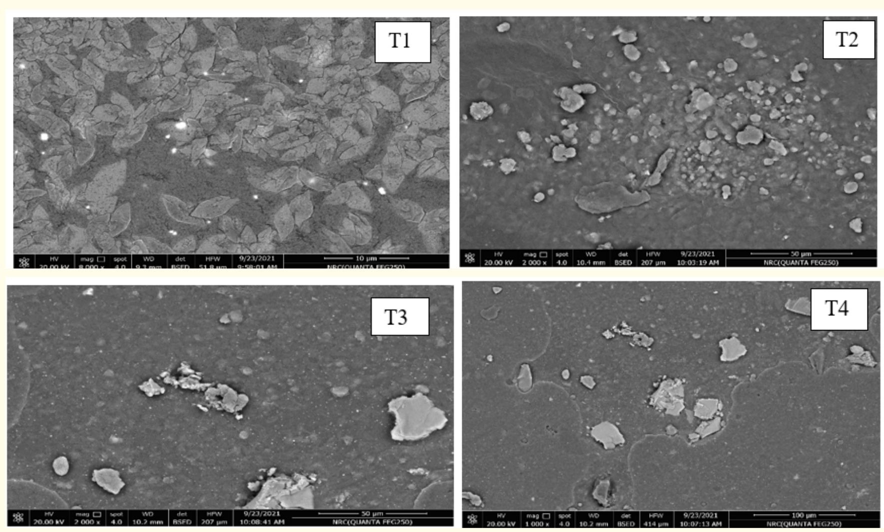


Figure 7: *Microstructure of nano edible coatings and films combined with $AgNO_3$/ZnONPs and phenolic compound active to produce edible films using scanning electron microscopy (SEM) technology using scanning electron microscopy (SEM) at different treatments.*

FTIR analysis of prepared chitosan/gelatin nano edible coatings and films, which were combined with AgNO3/ZnONPs and phenolic compounds to produce edible films

The FTIR measurements of biosynthesized silver nanoparticles were carried out to identify the possible interaction between $AgNO_3$/ZnONPs and phenolic compounds active in producing edible films responsible for the formation and stabilisation of nanoparticles. Results of FTIR measurements showed transmittance peaks located at about 3000 cm^{-1}, 1750 cm^{-1}, and 1050 cm^{-1} (Figure 8). From the spectrum, the major peak was assigned at 3250 cm^{-1}, which indicates OH stretching in alcohols and phenolic compounds [30]. The absorption peak at 1700 cm^{-1} is assigned to the amide I bond of chitosan and gelatin arising due to carbonyl stretch in proteins that are present in leaf extract. The absorption peak at 1750 cm^{-1} is close to that reported for native proteins**.** This evidence suggests that chitosan and gelatin are interacting with biosynthesized nanoparticles and that their secondary structures were not affected during the reaction with Ag^+ ions or after binding with Ag nanoparticles [31]. A small peak at 1650 cm^{-1} is assigned to the NH/Zno stretch mode and was found to be enhanced when compared with the FTIR spectrum of leaf extract.

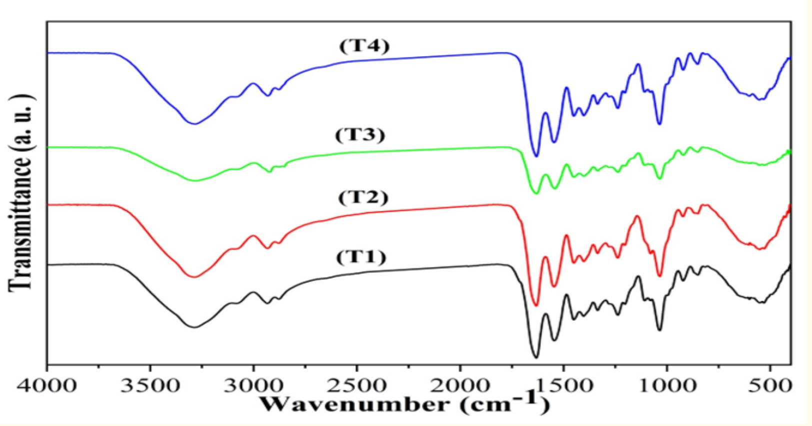


Figure 8: *FTIR spectrum of AgNO$_3$/ZnONPs and phenolic compound active to produce edible films.*

Physico-chemical and microbiological properties of nano edible film and coated Al Hulwah and Soukari dates during storage period

