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Application of Gum Arabic as Edible Coating for Improving Postharvest Quality of Potato Tubers

Rowaa B. Ghannam[a,*], Shimaa M. Abdelsalam[b], Afaf A. Amine[a], Maha A. Hewedy[b]

[a]Food Safety Department, Microbiology Unit, National Nutritional Institute (NNI), Cairo, Egypt

[b] Botany Department, Faculty of Women for Arts, Science and Education, Ain Shams University, Cairo, Egypt. Postal code 11757

Abstract

Hydrocolloid gums are extensively used in food industry. Recently hydrocolloid gums especially Gum Arabic (GA) has been widely used as edible coatings to extent shelf life of postharvest fruits and vegetables. The objective of this study was to evaluate the effect of GA edible film application mixed with glycerol and $CaCl_2$as base matrix with all GA films i.e. GA/EDTA,GA/*L. paracasei* supernatant and GA/EDTA /*L. paracasei* supernatant in preservation of potato tubers stored at 8°C and 30±5°C for 35 days. Physicochemical analyses including pH, weight loss percentage and total soluble solids percentage (TSS)**,** as well as microbial analysis (total counts of bacteria, mold and yeast and Enterobacteriaceae).The obtained result revealed that the total microbial count was found that GA/EDTA/ *L. paracasei* supernatant gave a very close results to petroleum coating (wax) and the best results compared withnoncoated (control) tubers, this was evident through the lower microbial load, better results than other treatments and noncoated tubers such as reducing weight loss, total soluble solids, better control on pH and expansion of the shelf life.

Keyword: Potatotubers, Postharvest quality, Edible coating, Gum Arabic, EDTA, *L. paracasei*, Microbial count.

1. Introduction

Potato (*Solanum tuberosum* L.) cultivation dates back to approximately 9000 years. Potato cultivation slowly spread throughout Europe in the following four centuries, and from there, to the rest of the world [22]. Potato by volume of production is the fourth important crop worldwide [46]. It is grown in about 140 countries; it is of high yielding and a low cost to the human diet and has a high nutritional value, as

***Corresponding author:** Rowaa B. Ghannam, Food Safety Department, Microbiology Unit, National Nutritional Institute (NNI), Cairo, Egypt.
E-mail: rowaaghannamm76@gmail.com

itcontains about 40 IU vitamin A, 12 mg ascorbic acid, 77.8% water, protein, 2.1%, 0.3% fat, 22.6% carbohydrates, 1.1% crude fiber, 0.9% ash/100 g of edible portion. It is also used for production of high quality alcohol, starch, etc. and its starch (farina) is used in textile mills for sizing yarn in laundries. It is also used for the production of glucose and dextrin [23,46].

Edible coating is one of the promising techniques used in postharvest crops preservation [14]. Edible coating can be described as thin film of edible material that obstructs water transfer, gas exchange and soluble movement (i.e. semipermeable thin layer around the fruit which slow oxidation process, weight loss and respiration). It is safe, not synthesized chemically and can be an alternative to other traditional methods, such as chemicals and radiation that have undesirable effects on the human systems [16,38].

Gum Arabic is one of the hydrocolloid gums, it is water soluble secretion from Acacia tree branches especially Acacia senegal [15]. It is a highly valued gum because of its higher emulsifying, solubility, flavoring and thickening characteristics [4]. The prebiotic potential of Gum Arabic (GA) increases its health benefits, since it is rich in dietary fiber and indigestible in small intestine and stomach so it is fermented in large intestine by the surrounding bacteria [25,36,47]. Niamah *et al.* [42] reported that the viability of probiotic bacteria was increased when incorporated with GA.

Several newly methods for fresh fruits and vegetables microbial safety have been investigated, these methods were able to inhibit the colonization of pathogenic microorganisms in food products using Lactic Acid Bacteria (LAB), which have an antimicrobial capacity, since they have bacteriocins, lactic acid and ethanol and generally recognized as safe (GRAS) by the United States Food and Drug Administration (FDA), and thus makes the ideal for developing an environmentally friendly bioprotective agents in fresh fruits and vegetables [31,40]. Furthermore, LAB can be directly applied as food additives, or their purified metabolites or fermentation products can be used instead [19].

The spectrum of LAB can be successfully broadened when it is applied in combination with chelating agent as Ethylene diamine tetra-acetic acid (EDTA)[39]. EDTA well-known chelating agent has been widely employed to control oxidation and other metal ion-catalyzed deteriorative reactions in food products. EDTA disodium or calcium disodium salts have been approved as food additives by FDA [19]. It also

preserves color, flavor and odor and it is worth mentioning that it doesn't accumulate in biological tissues and is not carcinogenic in 500mg/kg/day volume [7]. According to literature data, EDTA is known antimicrobial compounds [18], what was confirmed by Borowicz *et al*. [10], where EDTA has antimicrobial activity against some gram positive and gram negative bacteria.

Calcium is a key plant nutrient that has a significant role in cell functions, at various concentrations, as delaying the ripening, softening and senescence [9], also cross linking with calcium chloride generates stronger film gels [29].

