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Impact of propolis as a bio-product on pepper plants productivity and their fruits at shelf-life period

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Abstract

Two experiments were conducted to investigate the influence of propolis ethanolic extract (PEE) on development and productivity of sweet pepper plants in the first experiment and both of PEE and propolis aqueous extract (PAE) through fruit shelf life at room temperature during June of seasons 2019 and 2020 for 7 days in the second experiment. The concentrations of the two extracts were 3%, 6%, 9% and 12%. The results indicated that PEE at concentrate 9% was sufficient to obtain maximum values of vegetative growth yield characters i.e., fruit diameter, average fruit weight and total yield/feddan except plant dry weight which registered highly values with level 6%. The augment results for chemical fruit content i.e., TSS and ascorbic acid were obtained by the application of 12% of PEE. Data also indicated in the second experiment after shelf life period that PEE and PAE at concentrate 12% was significantly able to obtain the least percentage of fruit physical characters expressed as fruit weight, length and diameter especially PEE which was most superior to PAE. Concerning fruit chemical contents, dipping the fruits in the high concentrate 12% of PEE was the most effective in reducing the increase of TSS, while the same concentrate of PAE had the ability to reduce loss of ascorbic acid. On the other hand, both of two extracts PEE and PAE at high level 12% resulted in reduced fruit deterioration percentage in treated fruits especially those produced from plants that were treated by the same level (12%) in comparison with control treatment.

Keywords: Propolis; Sweet pepper; Fruit production; Chemical content; Shelf life period

1. Introduction

Sweet pepper (*Capsicum annuum* L.) is an important agricultural crop, not only for its economic importance, excellent source of ascorbic acid, contains high nutritive values but also for its export potentiality. Pepper is usually exposed to unsuitable conditions as high temperature and relative humidity during transportation and selling especially in hot seasons i.e., June, July and August result in higher respiration rates, shorter storage period which causes loss of fruit quality and quick deterioration [1]. Pepper fruit shelf life can't be extended for a long time due to their inherent compositional and textural characteristics [2]. In Egypt, pepper fruits are sold without packing on wooden shelves into some local markets in uncontrolled conditions. For extending pepper post-harvest longevity several materials are used in the coating formulations including polysaccharides, proteins, lipids, resins, hydroxypropyl methylcellulose and beeswax [3]. Coating by these procedures provides protection against weight loss and increases fruit shelf life [4] The effectiveness of the coating method improves fruit shelf life depending on thickness and the type of coating material [5]. Propolis is a natural resin substance (wax-like) in a sticky exudates form, collected by honeybees from various plants such as poplar, palm, pine and from leaf buds then mixed with salivary enzymatic secretions and pollen [6,7,8,9]. Propolis varies in its color from light yellow, green and dark brown [10], this bio-product has several benefits inside beehive as it use as a cementing material to fill cracks, sealing the spaces, maintained the temperature and humidity, moreover use as an antiseptic to protect the bees larvae and comb from microbial infections [11,12,13]. Propolis was

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described as composed of more than 300 components, the diversity of these compositions depending on the geographical region, time and methods of harvesting and the solvent which was used in extractions [14]. Most of these compounds play an important role in activating many physiological processes in the plant [15]. Propolis also contains several important minerals i.e., Ca, Zn, Fe, K, Na and Mg. beside to amino acids and vitamins particularly (B_1, B_2, B_6, C, E), sugars, polyphenol which include (flavonoids, phenolic acids and esters), terpenoids which consider the precursors of many phytohormones such as gibberellins which are necessary for growing plants [16,17,18,19,20,21]. Propolis was used as an anti-bacterial, anti-fungal, anti-viral anti-oxidant, anti-mutagenic during the 17th and 20th century in Europe and China [22,23,24]. Early Egyptians used propolis to preserve their corpses from decomposition [25,26]. Many studies have proven the useful impact of propolis extract on growth, yield, and chemical constituents of plants and fruit shelf life extending accordingly on several species of plants [27,28,29]. The aim of this study is to use the propolis as bio-stimulants to enhance pepper plant growth and produce abundance yield, in addition to use the propolis extracts as fruit protection coating to extend its quality and shelf life.