Weight loss percentage

Table 6 shows that the treatments (control, T1, T2, T3, and T4) increased the values of weight loss with increasing the storage period at cooled temperatures, and that the percentage of loss increased in the control and T1. It was also found that the treatments T2, T3, and T4 were low in percentage weight loss compared to other treatments. As noted, the values of the losses are increasing gradually with treatments (control**,** T1, T2, T3, and T4). Edible coating application results in reducing weight loss because it has semi-permeable properties, which led to extending shelf life by reducing moisture and solute migration, respiration, and oxidative reaction rates, as well as suppressing physiological disorders on fresh-cut fruits, as reported by [32].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	2.36	1.81	1.42	1.32	1.77	0.81	1.18	1.08	0.66	0.71
2	3.95	2.49	3.64	1.86	2.34	1.53	2.41	1.53	1.23	1.47
3	5.96	3.79	4.43	2.46	3.39	2.46	3.33	1.88	2.07	2.16
4	8.04	4.91	4.89	3.33	4.80	2.97	4.53	2.29	2.65	3.05
5	9.41	5.35	5.22	4.41	5.07	3.43	5.07	3.07	3.42	3.31
6	10.75	5.83	5.77	5.47	5.40	3.94	5.27	3.73	3.81	3.77
LSD	S = 1.876 T = 1.805 S&T = 0.264					S = 1.986 T = 1.864 S&T = 0.325				

Table 6: *Effect of nano edible film and coatings on weight loss (%) of Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Total soluble solids (TSS)

In general, there was a gradual increase in total soluble solids (TSS) during the complete storage period at chilled temperatures (Table 7), but the TSS was reduced in control as compared to other treatments. As noted, the values increased gradually with treatments (control, T1, T2, T3, and T4). The total soluble solids significantly ($p < 0.05$) increased with storage time in all treatments, with the exception of fruit covered with the bilayer film, which had no significant change with time. The foam tray wrapped with PVC film showed a small increase in total soluble solids and had higher total soluble solids and slightly advanced starch breakdown [33,34].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	36.40	36.70	36.10	36.90	36.20	48.10	49.30	50.60	51.40	49.90
1	38.10	38.30	37.60	38.20	38.50	49.50	51.20	51.70	52.60	51.20
2	39.40	39.90	39.10	39.80	39.90	50.30	52.50	52.90	54.30	52.60
3	40.60	40.50	40.00	41.30	41.80	51.60	53.80	54.60	55.70	54.80
4	41.50	40.20	41.80	43.50	43.70	52.90	54.70	55.10	56.80	55.70
5	42.30	43.10	42.60	44.80	44.30	53.40	55.60	56.50	57.20	56.60
6	42.90	43.70	44.70	45.8	45.40	54.60	56.30	56.60	57.40	57.90
LSD	S = 1.731 T = 1.675 S&T = 0.167					S = 1.873 T = 1.764 S&T = 0.194				

Table 7: *Effect of nano edible film and coatings on TSS of Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Total acidity

The total acidity of Al Hulwah and Soukari dates changed during storage at cool temperatures. The obtained results are recorded in table 8. The results showed that as the storage period at cooled temperature increased, the total acidity decreased gradually. It is also considered that coatings reduce the rate of respiration and may therefore delay the utilisation of organic acids [33,35] agree. However, the decrease in acidity during storage demonstrated fruit senescence. The same authors outlined that coatings may slow the changes in pH and titratable acidity and effectively delay fruit senescence. This was probably because the semi-permeability of coating films formed on the surface of the fruit might have modified the internal atmosphere, i.e. the endogenous CO_2 and O_2 concentration of the fruit, thus retarding the ripening process [32].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	0.14	0.15	0.16	0.17	0.16	0.20	0.21	0.22	0.23	0.21
1	0.14	0.15	0.16	0.17	0.16	0.19	0.20	0.21	0.22	0.20
2	0.13	0.14	0.15	0.16	0.15	0.18	0.19	0.21	0.22	0.20
3	0.12	0.14	0.15	0.16	0.15	0.17	0.19	0.20	0.21	0.19
4	0.11	0.13	0.15	0.15	0.14	0.16	0.18	0.20	0.21	0.19
5	0.10	0.12	0.14	0.14	0.14	0.15	0.17	0.20	0.21	0.18
6	0.09	0.11	0.14	0.13	0.13	0.15	0.16	0.19	0.20	0.18
LSD	S = 1.893 T = 1.643 S&T = 0.172					S = 1.963 T = 1.784 S&T = 0.195				