Meeting the criteria of high quality and reduce the use of chemicals to obtain food safety products are few of the factors contributing to this requirement. This has lead researchers and companies to explore different ways to improve their productivity in terms of maintaining freshness, quality and food safety, such as using sustainable materials in food packaging. Thus this study aims to evaluate the effect of glycerol (as plasticizer), $CaCl_2$ and GA with both EDTA and *L. paracasei* cell free supernatant in the component of potato edible film/coating and their effect on the pathogenic microbial composition and load in compared with wax as a petroleum product, to prolong the shelf life of potato tubers for local markets and exportation.

2. Materials and Methods

2.1 Sample collection:

Three groups of potato tuber samples were collected from local market, Cairo, Egypt. They were transported to Microbiology Unit, Food Safety department, National Nutritional Institute (NNI), Cairo, Egypt. The experiments were conducted for approximately 35 days under cold (8°C) and ambient temperature (30±5°C). The first group was let to spoilfor isolating the spoiled microorganisms that affect potato crops. The second group was selected as fresh, mature stage and homogenous appearance based on color, size and free of mechanical damage. The third group was prepared for coating by washing with tap water (5 mg/L free chlorine) [12] and dried at ambient air conditions before coating for proper adherence to the surface.

2.2Bacteria strain:

*Lactobacillus Paracasei*isolate was obtained from National Center for Radiation Research and Technology (NCRRT), Egyptian Atomic Energy Authority (EAEA), Cairo, Egypt.

Stock culture preparation and growth condition of *L. paracasei*:

Lactic acid bacterial isolate; *L. paracasei*was stored at -80°C MRS broth supplemented with 30% v/v sterile glycerol, it was reactivated and recultured under anaerobic conditions in CO_2 incubator (BPI, Italy) at 37°C for 48h. Subsequently, appropriate serial dilutions were prepared and precultured at plate count agar medium (PCA, Oxoid), to obtain 10^6 CFU/ml of *L. paracasei* [27,35]. The colonies were harvested with a sterilized loop and inoculated into screw-capped tubes of 9ml MRS broth, then centrifuged at 4000rpm for 30 minutes at 4°C [45]. The cell free supernatant was separated and the pellet was discarded.

2.3 Coating treatment

2.3.1Gum Arabic (GA) edible film

Ten g GA obtained from Sudan (from local market) was dissolved in 100ml distilled water and heated at 60°C for 30min. [2,17] with gentle stirring, and thenit was filtered. For all edible films preparation after cooling to 50°C, glycerol of (1.0% v/v) (99% purity, Sigma) as a plasticizer to improve the flexibility of coating solutions and $CaCl_2$ of (1.0% w/v) were added to GA solution [32].

The GA edible film was divided into four groups, one group was for the film only, the second was added to 2.5% Calcium disodium Ethylene DiaminTetraAcetate salt (EDTA), (Sigma, Aldrich- Germany) [10]**,** the third group was GA film with *L. paracasei*supernatant, (50% w/v)[27], and the fourth one was for the film in combination with both EDTA and *L. paracasei*supernatant.

2.3.2Wax film

Commercial Barrafin wax was melted and prepared for covering film

2.3.3 Application of coating solutions

The films were applied to the tuber samples by a casting method while the wax film was applied with a brush. All coated and noncoated tuber samples (control) were divided into two groups, one stored at 8°C and the other at 30±5°C. During the storage period microbial analysis were performed every 3, 5, 7, 10, 15, 20, 25, 30 and 35 days.

2.4 Microbial analysis

Both coated and noncoated crop samples were peeled off and 2cm^2 of the inner tissue was transferred for microbial examination to screw-capped tube with 9 ml buffered peptone water (0.1%) under sterile conditions and vortexed for 2min. Appropriatedilutions were prepared for the microbial analysis.The microbial analysis consisted of a plate count method for bacteria at 37°C for 24h in a plate count agar (PCA), mold and yeast at 22-25°C for 5 days in Sabouraud (SB) agar and enterobacteriaceae at 37°C for 24h in double layer Violet Red Bile Glucose Agar. Visible colonies were counted and CFU/g calculated. All analysis were performed in triplicates.

2.4 Postharvest quality

2.4.1 pH determination

Five grams of groundedpotato tuber samples for both coated and noncoated samples in 50 ml distilled water were used to measure samples pH at 25°C with subsequent reading in a digital pH- meter (240A Orion, USA).

2.4.2 Weight loss percentage

Weight loss (expressed as percentage) for both coated and noncoated tubers were calculated from zero time and days 3, 5, 7. 10, 15, 20, 25, 30, 35 during the storage period, using the following equation:

$$\text{Weight loss} = \frac{\text{fruit initial weight} - \text{fruit weight on sampling day}}{\text{fruit initial weight}} \times 100$$ [32].

2.4.3 Total soluble solids TSS percentage

During the storage, the TSS percentage was determined from grounded (as mentioned in pH) tuber samples, using Car Zeiss hand refractometer, Germany, as described in AOAC [5].

