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Research Article

Silver Nanoparticles in Polymeric Matrices for Keeping Quality of Dates Packaging

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ABSTRACT

Recently, edible coatings are used to enrobe fresh produce. Date fruits (Hyani cv.) are in mature stage with high prefer ability, unique taste besides and high nutrition values to consumer. Unfortunately, these soft fruits are rapid deterioration (loss of moisture, ferments and spoil rapidly)leading to rejection by consumer either during storage or few days of marketing. The present work aims to prolong the shelf –life period either during storage or marketing with high quality by using Nano-technology. Nano-silver/PVA films were prepared with different concentrations (25, 50 and100 mg .kg-1),then fruits were dipped and stored at cold conditions (0±1°C, 90-95 %, RH). Different spectrometry instruments were used to verify the obtained edible blend structure of silver Nano -particles(AgNPs)characterization as transmission electron microscopy, X-ray diffraction, UV–Visible scanning and FT-IR spectroscopy. The freshness of Rutab dates was assessed by regularly measuring the microbiological, physicochemical properties of dates as total count of bacteria and fungi, decay(%)moisture content(%), weight loss(%),shelf life and the sensory evaluation of each treatment. The obtained results showed that active AgNPs at 100 ppm, then 50 ppm+PVC were more affecting to improve quality ,by comparing with PVA or control. Its effects reflected in extension of dates shelf life with high quality ,besides consumer's acceptance either during long cold storage (0±1°C, 98 %, RH)or retail period (12±2°C,55-70 %RH), which extended to 30 days than untreated which spoilage after one week. Finally, it could be recommended that the potential applications of nano-particles as combined treatments to fresh fruits are more safe for human health and easily for application.

Keywords: Edible Coating ,Nano -silver, PVA, dates, Hyani, coating, marketing

INTRODUCTION

Most of fruits and vegetables are perishable easily to injure during long trip from post harvest to marketing and consumption. Therefore, new trends are introduced to avoied and control loss of products as nano-biocomposites and edible coatings [1].Egypt, consider the first producer of dates in the world , including different types mainly soft, semi-dry and dry dates [2]. Hayani fruits belong to fresh soft dates , its oblong shape , red color at khalal stage then turned to black color at rutab stage(its call in Arabic Rutab).The soft tissues as fresh are prefer to consumers but rapidly deteriorate besides short time of shelf-life during marketing under un-controlled conditions [3,4].

Recently, new trends of edible coating as an alternative for extending the shelf life of susceptible products [5]. A recent review shows that food- involved fruits- transmission of the corona virus disease 2019 (COVID-19) can be done by contaminated fruits by handling during transmission and storage. Edible coatings and films are employed as matrixes for

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incorporating antimicrobial Nanoparticles (NPs) can protect fruits for human health. There is no evidence that COVID-19 can be caught from fresh products[6] .It has been shown that the viruses causing these diseases can survive and spread on hard surfaces, therefore, fresh fruits and vegetables cannot be excluded i.e to wash well and cleaned well as they have the chance to be contaminated with human viruses, including the virus causing COVID-19[7].

Currently, silver nano-particles (AgNPs) have earned enormous popularity in scientific literature due to their exclusive and desirable antibacterial properties against a wide range of bacteria and fung[8] . Studies have shown that Ag particles have antibacterial effects[9].Stored fresh melon cuts in plastic films based on cellulose incorporated with spherical (AgNPs) ,then the obtained low counts of yeasts, bacteria with comparing zero silver . AgNPs demonstrated to have the most effective bactericidal properties against a wide range of pathogenic microorganisms, including bacteria, yeasts, fungi and viruses[10,11].

Therefore, (AgNPs) have been widely used in food packaging, textiles, water filtration, and healthcare[12,13]. Safety of AgNPs for packaging food materials have been approved by the U.S. FDA(2015)[14].Nevertheless, multiple latest research studies suggested that silver nano composites are safe for food packaging, with no detectable or insignificant levels of AgNPs that are released and migrated from impregnated containers into real food samples and food stimulants[11,15]. AgNPs coating materials were tested on fresh , minimally processed fruit and vegetables as a solution to limit the spoilage to increase the shelf life during post-storage showed that limitation of spoilage with extension of shelf-life of different of fruits and vegetable[16-17]. AgNPs can be combined with both non-degradable and edible polymers for active food packaging.Polyviny l- alcohol (PVA) is the most common hosting polymer among many other polymers[18-21].A lot of work has been concerned with PVA as a matrix and silver nitrate as a metal precursor [21-23]. Therefore , the present work used AgNPs for preparation suspended Immersion as(AgNPs /PVA) blend for dipping Hayani fruits for minimization the spoilage ,keeping quality, freshness of Rutab dates during storage ,marketing and retail period marketing. The study extended to verify the residues of silver in fruit parts after treatments.