Table 8: *Effect of nano edible film and coatings on acidity of Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Total sugar and reducing sugar in Al Hulwah and Soukari dates during storage at 2 - 4ºC

The results obtained in table 9. The total sugar gradually increased with the lengthening of the storage period in both samples kept in packaged plastic trays and in carton boxes. While reducing sugar gradually decreased with increasing storage period, indicating that cooling temperatures encouraged the inversion of fruit starch to simple sugars and thus increased fruit sweetness. The obtained results are consistent with those obtained by Bai., *et al*. (2003), who reported that the total soluble sugar gradually increased in coated fruits during storage temperature; the authors discovered that the total sugar increased with increasing storage [36]. Who found that the total sugar content of all coated, packed and control fruit quality significantly increased " total sugar " fruits were highest in reducing sugars content (47.94%) [32]. This decreasing might be due to consumption of reducing sugars through respiration [35] edible films nanomaterials reduced the reducing sugars loss significantly as compared with the edible films.

Storage period week	**Reducing sugar**									
	Al Hulwah					**Soukari**				
	Treatments					**Treatments**				
	Control	**T1**	**T2**	**T3**	**T4**	**Control**	**T1**	**T2**	**T3**	**T4**
0	42.17	44.61	45.10	43.09	41.68	48.56	49.21	47.49	48.11	48.36
1	41.61	43.70	44.83	42.51	41.23	48.10	48.57	46.71	47.24	47.41
2	40.86	42.81	43.29	41.89	40.76	47.23	47.19	45.23	45.89	45.36
3	39.98	41.63	42.76	41.07	39.57	45.89	45.98	44.69	44.31	44.79
4	38.21	40.98	41.89	40.36	38.13	44.23	44.53	43.59	43.62	43.09
5	37.48	39.42	41.07	39.11	37.97	43.89	43.21	42.10	42.91	42.81
6	36.17	39.09	40.29	38.93	37.68	41.32	42.99	41.56	42.00	42.36
L.S.D	S = 1.489 T = 1.479 S&T = 0.172					S = 1.689 T = 1.572 S&T = 0.189				
Total sugar										
0	45.63	48.31	49.27	47.73	48.54	56.17	57.81	58.24	59.13	57.80
1	46.41	49.27	50.43	48.27	49.16	57.24	58.37	59.03	60.24	58.17
2	47.39	50.61	51.19	49.33	49.91	58.41	59.01	59.84	60.81	59.01
3	48.97	51.49	51.87	50.49	50.39	58.93	59.87	60.17	61.49	59.75
4	49.67	52.84	52.63	51.29	51.65	59.75	60.63	60.87	61.92	60.34
5	50.65	53.24	52.91	51.86	52.09	60.83	61.97	61.09	62.45	60.97
6	51.73	53.61	53.07	52.23	52.64	61.67	62.41	61.64	63.13	61.60
L.S.D	S = 1.841 T = 1.764 S&T = 0.169					S = 1.562 T = 1.491 S&T = 0.147				

***Table 9**: Effect of nano edible film and coatings reducing sugar and total sugar in Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Total count

The results in table 10 showed that the microbial load increased with the increase in storage in all storage treatments, but that the increase in control and T1 was higher than in other treatments. It was also found that the treatments (control**,** T1, T2, T3, and T4) are lower in microbial load than the treatments (T2, T3, and T4). The counts reached 10^1 CFU/g after 12 days of storage in both coated and uncoated samples, as compared with the initial counts ease in control and T1 was higher than in other treatments. It was also found that the treatments (control, T1, T2, T3, and T4) are lower in microbial load than the treatments (T2, T3, and T4). The counts reached 10.89 - 12.0 10^1