2.5 Scanning Electron Microscopy (SEM)

The outer peel of both coated and noncoated potato tuber samples of the promising film (GA/EDTA/*L. paracasei* supernatant) were fixed in 2-5% glutaraldhyde for 24h. at 4°C and was post fixed in 1.0% osmium tetraoxide for 1h. at room temperature [24]. Then the specimens were dehydrated with ascending concentrations of acetone, critical point dried, and finally sputter was coated with gold. The

photographing and examination had been done through Jeol Scanning Electron Microscope (JSM-5200LV-LGS, JEOL Japan) and accelerating voltage of 30kv and magnified 50 and 100X.The SEM was performed at Applied Nematode Incest Centre, Faculty of Agriculture, Cairo University.

2.6 Statistical analysis

The experiments were carried out in completely randomized design with two replicates. Analysis of variance (ANOVA) was conducted according to Casella [11], using Statistix 10 software program for discriminating the treatment means, the Duncan's multiple range test at $P<0.05$ was used

3. Results

Results in Tables (1&2) representing the effect of GA edible films and wax on total Enterobacteriaceae count of both coated and noncoated potato tubers in both cold and ambient temperatures, data showed better control of GA/EDTA/*L. paracasei* supernatant film as well as wax on tubers compared with noncoated (control) tubers. During 35 days of storage the total Enterobacteriaceae count for all treated tubers was ≤10 CFU- g^{-1} while control samples recorded counts after twenty days at cold storage and represented as 10 CFU-g^{-1}, day 25 represented as 70 CFU- g^{-1} and day 30 (deterioration day) recorded 300 CFU- g^{-1}. Approximately same results were detected at ambient storage temperature, from day 15 and represented as 80 CFU-g^{-1} and recorded 700 CFU- g^{-1} at deterioration day (day 20).

Table (1): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on the total Enterobacteriaceae count during storage at 8°C

Storage days / Treatments	0	3	5	7	10	15	20	25	30	35
Gum Arabic	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
Gum Arabic/ EDTA	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
Gum Arabic/ *L. paracasei* supernatant	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
Gum Arabic/ EDTA/ *L. paracasei* supernatant	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
Wax	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
nonncoated Control	≤10	≤10	≤10	≤10	≤10	≤10	≤10	70	300	cd

cd =complete deterioration

Table (2): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on the total Enterobacteriaceae count during storage at 30±5°C

Storage days / Treatments	3	5	7	10	15	20	25	30	35
Gum Arabic	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
Gum Arabic/ EDTA	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	cd
Gum Arabic/ *L. paracasei* supernatant	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	0
Gum Arabic/ EDTA/ *L. paracasei* supernatant	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	0
Wax	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10	≤10
nonncoated (Control)	≤10	≤10	≤10	≤10	80	700	cd	cd	cd

cd =complete deterioration

On examining the ability of GA/EDTA/*L. paracasei* supernatant edible film to preserve potato tubers from rotting, rooting, shrinking and sprouting compared with wax film and noncoated tubers at cold storage results in Figure (1) were obtained.

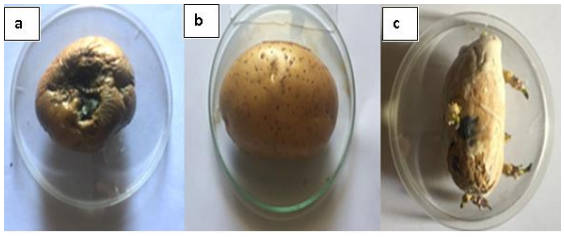

Fig. (1): photo of (a) noncoated potato tuber, (b) coated tubers with GA/EDTA/*L.paracasei* supernatant filmand (c) coated tubers with wax film after 35 days at 8°C.