MATERIALS AND METHOD

Materials

Polyvinyl Alcohol (PVA); CAS No. (9002-89-2),(M.W. 1,25,000) was obtained from Lab Chemical Suppliers, Manufacturers in Mumbai, India.Silver nitrate (AgNO3),reagents utilized in the following examinations, biological experiments were received at analytical standard grade (Sigma-Aldrich), and appropriated without additional purification. Date fruits were obtained at the beginning of Rutabe stage (Hyani variety). It collected after harvesting directly from the commercial farm near Giza, Egypt. Samples were prepared by removing the injured or decayed one, then sorted and packaged in carton boxes to transferee to NCRRT Laboratories.

Preparation of (AgNPs /PVA) Blend:

Silver nitrate (AgNO3) and Polyvinyl pyrrolidone (PVP) solutions were used for the synthesis of AgNPs. The modified method was applied as follows: 10 ml of 5% PVA solution was mixed with 90 ml of 5.0 mM AgNO3 solution then mixtures were exposed to γ-irradiation at dose 25 kGy at room temperature, then the produced blend was characterized according to recommended methods[25-26].The irradiation was conducted at National Center for Radiation Research and Technology(NCRRT). The facility practiced was 60 Co-Gamma chamber 4000-A-India. Irradiation was administered at a dose rate 1.429kGy/ hour at the time of the experiment.

Structural Characterization:

The samples were characterized by the following equipments: Dynamic Light Scattering (DLS):The size of silver nano-particles was investigated by DLS[21,24]. Whereas, X-ray Diffraction (XRD) of AgNP's was carried out using an X-ray diffract meter using Shimadzu XRD6000 diffract meter with Cu target. The X-RD runs were carried out over the 20 ranging from 10o to 40o at a scan speed of 8o/min[21].Also Fourier Transform Infrared (FTIR)Analysis (FT-IR) were recorded over the range400–4000 cm−1, in a Bruker, Unicom infra-red spectrophotometer (Germany)[24-26].Besides, the UV-Visible spectra of the prepared films were recorded using a Specord 210 in the absorbance mode, and in the wavelength range between 200 to 1200 nm. In addition , High Resolution Transmission Electronic Microscope (HRTEM) Micrographs of silver nano-particles were obtained with a transmission electron microscope (JEOL2100-Lab6) at Egyptian Petroleum Research Institute. A drop of the silver dispersion was placed on a carbon-coated copper grid, which was allowed to dry before observation under the microscope.

Residual of nano-particles (AgNPs) was determined using Inductively Coupled Plasma (ICP) (as mg .kg-1), were done in date parts as peel , flesh and all fruit., ten replicates were used to get the average per every part to get concentration (as ppm or mg .kg-1).The calculation was carried out as fellow. AgNPs-Residues (%)= (Samples content ppm –Control content ppm / Control content ppm) x100.The analysis was done according the recent recommended method[27].

.Parameters of date quality :Fresh date fruits were washed; air dried then dipped in a coating for one minute at room temperature, the fruits were left even to dry completely as a thin layer coating. Each treatment was represented by six replicates each of them was packed in 6 carton boxes/ 1 kg. The coated fruits were stored at cold storage (0±1.0C, 98 %, RH). Some parameters were calculated for evaluating the efficiency of edible coatings as a fellow:

Decay (%) of fruits and Shelf life in days: were determined for the stored fruits at cold storage(00C ±2 ,95- 98 % RH),as percentage of rotted, fermented, unripe fruits. Besides the days before spoilage were counted to determine the shelf life for all treatments [28-29].Also, Shelf -life (days)during marketing or retail period to study the efficiency of treatments on dates quality during trail period(day).The tested stored fruits were

transferred ,sorted on shelves inside glass room during marketing for consumers at (12 oC ±2, 55-70 %, RH).[29].

Moisture content (%), Its determined in flesh dates using Association of Official Analytical Chemists [31]. Whereas, the samples were dried at700C / 48 even the dried parts fixed at constant weight. Whereas, the weight loss of fruits (%), was calculated between the differences in weight between the initial of packaged dates samples at zero time and weight of same packaged dates at interval time were recorded monthly[31]using an electronic balance with sensitivity about (0.01g).