2. Material and methods

2.1 Preparation of propolis extracts.

Fine ground propolis was brought from Faculty of Agriculture, Fayoum University, Egypt. The propolis was solvent by use two methods whereas, two equal weights (25gm) of propolis fine ground were putted in glass bottle, in first weight the glass volume was completed to 250ml by ethanol 95%, to receive propolis ethanolic crude extract and anther weight was completed by hot water 40°C to obtain propolis aqueous crude extract. The different crude extracts are left at room temperature for 7 days and stir by hand for 1 min once every day as described by Carvalho et al., 2013) [30]. Then, the crude extracts were filtered by (Whatman No 1) filter paper. The required concentrations were prepared from the two filtered extracts. 30, 60, 90 and 120ml were taken and diluted by 970, 940, 910 and 880ml distilled water to reach the concentrate of (3, 6, 9 and 12%) respectively. The propolis ethanolic extract (PEE) was used as foliar spray during pepper plant development in the first experiment. Meanwhile, both propolis ethanolic extract PEE and aqueous extracts PAE were used in the pepper fruit postharvest conservation experiment. The chemical composition of PEE was registered as follows Ca= 915 mg/kg P= 89 mg/kg, K= 368 mg/kg, Mg= 212 mg/kg, Fe= 124 mg/kg and protein 6.2 g/100 g.

The chemical composition of PAE was registered as follows: Ca= 328 mg/kg P= 37 mg/kg, K_2O= 65 mg/kg, Mg= 0.1%, Fe= 72 mg/kg and protein= 0.8 g/100 g.

2.2 First experiment: Effects of Propolis Ethanolic Extract (PEE) on pepper plant development

Table 1 Soil physical and chemical analyses.

Soil physical analyses				Soil chemical analyses																
Text.	Sand (%)	Silt (%)	Loam (%)	pH	E.C. (dSm^{-1})	$CaCo_3$ (%)	Soluble cations (M/L)				Soluble anions (M/L)			Macro elements (ppm)		Micro Elements (ppm)				
							Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	HCO^{-3}	Cl^{-2}	SO_4^{-2}	N	P	K	Fe	Cu	Zn	Mn
Sandy loam	80.3	2.0	17.6	8.4	0.2	5.2	1.0	0.5	0.3	0.2	0.2	0.5	1.3	40	66	40	3.0	0.8	1.0	1.5

The present investigation was conducted at the experimental farm of El-kassasein Station Farm, Ismailia governorate, Horticulture Research Institute, Agriculture Research Center during summer seasons of 2019 1nd 2020. Seeds of sweet pepper C.V. (Super Star) F 1, (Makka Company for Agriculture Seeds, Cairo) were sown in the nursery at the second week of February during the both growing seasons. After 45 day from sowing, healthy seedlings were selected and transplanted in the open field at 25 cm apart in one side of the ridge. The plot area was (9.8 m^2) includes 4 ridges (3.5 m length and 0.7 m width). The uniform of cattle manure 20 m^3/feddan was added to the soil before 3 days of transplanting, other fertilizers and agricultural practices were done according to the recommendation of the Ministry of Agriculture of pepper plants in open field. The experiment was laid out in a randomized complete block design with three replicates. After 30 days from transplanting the plants were sprayed every 15 days interval (5 times spraying) by different propolis ethanolic extract PEE concentrations i.e., 0, 3, 6, 9 and 12% using a hand pressure sprayer. Random

soil samples were taken before planting for chemical and mechanical analysis as described by [31,32]. The farm had a sandy loam soil texture; physical and chemical analyses were shown in Table (1).

2.2.1 Data recorded

- Vegetative growth parameters

A sample of five plants were chosen and taken randomly from each plot at the flowering stage in order to determine plant length (cm), number of branches per plant as well as fresh weight (g), then plants were dried at 70 °C till constant weight to calculate plant dry weight (g) as illustrated by [33]. Total leaf chlorophyll content was measured from the fourth upper leaves using Minolta chlorophyll meter SPAD-501 as SPAD units.