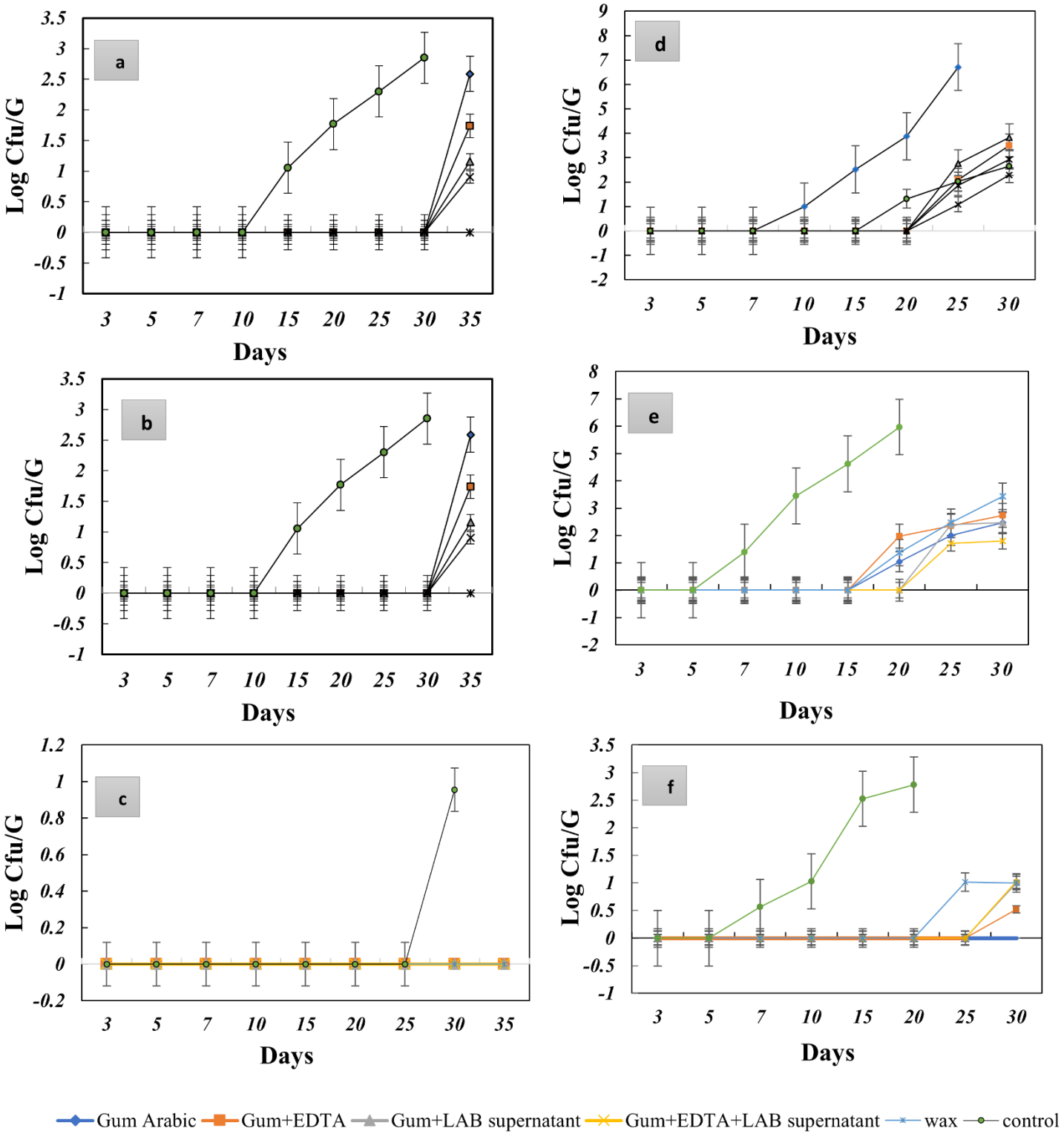

Fig. (2): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on bacterial, yeast and fungal count during the storage at 8°C (a: total bacterial count, b: yeast, c: fungi) and at30±5°C (d: total bacterial count, e: yeast, f: fungi).

Results in Figure (2a,b and c) showed that the cold storage (8°C) of potato tubers that coated with GA, GA/*L.paracasei* supernatant, GA/EDTA/ *L. paracasei* supernatant extend the shelf life of tubers as well as wax more than 35 tested days and tubers coated with GA/EDTA edible film were spoiled at day 35 and all films prevented spoilage compared with noncoated tubers (control), that decayed within 25 days ,while Figure (2d,e and f): at 30±5°C storage the samples coated with GA, GA/*L. paracasei* supernatant, GA/EDTA/ *L. paracasei* supernatant and wax continued up to 30 days without decay, while the tubers that coated with GA/EDTA were deteriorated at day 30 and bacterial and yeast count were recorded, although the coated tubers were better than noncoated (control) samples since the bacterial count and yeast and fungal counts were clear in addition to the complete decaying at day 20. As for pH, the increment of storage period led to a slight increase in pH value of stored potato tubers (Tables 3&4), especially at the end of storage period. The noncoated tubers scored lower pH value than other treatments and wax coating. There werevarieties between different treatments especially tubers coated with GA/EDTA/*L. paracasei* supernatant edible film that had the highest value of pH as well as wax coating during both thelow and ambient storage temperature compared with other edible films and noncoated tubers which scored lower pH value.

Table (3): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on pH during the storage at 8°C

Treatments	Storage time/ days										
	0	**3**	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**35**	**mean**
Gum Arabic	5.84	5.92	6.18	6.33	6.29	6.15	6.2	6.26	6.3	6.33	6.20^{bc}
Gum Arabic+EDTA	5.79	5.83	5.99	6.19	6.23	6.27	6.3	6.35	6.37	6.41	6.19^{bc}
Gum Arabic+*L. paracasei* supernatant	5.82	5.86	5.93	6.2	6.09	6.46	6.62	6.65	6.66	6.69	6.31^{b}
Gum Arabic+EDTA+ *L.paracasei* supernatant	5.81	5.95	6.08	6.26	6.39	6.57	6.7	6.73	6.75	6.78	6.43^{b}
Wax	5.84	6.05	6.27	6.63	6.85	6.99	7.1	7.12	7.16	7.17	6.77^{a}
control	5.8	5.83	5.87	5.92	5.94	5.97	6	6.02	6.05	cd	5.97^{c}
mean	5.82^{d}	5.91^{cd}	6.05^{bcd}	6.255^{abc}	6.30^{abc}	6.40^{ab}	6.48^{ab}	6.62^{a}	6.65^{a}	6.61^{a}	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s multiple range test.

cd= complete deterioration.