Microbiological Analysis:

Total Bacterial Count (TBC) and Total Fungal Count (TFC) were determined using plate count method[31].

Sensory Evaluation:

Twenty panelists participated from NCRRT –Staff, well trainer for the test of Sensory evaluation according method[29-30] .Its involved the appearance, color, taste, odor, texture, and overall acceptability were done in order to determine consumer acceptability. The tests were performed monthly. A scale ranging from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation.

Statistical Analysis:

The design of the experiment was completely randomized with six replicates (1 kg/ replicate). The data were analyzed using the analysis of variance technique (ANOVA) to comparing the average value of the parameters. Duncan's multiple range test (DMRT) was used to compare the mean values between the pair of treatments [32].

RESULTS AND DISCUSSION

Verification of AgNPs /PVA coatings constituents by UV visible Spectrum via reduction of silver nitrate in aqua PVA, can be characterized well by UV-visible spectroscopy especially the noble metals due to the Surface Plasmon Resonance (SPR) phenomena, Typical metals that support surface Plasmons are silver and gold[33]. UV-visible spectrogram for PVA/Ag nano-composites solutions after exposure to gamma irradiation (Fig. 1.).It is clear that the plasma on absorption bands due at about 431 nm indicating to the presence of spherical or roughly spherical Ag Nano-particles.[22,34-35].

Dynamic Light Scattering (DLS:

Dynamic light scattering (also known as Photon Correlation Spectroscopy or quasi-elastic Light Scattering) is a technique in physics that can be used to determine the size distribution profile of small particles in suspension (chemistry) or polymers in solution. Fig. 2 shows the different sizes for silver nano-particles in the PVA solution, they were less than or equal to 100 nm[22,36]. These results are consistent with the results of the High-Resolution Transmission Electronic Microscope (HRTEM), which shows the sizes of the silver nano-particles in Figure 3.

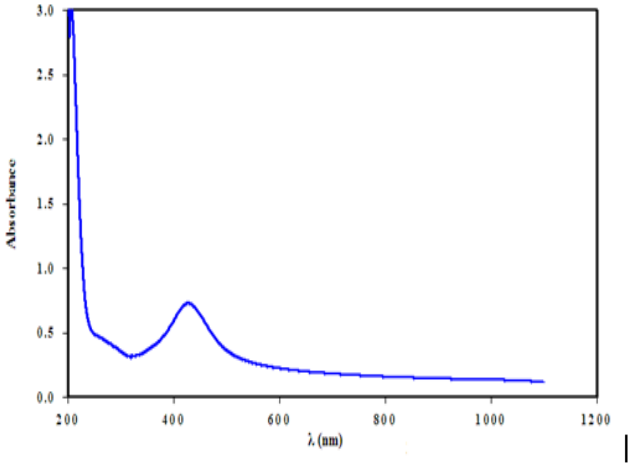

Figure 1: UV visible spectra Ag- NPs prepared in PVA film.

High-Resolution Transmission Electronic Microscope (HRTEM):

Fig. 3 shows the sizes and distribution of 100 ppm AgNPs in the PVA suspension. The nano particles had a narrow size distribution, it presents spherical and pseudo spherical shapes [22,35].From the figure, we can conclude that the Sizes of silver nano-particles ranged from 30.87 up to 80.14 nm[22,27,36]. It should also be noted that the DLS measured size was slightly bigger as compared to the particle size measured by TEM micrographs because the dynamic light scattering (DLS) method measures the hydrodynamic radius[36,39,41].

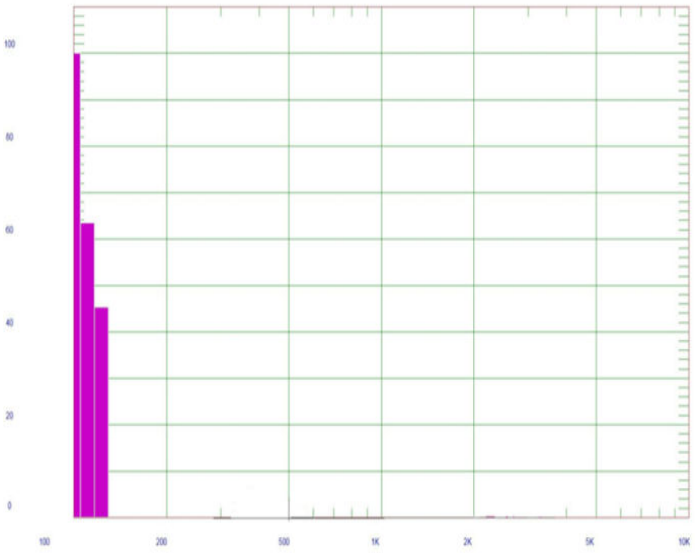

Figure 2: Dynamic Light Scattering (DLS) of PVA+ AgNPs solution.