CFU/g after 12 days of storage in both coated and uncoated samples, as compared with the initial counts. 0.35 10^{-1} CFU/g: this shows the changes in total bacterial counts of Al Hulwah and Soukari coated with nanomaterials during storage periods at 2 - 4°C. The data show that total counts of different edible films nanomaterial treatments (control, T1, T2, T3, and T4) gradually increased with increasing cold storage period in both Al Hulwah and Soukari. Bacterial counts reached 17.23 and 17.39 x 10^{-1} CFU/g for control and T1 of Al Hulwah and Soukari, respectively, while bacterial counts of Al Hulwah and Soukari coated recorded 12.26 and 12.83 x 10^{-1} CFU/g with T4 and T4 of cold storage, respectively, as compared to the initial counts (2.68 and 1.34 x 10^{-1} CFU/g) of Al Hulwah and Soukari after 6 weeks. which prevents respiration and leads to anaerobic conditions and fruit degradation. Furthermore, the edible coating and film nanoparticle material may have a significant effect on the rate of microbial counts during cooled storage [37].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	4.89	3.20	3.38	2.85	2.68	4.67	2.51	1.97	1.53	1.34
1	6.57	4.16	3.95	3.56	3.25	5.42	3.93	2.39	2.19	2.81
2	8.29	5.29	4.86	4.69	4.42	6.84	4.65	3.85	3.52	3.27
3	10.63	8.17	7.72	7.18	7.09	9.91	7.23	5.27	5.37	5.31
4	13.45	10.86	9.26	9.05	8.21	11.51	9.84	6.79	6.29	7.61
5	14.65	13.43	12.57	11.63	11.74	13.74	12.25	8.92	8.28	9.46
6	17.23	16.24	14.49	12.82	12.26	17.39	14.65	12.64	12.29	12.83
LSD	S = 1.982 T = 1.743 S&T = 0.846					S = 2.310 T = 2.176 S&T = 0.549				

***Table 10:** Effect of nano edible film and coatings on total count of Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Psychrophilic bacterial

Table 11 shows the changes in total bacterial counts of Al Hulwah and Soukari coated with nanomaterials during storage periods at 2 - 4°C. The data show that psychrophilic bacteria increased gradually as the cold storage period was increased in both Al Hulwah and Soukari of different edible films nanomaterial treatments (control, T1, T2, T3, and T4). Bacterial counts reached 10.26 and 11.83 x 10^{-1} CFU/g for control and T1 of Al Hulwah and Soukari, respectively, while bacterial counts of Al Hulwah and Soukari coated with T4 and T4 of cold storage recorded 12.26 and 12.83 x 10^{-1} CFU/g, respectively, as compared to the initial counts (1.23 and 0.39 x 10^{-1} CFU/g) after 6 weeks [37].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	1.23	0.75	0.63	0.59	0.46	0.87	0.39	0.26	0.31	0.38
1	1.86	1.25	0.96	0.83	0.67	1.79	1.32	1.49	1.52	1.20
2	3.20	2.81	2.65	2.98	2.45	2.86	1.87	1.94	1.75	2.98
3	4.97	3.36	3.11	3.98	3.84	4.69	3.11	2.61	2.34	3.96
4	5.53	4.73	4.17	4.93	4.00	6.75	4.65	3.87	4.20	4.19
5	7.62	5.99	5.63	5.64	5.87	9.47	6.32	5.76	6.34	5.89
6	10.26	7.24	6.35	6.89	6.97	11.83	6.73	6.61	7.18	6.72
LSD	S = 1.895 T = 1.796 S&T = 0.168					S = 1.229 T = 1.135 S&T = 0.119				

***Table 11:** Effect of nano edible film and coatings on Psychrophilic bacterial of Al Hulwah and Soukari dates during storage at 2-4ºC.*

Moulds and yeast

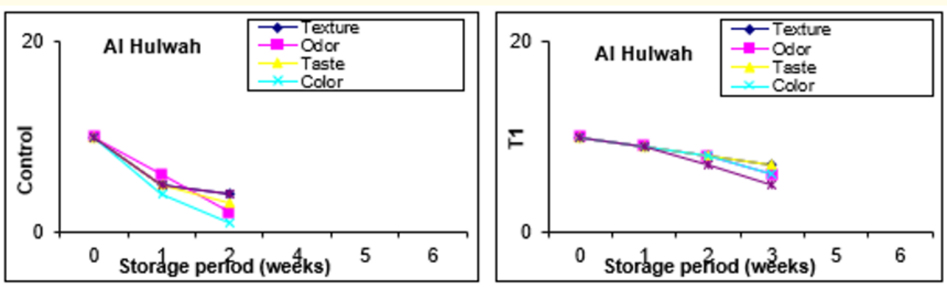
The changes in mould and yeast counts of fresh Al Hulwah and Soukari were determined during cold storage. Table 12 displays the obtained results. The results showed that the mould and yeast counts gradually increased with increasing storage time at a cold temperature in both coated and uncoated samples. Mold and yeast counts are higher in uncoated samples than in coated samples. The mould and yeast counts reached 11.83 and 9.83.85 10^1 CFU/g after 6 weeks of storage in both the control and T1 samples, as compared with the initial counts of 0.12 10^1 CFU/g. In addition, bio-films and coatings, by themselves, are acting as carriers of food additives (i.e. antioxidants and antimicrobials) and have been particularly considered in food preservation due to their ability to extend the shelf life [37].