Table (4): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on pH during the storage at 30±5°C

Treatments	Storage time/ days									
	0	**3**	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**mean**
Gum Arabic	5.78	5.8	5.84	5.94	6.3	6.55	6.89	6.9	6.91	6.32^{ab}
Gum Arabic+EDTA	5.9	6.3	6.43	6.81	5.93	6.16	6.22	6.43	6.57	6.31^{b}
Gum Arabic+*L. paracasei* supernatant	5.89	6.15	6.32	6.55	6.16	6.09	6.21	6.79	6.84	6.33^{ab}
Gum Arabic+EDTA+ *L. paracasei* supernatant	5.80	5.83	5.92	6.17	6.30	6.43	6.62	7.03	7.05	6.35^{ab}
Wax	5.86	6.20	6.37	6.73	6.86	6.92	6.99	7.01	7.02	6.66^{a}
Control	5.86	5.89	5.92	5.98	6.01	6.12	6.15	cd	cd	6.12^{b}
mean	5.85^{c}	6.03^{cd}	6.13^{bcd}	6.36^{abc}	6.26^{bcd}	6.38^{abc}	6.51^{ab}	6.77^{a}	6.83^{a}	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s multiple range test.

cd= complete deterioration.

Tables (5) and (6), show a gradual increasing in weight loss percentage for all samples during both low and ambient storage temperature, while the tubers coated with wax and GA/EDTA/*L. paracasei* supernatant edible film scored a significant lowest weight loss percentage compared with tubers coated with other treatments or noncoated ones.

Table (5): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on percentage of weight loss during the storage at 8°C

Treatments	Storage time/ days									
	3	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**35**	**mean**
Gum Arabic	0.19	0.25	0.42	0.67	0.82	1.01	1.13	1.29	1.34	0.72^{bc}
Gum Arabic+EDTA	0.21	0.33	0.48	0.72	1.02	1.15	1.26	1.3	1.31	0.81^{b}
Gum Arabic+*L. paracasei* supernatant	0.12	0.18	0.34	0.61	0.88	0.96	1.2	1.25	1.28	0.69^{cd}
Gum Arabic+EDTA+ *L. paracasei* supernatant	0.1	0.15	0.3	0.57	0.79	0.99	1.06	1.12	1.21	0.64^{d}
Wax	0.06	0.11	0.27	0.4	0.55	0.67	0.72	0.77	0.81	0.44^{e}
Control	0.39	0.65	0.98	1.13	1.37	1.63	1.88	1.89	cd	1.30^{a}
mean	0.17^{f}	0.27^{f}	0.47^{e}	0.68^{d}	0.91^{c}	1.07^{b}	1.07^{a}	1.15^{a}	1.29^{a}	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s multiple range test.

cd= complete deterioration.

Table (6): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on percentage of weight loss during the storage at 30±5°C.

Treatments	Storage time/ days								
	3	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**mean**
Gum Arabic	0.21	0.31	0.64	0.89	1.36	1.49	1.7	1.75	1.04^{bc}
Gum Arabic+EDTA	0.25	0.36	0.66	0.92	1.38	1.51	1.71	1.77	1.07^{b}
Gum Arabic+*L. paracasei supernatant*	0.19	0.29	0.62	0.88	1.33	1.47	1.69	1.74	1.03^{bc}
Gum Arabic+EDTA+ *L. paracasei* supernatant	0.17	0.25	0.59	0.93	1.28	1.43	1.65	1.69	1.00^{c}
Wax	0.15	0.22	0.5	0.82	1.11	1.25	1.32	1.38	0.84^{d}
Control	0.46	0.775	1.1	1.47	1.83	1.95	cd	cd	1.48^{a}
mean	0.24^{g}	0.37^{f}	0.69^{e}	0.99^{d}	1.39^{c}	1.51^{b}	1.69^{a}	1.74^{a}	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s multiple range test.

cd= complete deterioration.

Total soluble solids percentage (TSS%) of potato tubers was presented in Tables (7) and (8), it was increase proportionally with the increase of storage period for both storage temperatures, where treated tubers significantly retained lower TSS than the control. These results revealed that GA/EDTA/*L. paracasei* edible film supernatant and wax coatings efficiently reduced the rapid changes in TSS.

Table (7): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on percentage of Total Soluble Solids during the storage at 8°C

Treatments	Storage time/ days										
	0	**3**	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**35**	**mean**
Gum Arabic	5.75	5.79	5.87	6.17	6.26	6.33	6.29	6.17	6.19	6.22	6.10[c]
Gum Arabic+EDTA	6.25	6.26	6.38	6.46	6.49	6.34	6.48	6.5	6.53	6.57	6.43[b]
Gum Arabic+*L. paracasei* supernatant	5.81	5.83	5.95	6.09	6.17	5.96	6.07	6.2	6.23	6.38	6.07[c]
Gum Arabic+EDTA+ *L. paracasei* supernatant	5.72	5.75	5.78	5.82	5.83	5.89	5.7	5.69	5.66	5.63	5.75[d]
Wax	5.63	5.64	5.65	5.73	5.74	5.81	5.75	5.71	5.73	5.78	5.72[d]
Control	6.5	6.54	6.66	6.89	7.12	7.2	7.03	6.99	6.95	cd	6.88[a]
mean	5.94[a]	5.97[a]	6.05[a]	6.19[a]	6.27[a]	6.255a	6.22[a]	6.21[a]	6.22[a]	6.26[a]	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s le range test.

cd= complete deterioration.