- Fruit yield and its quality

A sample of five sweet pepper fruits at edible stage were randomly taken from each plot at the second picking to determine the following data: fruit length (cm), fruit diameter (cm), average fruit weight (g). The total fruit yield (ton/feddan) was estimated (the weight of the all pickings). A random sample of other three fruits from each plot was taken and dried at 70 °C till constant weight and the dry weight of fruit was determined using the standard methods as illustrated by [33].

- Fruit chemical content

A sample of five sweet pepper fruits at edible stage were randomly taken from each plot at the second picking to determined total ascorbic acid (Vitamin C, mg/100 g fresh weight) content was determined using 2, 6 dichlorophenol indophenols, method as described by [34]. Total soluble solids (TSS) of fruit were measured by a hand held refractometer (ATAGOS 28 E model). TSS value was expressed as oBrix.

2.3 Second experiment: Effects of Propolis Ethanolic Extract (PEE) and Propolis Aqueous Extract (PAE) on fruit pepper after shelf-life period

Table 2 Mean of meteorological data during the experiment period in the seasons of 2019 and 2020

June	**Average temperature ^{0}C**				**Relative humidity (RH %)**	
Experimental days	**Max.**	**Min.**	**Max.**	**Min.**		
	2019		**2020**		**2019**	**2020**
First day	35	20	38	23	35	28
The second day	36	20	35	24	38	29
The third day	34	19	34	21	43	32
The fourth day	36	21	34	21	42	33
The Fifth day	36	20	32	20	35	35
The sixth day	35	22	34	22	38	34
The seventh day	36	22	35	23	40	34

Source: Agricultural Research Center, Central Laboratory for Agricultural Climate, Ministry of Agricultural and Land Reclamation.

This experiment was conducted in the laboratory Department, Horticultural Research Institute, Giza Governorate. Sweet pepper fruits at edible stage from second biking were chosen and randomly divided into two groups, each group contain 450 fruits, first group were dipping into the PEE extract meanwhile second group were dipping into the PAE extract at different concentrations (0, 3, 6, 9 and 12%) for each extract, 90 fruits were soaked individually for 30 seconds in each concentrate (30 fruits per each replicate). After that the fruits were lifted at room temperature and lasted on the shelves for 7 days from June month. The experiment was arranged in a completely randomized design with 3 replicates.

The temperature and relative humidity the period of shelf life were registered in Table (2).

2.3.1 Fruits physical characters

The different parameters were conducted on five constant sweet pepper randomly chosen from each concentrate. The measurements were started at day zero and in each two days from the experimental period then, in the end of the postharvest conservation the data were computed according to [35]as follow:

- Weight loss % = (Initial weight – final weight)/ initial weight x 100.
- Length loss % = (Initial length – final length)/ initial length x 100.
- Diameter loss % = (Initial diameter – final diameter)/ initial diameter x 100.

2.3.2 Fruit chemical content

Five fruits of sweet pepper from each treatment of previous experiment were randomly taken to measure both of initial TSS and ascorbic acid at day zero of postharvest conservation experiment. In the end of shelf life period another five fruits from each concentrate of PEE and PAE were randomly chosen to record the final TSS and ascorbic acid in treated fruits. The data were computed as follows: Total ascorbic acid (Vitamin C, mg/100 g fresh weight) content was determined using 2, 6 dichlorophenol indophenols, method as described by [34].

- Ascorbic acid loss % = (Initial ascorbic acid– final ascorbic acid)/ initial ascorbic acid x 100 according to [35]
- Total soluble solid (TSS) of fruit were measured by hand held refractometer (ATAGOS 28 E model). TSS value was expressed as Brix.
- The total soluble solid % = (Initial TSS – final TSS)/ initial TSS x 100 according to [35]

2.3.3 Deterioration fruits

Physiological disorders, fungal decay and fruit rot visually observed each two days interval the symptoms are considered as deterioration fruits. The incidence of physiological disorders was determined when injury covered more than 15% of the fruit surface.

Deteriorated fruits % = (The total number of deteriorated fruits)/ the total number of fruits) x 100 [36,37].

2.4 Statistical analysis

All data were subjected to statistical analysis according to the procedures reported by [38] using a split plot design system. Statistix 8 program and means were compared by L.S.D multiple range tests at the 0.05 level of probability in the two seasons of experimentation.