X-ray Diffraction (XRD):

X-ray diffraction is a unique method to analyze the change of crystallinity of irradiated pure PVA and PVA/Ag+ gel in Fig. 4

which displays the XRD patterns of PVA and PVA/Ag+ composite gel. The sharp crystalline reflection with great intensity at around 19.7°2θ was observed in the PVA hydro gel due to strong intermolecular interactions between the PVA polymer chains. The intensity peak of PVA/Ag+ is slow to arise than of pure PVA samples, this is due to an increase in the crystallinity of the samples The increase in the intensity of the diffraction peak at 2θ =19.6 is due to the increased crystallinity resulting from increased network bonding due to the addition of silver ions that improve the bonding of the three-dimensional network through condensation reaction in the polymer matrix. The peak of 2θ = 37.8 referred to Ag nano-particles and indicated the reduction of the Ag ions in the polymer matrix[34,35].

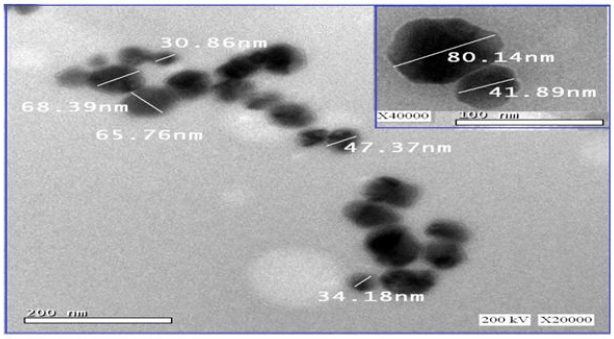

Figure 3: Scanning electron micrographs with High Resolution Transmission Electronic Microscope.

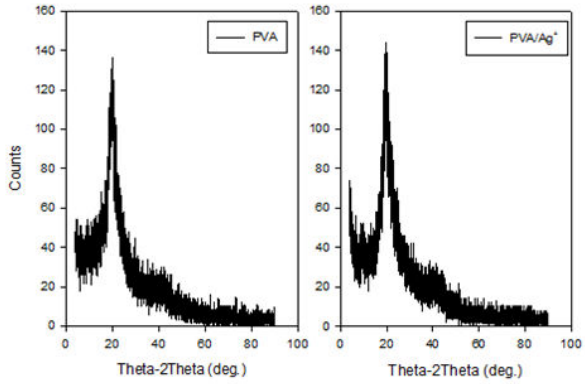

Figure 4: XRD patterns of PVA and PVA+AgNPs film.

Fourier Transform Infrared (FT-IR:

FTIR spectrum of pure PVA sample is shown in Fig.5. It clearly reveals the major peaks associated with poly (vinyl alcohol). All major peaks related to hydroxyl and acetate groups were observed. Typical strong hydroxyl bands (large band) for free alcohol (non-bonded –OH stretching band at (3200–3500 cm^{-1}) due to intramolecular and intermolecular hydrogen bonding among PVA chains due to high hydrophilic forces. The vibrational band observed at 2934 cm^{-1} refers to the stretching C–H from alkyl groups. The peak at 1725 cm^{-1} is due to the stretching C-O from the acetate group remaining from PVA. An import absorption peak was verified at a frequency of (C–O, 1085–1245 cm-1) is due to the carboxylic stretching banding which responsible for the crystallinity of PVA[56]. FTIR spectrum of hybrid made of PVA/Ag+ was showed in Fig. 5. It can be observed that all peaks at the same region but smaller than peaks of pure PVA, this is due to that, the addition of silver Nanoparticles to form hybrid polymer between inorganic materials and organic polymer lea to condensation and esterification reactions during the gel formation and cross-linked structure for the PVA hydrogel. The reaction of Nano-silver ions with PVA solution during gel formation using gamma irradiation enhances the hydrogen bond formation between the –OH and C-H groups. The hydrogen bonding plays an important role in the rearrangement of the structure and the crystallinity of the prepared polymer which depends on the balance between hydrophilic and hydrophobic forces .FTIR spectrum of cross-linked hybrid gel PVA/Ag+, introducing Ag-OH and Ag-O formation through condensation reaction leading to an increase in the crystallinity of the hybrid polymer and this is what we will discuss in the next paragraph[35].