Table (8): The effect of Gum Arabic edible films, wax film and noncoated (control) potato tubers on percentage of Total Soluble Solids during the storage at 30±5°C

Treatments	Storage time/ days									
	0	**3**	**5**	**7**	**10**	**15**	**20**	**25**	**30**	**mean**
Gum Arabic	5.53	5.56	6.01	6.51	5.95	6.13	6.32	6.4	6.44	6.09^{ab}
Gum Arabic+EDTA	5.62	5.83	6.25	6.25	6.63	6.07	6.18	6.22	6.3	6.15^{ab}
Gum Arabic+*L. paracasei* supernatant	5.7	5.77	5.84	5.91	6.17	6.22	6.18	6.2	6.07	6.01^{ab}
Gum Arabic+EDTA+ *L. paracasei* supernatant	5.67	5.69	5.79	5.85	5.82	6.09	6.22	6.34	6.35	5.98^{ab}
Wax	5.43	5.45	5.6	5.83	5.93	6.18	6.25	6.33	6.36	5.93^{b}
Control	5.67	5.89	6.03	6.15	6.25	6.63	6.85	cd	cd	6.29^{a}
mean	5.60^{c}	5.70^{bc}	5.92^{abc}	6.08^{ab}	6.13^{ab}	6.22^{a}	6.33^{a}	6.34^{a}	6.30^{a}	

Means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan' s multiple range test

cd= complete deterioration

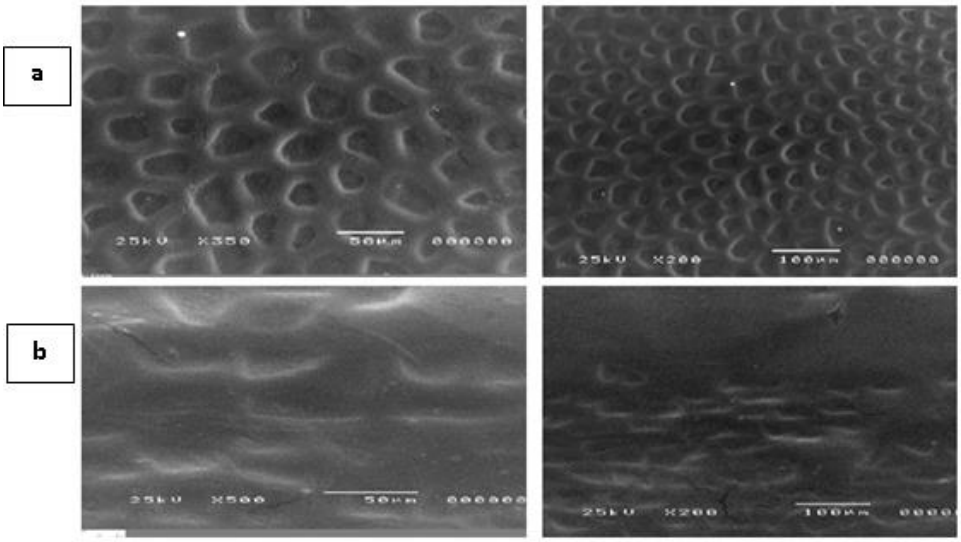

Figure (3): SEM photo of (a) noncoated potato tubers**,** (b) coated potato tuber with GA/EDTA/*L. paracasei* supernatant

Figure (3 a&b) represents pictures of potato tubers' peel which were captured for the best edible film GA/EDTA/*L. paracasei* supernatant by Scanning Electron Microscope (SEM) to study the physical featured of coated potato tubers compared with thenoncoated tubers. Figure (3a) represents noncoated tuber peel, which has district separation, while Figure (3b) showed homogeneity, minimum pores and cracks and better structural continuity of edible coating.

4. Discussion

Food safety and quality is the most important standard for every consumer and also it is the priority for food industry. Edible films/coatings provide edibility, biodegradability, compatibility and eco-friendly food food packaging option instead of petroleum option like wax, especially for ready to eat food like vegetables and fruits.

Contamination of food with spoiled microorganisms reduces its quality;however the existing pathogenic microorganisms present a serious health problem. Temperature, humidity, pH, water as well as carbohydrate content of potato tubers greatly affect the behavior of pathogens. Lazarovits *et al*. [28] reported that about 10^7 CFU/g of the soil lived in potato rhizosphere and geocaulosphere; which is the volume of the soil surrounding the tubers.