Storage period week	Al Hulwah					Soukari				
	Treatments					Treatments				
	Control	T1	T2	T3	T4	Control	T1	T2	T3	T4
0	2.36	0.97	0.87	0.93	0.82	1.42	0.57	0.43	0.62	0.49
1	4.79	1.63	1.91	1.49	1.61	2.17	1.16	1.37	1.23	1.65
2	6.23	2.98	2.56	2.17	2.89	4.57	2.63	2.48	2.56	2.89
3	7.93	3.16	3.79	3.52	4.02	6.72	3.10	3.65	3.87	4.06
4	9.62	4.29	5.23	4.69	5.73	7.19	4.81	4.23	4.69	4.93
5	10.45	6.81	7.37	6.69	7.29	8.27	5.27	5.62	5.83	5.29
6	11.83	8.23	8.96	7.67	8.78	9.83	6.53	6.17	6.20	6.02
LSD	S = 1.935 T = 2.056 S&T = 0.264					S = 1.986 T = 2.137 S&T = 0.219				

Table 12: *Effect of nano edible film and coatings on molds and yeast of Al Hulwah and Soukari dates during storage at 2 - 4ºC.*

Sensory evaluation of nano edible film and coatings fresh Al Hulwah and Soukari

The mean scores of the sensory properties (texture, odour, taste, color, and general acceptance) of fresh Al Hulwah and Soukari are shown in figure 9 and 10. Fresh AlHulwah and Soukari had a high palatability for panellists and were generally well accepted on the first day. Control treatment was rejected after one week of storage, while coated treatment continued with the nanoedible coating for six weeks. On the other hand, the results of the statistical analysis showed that treatments (T3 and T4) had the best appearance, followed by treatment (T2). T3 and T4 treatments had the highest taste and texture values, followed by T1 and T2 treatments throughout the storage period. In terms of overall acceptance, all treatments were well received when stored for the first time, but not after 6 weeks. Generally, it could be concluded that the alginate coating of fresh Alhulwuh and Soukari prolonged its shelf life, freshness, and eating quality upon storage at a cold temperature. However, storage of the coated Also, packaging with a nanoedible coating had a large effect on the keeping quality and shelf life of the examined samples. Based on the results obtained in this study, it can be concluded that these results may be useful for application in the field of the dating industry and its products.