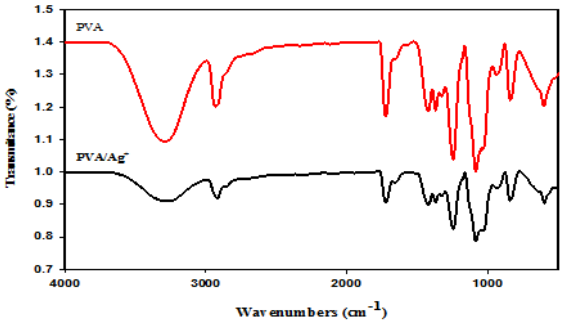

Figure 5: FTIR spectra of PVA and PVA+100 ppm AgNPs.

EFFECTS OF (AGNPS) COATINGS ON DATE FRUITS STORAGE-ABILITY PARAMETERS

Fruit Decay (%) During Long Cold Storage:

All tested samples recorded low values of decay (%) even 5 months of cold storage (00C ± 2 and 95- 98 % RH). The storage of Hyani dates extended to 8months, uncoated dates (control) was (˜ 1%) in the third month of storage then gradually increased to (21.1%) at end of the storage period .Whereas, the decay (%) of coated PVA and PVA+25 ppm AgNPs was (˜ 0.9 and 1%) in the fifth month of storage and gradually increased to 4.44 and 3.7% respectively. In the same time, PVA+50 or 100 ppm AgNPs coated dates ,were recorded low values as observed after 8 months of storage as shown in Figure 6. At end of long cold storage ,the best treatments to reduce decayed fruits were coated dates with PVA + 50 or 100ppm AgNPs even end of storage (8months). These differences were significant comparing with all coating treatments to control. But, the decay (%) of coated dates with PVA+ 100 ppm AgNPS was zero even end of storage period. The highest efficiency of treatments were PVA only then with 100 ppm, 50 ppm, 25 ppm- significantly, respectively. Same results were obtained by workers on strawberry, fresh-cut

watermelons, mandarins, grapes, tomatoes, and strawberries significantly [43,51].

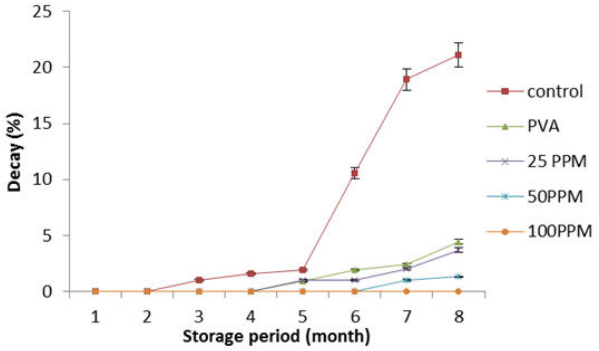

Fig.6: Effect of PVA and PVA+ AgNPs coatings on fruit decay (%) of Hyani date during cold.

Shelf Life of Marketing Period Test (day:

The packaged fruits were transferred from cold storage(00C ± 2.0,95- 98 % RH)to test the shelf- life at intervals to check the period in days for retail period.The fruits were sorted on shelves inside glass room(12°C ± 2.0,55-70 %RH). The spoilage started clearly in first group -after one week of long storage - (uncoated dates) and discarded after about one week during marketing , (Fig. 7).Whereas ,same treatment discarded after ~4 days for last group - after 8 months of storage at cold storage. Whereas, coated fruits -PVA only, showed a longer shelf life than uncoated dates. This prolongation of the shelf life may be due to the antimicrobial effects of PVA , which depend on its molecular weight as mentioned[42,47,56], Other researchers also mentioned that edible coatings like PVA...etc. being able to control the respiration rate and water loss .It also acts as a carrier of active compounds, which may reduce the spoilage of fresh fruit by preventing microbial growth [29,42,43].It is noted as presented in Figure 7 that using of AgNPs+ PVA can increase the shelf life period during retail of Hyani dates near one month at a high concentration of AGNPs 50 or 100 ppm, either at zero time or after 8 months., Comparing with the control which are spoiled during few days. This positive trend in the shelf-life may be due to the wide range antimicrobial effects of AgNPs against pathogenic microorganisms, besides to the controlling of respiration rate and the water loss by PVA as reported by many researcher on strawberry and apple [46,49].