Temperature and humidity in general provide a favorable environment for the development of microorganisms. Therefore we investigated the ability of GA,

GA/EDTA, GA/ *L. paracasie* supernatant and GA/EDTA/*L. paracasei* supernatant edible film supernatant/coatings to prevent microbial development in potato tubers both in cold (8°C) and in an ambient temperature (30±5°C). In fact GA/EDTA/*L. paracasei* supernatant coating showed a remarkably inhibitory effect on microbial growth during storage period where cold storage (8°C) helps to extend shelf life of tubers up to 35 days than ambient temperature (30±5°C) that preserve tubers up to 30 days, as shown in Figure (2a,b,c,d,e and f). This synergistic effect against spoiled strains is enhanced by hycolloidal edible coatings such as Gum Arabic that has a protective effect since it acts as a barrier to moisture and gas, also it has antioxidant action [41], and antimicrobial activity against some strains of G-ve, G+ve bacteria, fungi and yeasts [30].

The prepared film (Gum Arabic+EDTA+ *L. paracasei* supernatant) was found to preventboth rooting and sprouting growth at 8°C as shown in Figure (1), since storage of potato tubers at 8–12 °C is common practice, where the accumulation of sugars is minimum and potatoes remain suitable for processing. However, this temperature is suitable for sprout growth. Therefore, use of a sprout suppressant becomes essential. Isopropyl N-(3-chlorophenyl) carbamate (CIPC) is the most commonly used sprout suppressant used in potatoes.This is the most common way of long-term (up to 6 to 9 months) storage of potatoesin tropical, sub-tropical and sub-temperate countries of the world. CIPC belongs to group of pesticides known as carbamates,3-chloroaniline (3-CA) this is considered more polluting and highly toxic to human and environment. CIPC is more harmful to birds, fishes and other aquatic animals, hence its washing contaminate water bodies, environment and worms. There are growing concerns regarding degradation products/metabolites of CIPC as they are more toxic and cytolytic in nature;highly toxic, carcinogenic, cause reduction in ATP synthesis so bring about modifications in cell permeability besides being pollutants [43]. Hence, Application of natural products that applied in the present study may help in solving such problems.

Saha *et al*. [50] investigated the effect of chitosan and whey protein in the quality of potato tubers and extend its shelf life to 60 days at 20°C. Also Marquez *et al*. [37] preserved potato tubers up to 10 days by whey protein/ pectin/ transglutaminase coating that show a significant inhibitory effect on mesophilic colonies growth in all tuber samples. Calcium chloride helps to generate stronger film gel as it affects the

kinetics of gelation , so the steady-state gel strength was reached fastest by $CaCl_2$ [29]. $CaCl_2$ has significant role in plant cell function at various concentrations as delayed the ripening, softening and senescence [18]. It has been also reported to aid in reduction of browning by inhibiting poly phenol oxidase (PPO) which has been demonstrated for potato [8]. The presence of LAB in the matrix that produce antimicrobial substances such as bacteriocins or organic acid, it also decreases pathogen adhesion, promote recovery or enhance stability of commensal microbiota when perturbed and delivered functional enzymes proteins as reported by Gayathri and Ramesha [21], this is supported with Maarof *et al*. [35], who concluded the antimicrobial of probiotic strains isolated from milk products against some common food-borne pathogens as they show bactericidal effect on *E. coli* and *Salmonella spp*. while have bacteriostatic effect on *Staphylococcus aureus*. and against *R. solanacearum*.

Washing with tap water that contains 5mg/L free chlorine has significant effect on spoilage microorganisms. Similar results was obtained by the work of Lu *et al*. [34], who found that the final bacterial number predicted on lettuce treated with chlorinated water was lower than that on non-treated lettuce. This also agrees with that obtained by Rico *et al*. [49], who found that washing with chlorinated water decontaminate vegetables.

EDTA supports and potentiates the sensitivity of Gram negative bacteria to bacteriocin particularly nisin; a propiotics' product [34]. EDTA inhibits bacterial adhesion as it has antimicrobial properties against *P. flourescencs, E. coli, Bacillus sp* and *Proteus sp.*[10]. Trejo-Gonzalez *et al*. [51] also reported its inhibitory effect.

On the other hand the presence of EDTA may causea reduction in GA antimicrobial activity; several mechanisms could be responsible for the antagonistic effect between GA and EDTA. EDTA might prevent GA from being taken up by the cell or vice versa. Alternatively, the interaction between EDTA and GA may prevent GA from reaching its target of its activity or it mayinterfere with its composition or structure its specific activityto be reduced this need further investigation.

The active food packaging include desirable interactions with food, in a way that is related to extending food stability, by interacting with product or headspace inside to prevent, decrease or delay microbial growth onthe food surface [15], in contrast to wax which act as barrier possesses no interaction with theproduct. This gasses exchange barrier blocking the supply of O_2 through the tuber peel needed for

respiration or CO_2releasing, this block causes off-flavor development due to anaerobic fermentation and this is in agreement with the results of previous studies [52].