3. Results and discussion

3.1 First experiment: Effects of Propolis Ethanolic Extract (PEE) on pepper plant development.

3.1.1 Vegetative growth parameters

Data in Table (3) revealed that all pepper vegetative growth expressed as plant length, number of branches, fresh weight, chlorophyll content were appeared significantly positive response to propolis ethanolic extract PEE compare to the control especially the concentrate of 9% (T4) except plant dry weight parameter which recorded high result with concentrate 6% (T3). These results may return to the capability of PEE in forming wax layers on plant leaves which accumulate with the foliar spray repetition resulting in reduced water loss from leaves. So this phenomenon explains the observed boost in pepper fresh weight which occurred with concentrate 9% of PEE. Moreover, with the same level high chlorophyll *content was registered, thereby returning on vigorous vegetative growth i.e., plant length and number of* branches/plant. The positive effect of PEE on pepper leaves chlorophyll content may be returned to the accumulation of Mg in pepper leaves by using PEE applications as reported by [39]). It is known that Mg considers the principal element in the structure of chlorophyll [40] and is present in almost all the enzymes responsible for metabolism and growth of plants [41] Thus, enhance the levels of photosynthesis which reflects on plant growth [42]. Other studies attributed the organizer role of propolis to its high levels of biochemical compounds beside it's contain a large amount of antioxidants that prevent the damage of plant and maintain plant growth [43,44,45]. From another view, the role of propolis foliar spray as enhancer plant growth probably returned to two reasons first, the rising indoles portion inside plants treated by propolis that stimulate an increase cell division and enlargement as reported by [28,46]. Second, propolis treatment enhances plant metabolism because of the presence of a high amount of terpenoids, amino acids,

several phenols groups and antioxidants in PEE chemical components [47]. Thus, these components improve and provide vigorous plant growth. Our results were confirmed with [48,49,50].

Table 3 Pepper vegetative growth as affected by propolis ethanolic extract foliar spray in the two growing seasons of 2019 and 2020

Treatments	1st Season					2nd Season				
	Plant length (cm)	No. of branches /plant	Fresh weight (g)	Dry weight (%)	Cholorophyll (Spad)	Plant length (cm)	No. of branches /plant	Fresh weight. (g)	Dry weight (%)	Cholorophyll (Spad)
T1	40.44	20.33	221.33	17.00	55.90	47.52	24.33	240.17	19.00	50.19
T2	42.00	20.66	231.33	18.33	54.06	52.30	26.33	245.09	19.33	50.52
T3	48.43	28.00	246.33	23.00	58.32	58.70	31.66	260.69	25.66	54.36
T4	58.47	31.33	263.00	19.33	62.700	62.48	36.66	284.73	21.21	59.97
T5	39.00	18.33	219.75	19.00	59.09	41.38	20.33	227.15	19.66	54.10
L.S.D at 5%	3.43	1.97	3.37	1.61	3.33	2.63	2.28	4.41	1.53	1.13

T1: Plants treated by tap water (control treatment); T2: Plants treated by PEE at concentrate 3%; T3: Plants treated by PEE at concentrate 6%. T4: Plants treated by PEE at concentrate 9%; T5: Plants treated by PEE at concentrate 12%

3.1.2 Fruit yield and its quality

Table 4 Pepper fruit yield and its physical quality as affected by PEE foliar spray in the two growing seasons of 2019 and 2020

Treatments	1st Season					2nd Season				
	Fruit length (cm)	Fruit diameter (cm)	Ave. fruit weight (g)	Fruit dry weight (%)	Total yield ton/ feddan	Fruit length (cm)	Fruit diameter (cm)	Ave. fruit weight (g)	Fruit dry weight (%)	Total yield ton/ feddan
T1	8.23	3.34	35.02	7.21	9.72	8.49	3.56	38.17	7.30	9.98
T2	8.30	3.44	39.61	7.52	9.78	8.45	3.80	42.85	7.33	10.16
T3	8.50	3.89	41.87	8.18	9.86	8.52	4.15	48.00	8.34	10.33
T4	8.57	4.41	48.69	8.03	10.13	8.71	4.43	51.02	8.29	10.68
T5	8.28	3.61	36.27	6.94	9.81	8.62	3.47	36.70	7.05	10.19
L.S.D at 5%	0.41	0.20	2.16	0.24	0.12	0.28	0.16	1.48	0.32	0.09

T1: Fruits produced from plants treated by tap water (control treatment); T2: Fruits produced from plants treated by PEE at concentrate 3%; T3: Fruits produced from plants treated by PEE at concentrate 6%; T4: Fruits produced from plants treated by PEE at concentrate 9%; T5: Fruits produced from plants treated by PEE at concentrate 12%.