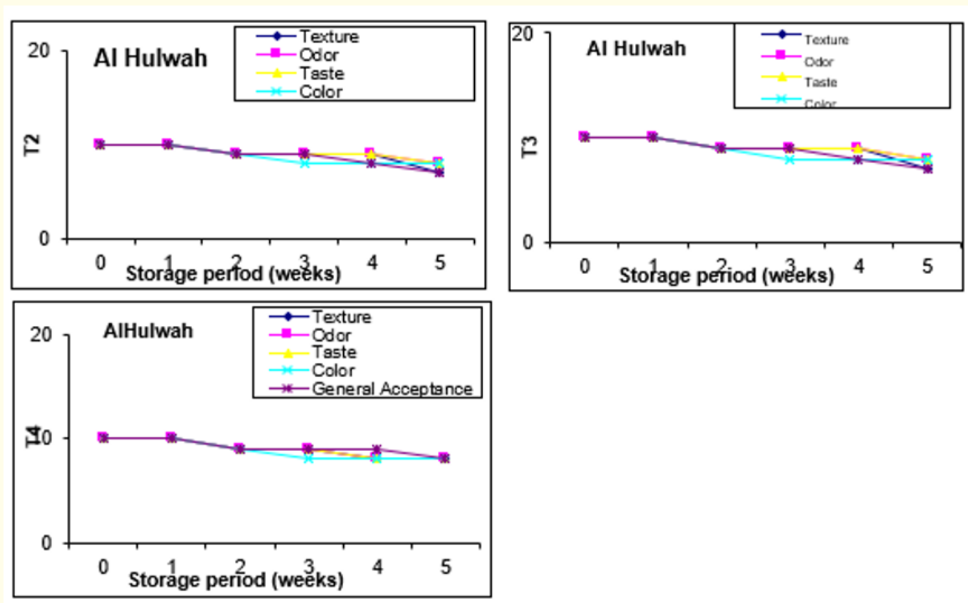
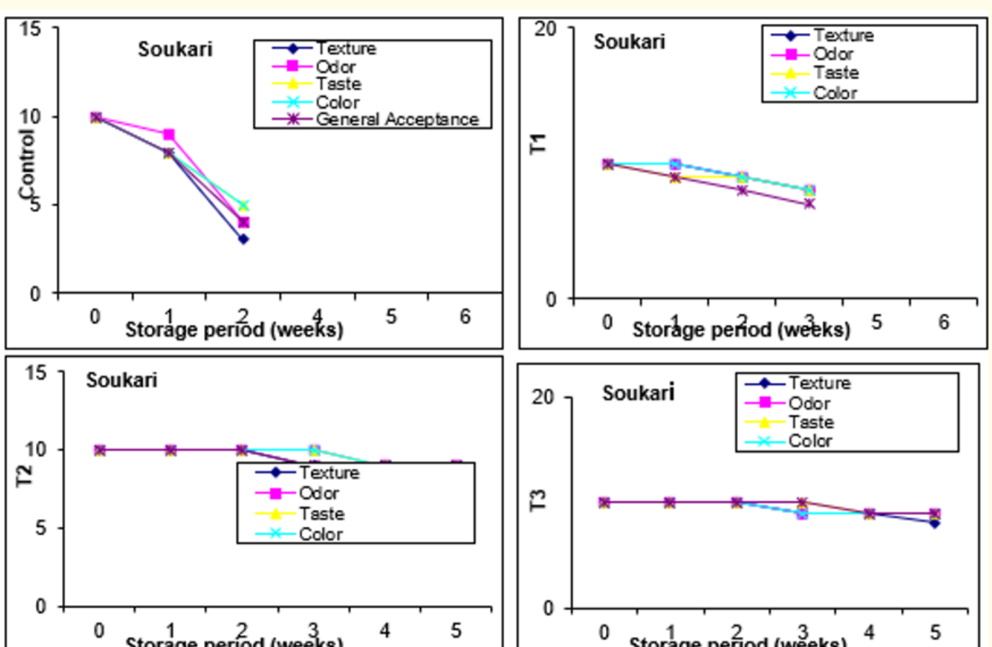


Figure 9: *Sensory evaluation of nano edible film and coatings Fresh Al Hulwah during cold storage (4 ± 1oC). Color [LSD0.05 = S = 0.440, T = 0.443, S*T = 0.761], Taste [LSD0.05 = S = 0.312, T = 0.372, S*T = 0.542], Texture [LSD0.05 = S = 0.358, T = 0.354, S*T = 0.619], Odor [LSD0.05 = S = 0.372, T = 0.375, S*T = 0.645] General acceptance [LSD0.05 = S = 0.361, T = 0.362, S*T = 0.625].*



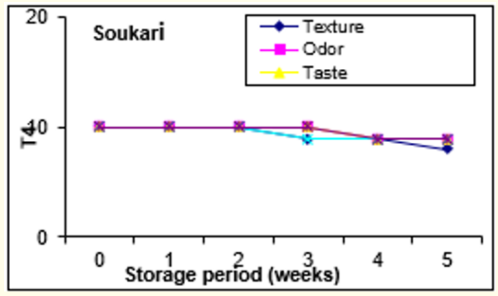


Figure 10: *Sensory evaluation of nano edible film and coatings Fresh Soukari during cold storage (4 ± 1oC). Color [LSD0.05 = S = 0.258, T = 0.256, S*T = 0.447], Taste [LSD0.05 = S = 0.266, T = 0.255, S*T = 0.461], Texture [LSD0.05 = S = 0.243, T = 0.240, S*T = 0.422], Odor [LSD0.05 = S = 0.235, T = 0.237, S*T = 0.405] General acceptance [LSD0.05 = S = 0.232, T = 0.230, S*T = 0.402].*

Conclusion

It could be concluded that T2 films the best samples of treatment (T4 and T3) as compared with control and T1. Other methods include rheological and mechanical properties, permeability, particle and zeta potential emulsions, and scanning electron microscopy. In alhulwuh and alsukraa dates, he discovered that the control and T1 samples were rejected after 6 and 15 days, respectively, whereas the remaining treatments lasted up to 6 weeks. T2, T3, and T4 coatings reduced weight loss and microbial count. The effect of combining $AgNO_3$/ZnONPs with Luria leaf extract nanomaterials on chitosan/gelatin films to prolong and extend product shelf life, reduce the risk of microorganism growth, and improve quality on alhulwuh and alsukraa dates. and sensory evaluation.

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