For pH value in this study, it was noticed that the progress in storage period slightly increases the pH value, the same finding was found by Saha *et al*. [50] on stored potato tubers by chitosan. GA/EDTA/*L. paracasei* supernatant edible film showed better control on pH as well as wax coating during entire storage periods as compared either to other treatments or to the noncoated potato tuber this might be referred to more moisture content, increasing respiration rate and the conversion of organic acids to sugars, which is consumed during storage in some metabolic processes [27].

Weight loss is a quality index of the post-harvest life of tubers. Weight loss of treated potato tubers was significantly lower than untreated tubers during the entire storage periods as represented in Tables (5 and 6), the similar results was reported by Khaliq *et al*. [26], in which weight loss was reduced by GA treatment for mango fruits. This reduction in fresh weight of tubers was attributed to the effect of edible coating that act as a fence against gas exchange and water loss through respiration and transpiration [1,37]. In contrast to noncoated tubers, the increase in weight loss is due to the increase in transpiration process and cellular breakdown of crop samples [13].

Total soluble solids (TSS) percentage is a maturity and quality measurements of tubers. In this study,TSS gradually increased in all samples regardless of treatments as the storage time increase. Similar trend in the results was revealed in mango [31,53] and also previous report by Saha *et al*. [50] on potato tubers. The slight increasing in TSS is due to hydrolysis of potato starch by the action of enzymes into sugars. GA act as barrier to gas exchange, results in delaying the respiration rate and hence hydrolytic enzymes action. This is reflected on carbohydrate consumption that decreasing TSS content and this agrees with Khaliq *et al*. and El-abbasy *et al*. [13,26].

Photos (Figures 3: a&b) of potato tuber peel were captured by scanning electron microscope (SEM) to study the physical structure of coated tubers with the best film, compared to noncoated (control). Figure (3a) represents the noncoated tuber peel which has district separation, while Figure (3b) shows better structure content, homogenization and minimum pores and cracks compared with control. This structure reflects the gelatinized GA matrix dissolved in *L. paracasei* supernatant edible film, that was homogenous but not heavy and the presence of glycerol (plasticizer) provides flexibility, well thickness for the film in addition to a good moisture content, this was

agreed with Adjoumar *et al*. [3] in cassava film that was homogenous, crack free, transparent due to glycerol content.

5. Conclusion

From this study we can conclude that the combination of Gum Arabic, EDTA and *L. paracasei* supernatant edible film can be used as an alternative choice for petroleum products (wax) to keep potato tubers as a safe, environmentally friendly, and in reducing microbial load in comparison with petroleum product as wax.

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7. Conflict of Interest

The authors have declared no conflict of interest.

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الملخص العربى

تطبيق الصمغ العربي كأغشية صالحة للأكل في حفظ ما بعد الحصاد وجودة درنات البطاطس

رواء بلال غنام[1] ، شيماء محمد عبد السلام[2]، عفاف علي أمين[1]، مها أمين هويدي[2]

1: قسم صحة الطعام- وحدة الميكروبيولوجي- المعهد القومي للتغذية – القاهرة - مصر

2: قسم النبات - كلية البنات للآداب والعلوم والتربية -جامعة عين شمس- القاهرة- مصر

الملخص

تستخدم المواد الغروية على نطاق واسع في صناعة المواد الغذائية، وقد تم استخدامها مؤخرًا وخاصة الصمغ العربي (GA) على نطاق واسع كأغشية / أغلفة قابلة للأكل لتمديد فترة صلاحيةالفاكهة والخضراوات بعد الحصاد.

الهدف من هذه الدراسة هو تقييم تأثير غشاء الصمغ العربي(GA)القابل للأكل ممزوجا بالجلسرين و كلوريد الكالسيوم ($Cacl_2$) كمكونان أساسيان مع جميع أفلام الصمغ العربي وثلاث معاملات مختلفة من GA مع EDTA و *L. paracasei*supernatant وذلك ع النحو التالي:(GA / EDTA) (، (GA / *L. paracasei* supernatant) و GA / EDTA / *L. paracasei* supernatant)في الحفاظ على درنات البطاطس المخزنة عند 8 درجات مئوية و 30 ± 5 درجة مئوية لمدة 35 يومًا مقارنة بالشمع (الغلاف البترولي المستخدم كمادة حفظ). التحليلات الفيزيائية والكيميائية بما في ذلك الأس الهيدروجيني ونسبة فقدان الوزن ونسبة المواد الصلبة الذائبة الكلية (TSS) ، وكذلك الفحوصات الميكروبية (العد الكلي لكل منالبكتيريا ، الفطريات و الخمائرومجموعة البكتيريا المعوية).

أظهرت النتائج أن الفيلم المكون منsupernatantGA / EDTA / *L. paracasei* أعطى أفضلالنتائج والتي كانت قريبة جدًا لنتائجالغلاف البترولي (الشمع) مقارنة بالدرنات غير المغلفة (الضابطة) والتي غلفت بالافلام ذات المعاملات الاخرى ،وقد كان ذلك واضحا من خلال انخفاض الحمل الميكروبي ، و تقليل فقدان الوزن ، كذلك تقليل إجمالي المواد الصلبة الذائبة ، مما أدى الى تحكم أفضل في الأس الهيدروجيني وزيادة فترة الصلاحية.