Data in Table (4) showed that the boosted values of fruit diameter and average fruit weight in addition to the total yield/feddan were significantly evident by fruits produced from plants treated by PEE at concentrate 9% (T4) compared with other levels or control treatment (tap water). Meanwhile, PEE different concentrations i.e., 3%, 6%, 9% and 12% beside 0% (control treatment) did not significantly differ with respect to fruit length. Data also clear that the highest result of fruit dry weight was achieved by concentrate 6% (T3) of PEE with no significant difference with concentrate 9% (Table, 4). The encouragement of PEE at concentrate 9% that our results showed on fruit diameter and average weight beside to total yield might be due to promoted availability of micro and macronutrients [51] the presence of a high content of nutrient and active components in PEE [52] and as mentioned in the chemical composition of PEE (material and method section) authorize the pepper plants to grow healthy promoted yield abundance and enhancer fruit physical quality. In agreement with our findings, other studies reported that the high yield of the plants treated with propolis extract is related to its vegetative vigorous growth, as propolis enhance plant metabolism which

ultimately leads to high production [17], also these results are confirm with which finding by [50]) who deduced that propolis as foliar application resulting in highest tomato fruit weight and total yield.

3.1.3 Fruit chemical content

As shown in Table (5) both of total soluble solids and ascorbic acid content in fruits were response to PEE treatments where, increased linearly with an increase in PEE levels from 3% to 12%. The significant differences were observed for mean values of ascorbic acid in the first season and TSS in the two seasons from this concern, the higher fruit content of TSS and ascorbic acid were resulted by 12% concentration in two seasons. Meanwhile, the lower results were recorded with control treatment (T1). TSS are one of the main components that determines food taste. maintaining a reasonable content of total soluble solids in the fruits is highly important for keeping the acceptability of the foods by the consumers [53]. This positive results of propolis influence extract PEE on fruit TSS content may be due to that it has a very rich chemical composition, specifically its phenolic compounds, flavonoids, vitamins, enzymes, heteroaromatic compounds, minerals, terpene and has a high antioxidant [54,55] however antioxidant activity is an important example of functional benefits of plants which directly scavenge free radicals and prevent/reduce the oxidation of lipids, proteins, DNA, or other molecules and/or indirectly prevent the formation of free radicals [56], causing plants in healthy growth and certainly produced fruits with high chemical content of TSS and ascorbic acid. These results are closely with those findings by [49] on spinach and [50] who revealed that the maximum total soluble solids (TSS) in tomato fruits were recorded with plants sprayed by salicylic acid combined with propolis at concentrate100 mg/mL^{-1}.

Table 5 Effect of PEE at different concentrations on pepper fruit chemical content of total soluble solids and ascorbic acid in the two growing seasons of 2019 and 2020

Treatments	1st Season		2nd Season	
	Total soluble solids (°Brix)	Ascorbic acid (mg/100g F.W)	Total soluble solids (°Brix)	Ascorbic acid (mg/100g F.W)
T1	2.45	160.67	3.03	168.33
T2	2.86	167.00	3.20	171.00
T3	3.14	173.67	3.42	172.67
T4	3.57	178.00	3.69	175.67
T5	4.12	180.90	3.88	177.60
L.S.D at 5%	0.20	2.73	0.16	2.27

T1: Fruits produced from plants treated by tap water (control treatment); T2: Fruits produced from plants treated by PEE at concentrate 3%; T3: Fruits produced from plants treated by PEE at concentrate 6%; T4: Fruits produced from plants treated by PEE at concentrate 9%; T5: Fruits produced from plants treated by PEE at concentrate 12%

3.2 Second experiment: Effects of Propolis Ethanolic Extract (PEE) and Propolis Aqueous Extract (PAE) on fruits pepper after shelf-life period