Weight Loss (WT %:

It is one of the important indicators affecting on quality of Hyani dates during long cold storage .The obtained results of using treatments during long cold storage on (WT %) of tested samples are shown in Fig.8. Generally, its clear that (WT %)gradually increased gradually significantly during storage period especially at control. But the effect of coating materials was clear for reducing (WT %)in treated samples with coated materials. The value of control recorded high (WT %) at end of cold storage (8 months),whereas,the tested samples bwere better and less loss of weight.The uncoated fruits lost recorded in untreated value (~ 42%)but less values were observed in all coated fruits. The values of (WT%) were significantly lower in all of the coated fruits, its were (~ 36,~ 34.9, ~ 34.8, and~ 34.4 %) with PVA, PVA + 25 ppm AgNPs, PVA + 50 ppm AgNPs, and PVA + 100 ppm AgNPs respectively ,same trend were obtained by workers[43,46]. The role of PVA either with or without AgNPs in reducing WT% may be due control moisture loss by these materials as semi permeable membrane, or/ suppresses the gas transfer consequently reduce the respiratory rate weight loss[46,48, 50,62].

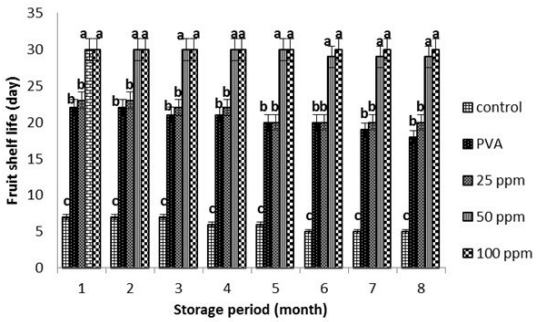

Figure7: AgNPs coatings effects on shelf life (day) of Hyani dates during the retail period.

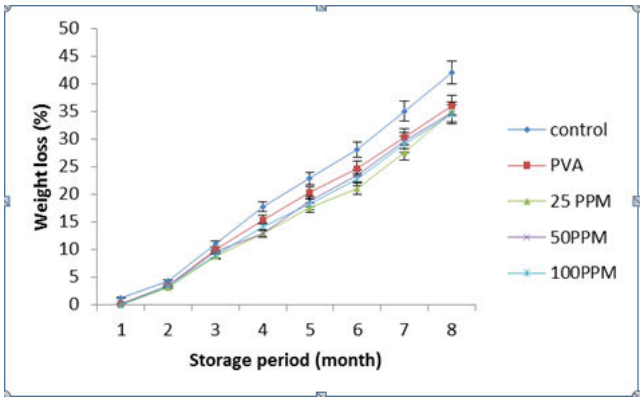

Figure 8: AgNPs coatings effects on weight loss (%) of Hyani dates during long cold storage.

Moisture Content (MC%):

The results of(MC%) of stored fruits were in opposite trend of weight loss (%).It recorded in control the lowest values (45.41 %) after 2 month of cold storage to decrease to (28%) after 8 months. In the same time all coated fruits with or without(AgNPs) contained high values either at beginning or end cold storage period (Table 1).Same trends were obtained by workers before[21,46,48].The authors explained that by reduction of respiration or evaporation besides the main roles as anti-microorganisms during long cold storage at 00C ±2 and 95-98 % RH. Besides, the role of AgNPs to prevent the growth of molds, which was clear at all concentrations especially high concentration (100-ppm+PVA) (Table 1). These differences were significantly clear . Like these data were obtained by workers before [1,21,53,57,62].

Table (1): Moisture content (%) of treated date fruits during cold storage (00C ± 2 and 95- 98 % RH)

Treatments	Moisture content (%) in Hyani dates

	Storage Period (month)			
	2th	4th	6th	8th
Control	45.41 d	40.30 ef	38.12 f	28.12 h
PVA	47.52 cd	41.62 e	40.37 ef	30.23 gh
PVA+ 25 PPM	47.72 cd	41.65 e	40.16 ef	30.43 gh
PVA+ 50PPM	47.89 cd	42.00 e	40.27 ef	30.40 gh
PVA +100PPM	48.83 bc	42.17 e	40.51 ef	31.20 g

* Means followed by the same letters are not significantly different at 5% level.

Microbiological Analyses:

The spoilage or decay of date fruits usually occur through infection of microorganisms the injured, pores or damaged tissues. Therefore, controlling of surface fruits microorganisms can help raise dates quality. PVA +AGNPs consider the most effective bactericidal properties against a wide range of pathogenic microorganisms ,including bacteria, yeasts, fungi and viruses[31,47].Same trends are shown in our results ,(Table 2),the highest microbial counts(TBC or TFC) were observed in control dates (uncoated) samples . The counts in the coated dates with PVA+ 100 ppm AgNPs were significantly less than the other coated dates especially at high concentration of AgNPs . This reduction caused by Silver Nano-particles which have a wide-range antimicrobial activity against Gram-positive and Gram-negative bacteria, including antibiotic-resistant strains, fungi ,yeasts, and certain viruses[54,55).Also, silver ions cause the release of K+ ions from bacteria; thus, the bacterial plasma or cytoplasmic membrane, which associate with many important enzymes and DNA, is an important target site of silver ions[20,57].Some workers mentioned that AgNPs can minimizes the microbial load because AgNPs release antimicrobial Ag ions, which bind to electron donor groups in molecules containing oxygen or nitrogen, thereby damaging the cell division mechanism, ultimately inducing cell death[21,47,48].

Also, Showed that the antimicrobial effect of the silver Nanoparticles coating films is due to the release of silver ions from coating film, When the silver ions enter the bacterial cells by penetrating through the cell wall turn the DNA into a condensed form to react with the thiol group proteins and provoke the cell death.Its recommended to use 100ppm to keep dates even end of storage at cold storage[57].

The snow trout belongs to Schizothoracinae, a subfamily of the Cyprinidae that comprises 10–13 genera with about 100 species. The group represent an important taxon where fishes can survive at an extreme cold and pathogen prone environment. Although the present study did not conclude any concrete mechanism exhibited by snow trout in Aeromonas hydrophila infection, the study did highlight few explorable mechanisms in fish immune response. Various cell surface receptors including toll like receptors and c-type lectin receptors might play important role in immune response of snow trout. Cytokines (IL1β1, B-cell lymphoma 3 protein homolog, Prostaglandin-endoperoxide synthase 2b) and caspases could be responsible for modulating the balance between humoral and cell-based immunity and regulation of cascade of immune function in bacterial infection. At present, a number of outstanding questions remain to be addressed to understand the snow trout's immune response in bacterial infection that require functional studies to reveal the role of specific effector during pathogenesis.

Table (2): Total bacterial count(TBC)and total fungal count(TFC)of tested Hyani dates during cold storage.

Treatment	TBC (Log CFU/g)		TFC (Log CFU/g)	
	Zero time of storage	End 8months	Zero time of storage	End 8months
Control	7.03	7.91	2	5.2
PVA	7.05	7.86	0	2
PVA+ 25 ppm	4.83	4.85	0	1.6
PVA+ 50 ppm	4.74	4.84	0	0.3
PVA+100 ppm	4.58	4.68	0	0

Inductively Coupled Plasma (ICP) for Determination of AgNPs Residues:

Silver nanoparticles (AgNPs), in particular, have different positive effects for healthy food for human consumption.. The actual application of AgNPs in food packaging is regulated by EU and USA food safety authorities in a prudent way, due to the inability to make conclusive statements on their toxicity[52].The determination of silver residues (as ppm) was done in date parts as peel, flesh and kernel. Dipping inAgNPs – emulsion at concentration 0f 100 ppm was carried at room temperature(20°C, 70%-75% RH). The analysis was done using ICP; ten replicates were used to get the average per everypart. Generally, the absorbed of AgNPs concentrations were compared the differences before and after washing with distilled water depended on the date part of fruits .For instance, the concentrations of AgNPs in Peel>Flesh > whole fruit as shown in table (3) were 13.34%, 11.09% and 3.98% respectively. Peel tissues were highest absorbed than flesh edible parts .

AgNPs absorption in different part date fruits were determined, the peel and flesh as shown (Table 3) were ~ 25.4 and 0.3 ppm respectively before washing by distilled water. Leaching by washing,decreased to ~ 1.01 and 0.05 in the peel and flesh respectively. The peel tissues absorbed more silver nano-particles than the flesh edible parts (Table3). This

logically due to the anatomical structure of peel which contains ruptures in the surface which Facilitate the penetration or absorption -AgNPs molecules. On the other hand, these ruptures make it easy to release silver Nano-particles and lose ~ 96.02 % of them by distilled water washing on dates[59] .According the calculation of residual of fresh flesh(Table 3), contain 0.05 ppm after using 100ppm of AgNPs as showed by EFSA(2011)[52].Some workers succeeded in using AgNPs plus polymers as packaging fruits for keeping quality as Strawberry[49,62] , Barberry [58] (Falguera et al., 2011)The concentration of 0.05 ppm are safe at edible flesh parts , within the limits authorized by the European Food Safety Authority [52], which has recommended that the upper limits of Ag migration of packaging materials should not exceed 0.05 mg / l in water and 0.05 mg/kg in food [60].

Table 3: The residual content of AgNPs at different parts of treated Rutab-hyani dates with 100 (ppm) before and after washing with distilled water.

Fruits parts	AgNo-residues (ppm)			
	Before	After	Residue (%)	Losses by washing (%)
Peel	25.4a	1.01b	3.98c	96.02a
Flesh	0.3a	0.05a	16.66a	83.34c
Whole fruit	5.05a	1. 06b	21.16b	78.84b

* Means followed by the same letters are not significantly different at 5% level.

** AgNPs content (ppm) in Control dates (after washing) (0.69b,peel), 0.05a,flesh &0.39b whole fruits).

Sensory evaluation: Foods are generally perceived by appearance, odour/fragrance, consistency/texture and finally flavour; however, in reality, these perceptions often occur in parallel as an overall sensory experience. Sensory evaluation attempts to isolate the sensory properties of foods and other products and can be defined as a scientific method that is used to evoke, measure and interpret responses to the sensory properties through the senses[62].

Generally, testing the treated fruits are perceived through consumers during marketing or retail sail . This done by ten well trainer panelist to tast, check of color, , odor, texture, finally flavor; for all acceptance or not .Stored fruits at cold storage conditions for 8 months were tested two times at zero time and end of cold storage (00C ± 2 and 95- 98 % RH). Both of them either first or second one were conducting at (12 °C ± 2, 55-70%RH) during test. The obtained results (Fig. 9) showed that only AgNPs at 50 and100 ppm has the preferability for application to keep quality of Rutab dates Hyani during long storage and marketing [21]. As, shown in Figure7,the original photos for treated dates fruits.Its clear that the best fruits can eat fleshy of Rutab dates Hyani which coatedPVA+ AgNPs with 100 ppm, 50 ppm and 25 ppm respectively.

CONCLUSION

From the previous results, we can conclude that to maintain the highe quality of Rutabe dates (Hayani cv.) during storage at cold conditions (0 ± 2°C and 95-98 % RH)for 8 months and extending the shelf-life period to 30 days at(12 ± 2°C and 55-70 % RH) during retail or marketing even 30 days. It is recommended to use 50 or 100 ppm+ PVA coating films. Besides , washing the coated Hayani dates with distilled water few minutes before eating them.

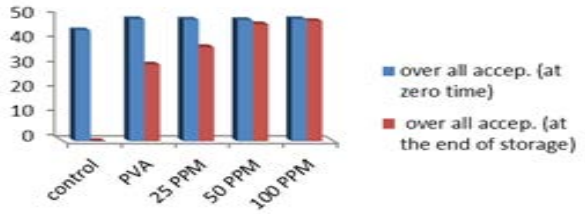

Figure 9: Comparison between the overall consumer acceptance for AgNPs- coated , un-coated Hyani dates with or witout PVA at zero time of cold storage during marketing test (12 °C ± 2/ 95-98%RH)

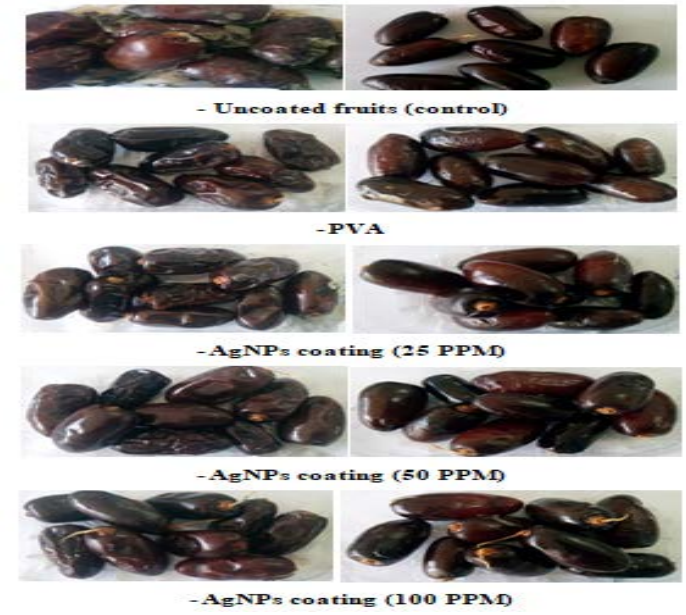

Figure 10: Hyani dates after 30 days during marketing (12 ± 2°C, 98%, RH.(right, photos of fruits at beginning of marketing. Whereas, left one at end after 30 days on marketing).

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