3.2.1 Fruits physical characters

Data in Table (6) showed the capability of PEE and PAE at different concentrations to reduce the percentage of loss fruit physical characters i.e., weight, length and diameter after the shelf life period, Where, the higher concentrate (12%) of both extracts significantly delays all fruit loss of physical measurements especially those fruits obtained from plants treated with the same level (T5). So the highest mean values of above parameters were observed with control (0 concentrate). It is noteworthy to note that the loss percentage in both fruit weigh and length were moderately small with level 12%, but in case of fruit diameter the loss percentage values were greater which, registered 4.72% and 5.03% with PEE and 7.00% and 6.14% with PAE (T5, treatment) in the two seasons respectively. Also, PAE as bio-coating could be able to achieve lowering loss of fruit physical characters but not efficient as PEE (Table, 6). The foregoing results may be attributed to forming a biodegradable semipermeable film on the surface of treated fruit composed by the hydrophobic component in propolis extracts that might limit water loss and gas exchange in various fruits as reported by [57].. Thus, it preserves the appearance of the fruits and reduces its progression toward deterioration represented by rapid loss in fruit physical parameters. Our results are in agreement with the findings of [58] who reported that bio-coating treatments might form a protective layer around fruit cellular-membranes, which may delay fruit peak. He added the favorable effects of bio-coating in reducing loss in fruit weight, length and diameter could be due to the blockage of stomata and guard cells that ultimately slowed down the active metabolic processes such as transpiration

and respiration in treated fruit. Meanwhile, as reported by [59] these effects may be returned to that fruits treated by bio-coating might have developed resistance against compositional changes in cell wall and moisture loss, thereby resulting in reduced softening. Also, have inhibited pectin enzyme by slowing down the metabolic processes and keeping fruit firmer. Furthermore, [60] reported that edible coatings act as a barrier to water vapor and gasses. These coatings have antimicrobial or antioxidant properties that reduce the decay without influencing quality. Also, they act as the best alternatives to natural coverings by improving external appearance and changing internal atmosphere, which ultimately influences the shelf life and prevents disorganization of cell membranes [61]. Our findings are in accordance with [62,63,64] on tomatoes.

Table 6 Effects of PEE and PAE at different concentrations on pepper fruit weight, length and diameter losses percentage after shelf life period in the two growing seasons of 2019 and 2020

Treatments	1st Season					2nd Season				
	PEE concentrations									
	Weight loss percentage									
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	5.83	3.79	3.35	3.07	1.87	6.18	3.65	3.00	2.60	1.67
T2	5.19	3.67	3.12	2.87	1.74	5.83	3.33	2.80	2.41	1.83
T3	4.41	3.19	2.41	2.33	1.59	4.63	3.07	2.64	2.16	1.52
T4	4.18	2.62	2.36	2.21	1.50	4.06	2.53	2.20	2.00	1.32
T5	3.69	2.53	2.28	2.02	1.34	3.82	2.25	2.08	1.93	1.25
L.S.D at 5%	0.23	0.06	0.05	0.11	0.08	0.20	0.13	0.06	0.07	0.06
Length loss percentage										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	5.33	4.28	3.96	3.72	2.22	4.89	4.05	3.72	3.68	2.09
T2	4.69	3.73	3.68	3.28	1.91	4.37	3.42	3.31	3.28	1.70
T3	4.46	3.50	3.38	3.11	1.77	4.11	3.29	3.13	2.86	1.54
T4	4.21	3.27	3.22	3.00	1.55	3.87	3.16	2.77	2.35	1.39
T5	3.17	3.13	3.00	2.73	1.36	3.41	2.94	2.42	2.15	1.33
L.S.D at 5%	0.22	0.09	0.15	0.11	0.13	0.19	0.12	0.14	0.11	0.05
Diameter loss percentage										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	13.52	9.15	7.26	6.94	6.61	13.79	8.27	7.03	6.72	5.65
T2	11.53	8.22	7.05	6.60	6.22	13.42	8.03	6.76	5.92	5.52
T3	10.54	8.07	6.86	6.34	5.73	10.45	7.50	6.65	5.62	5.39
T4	9.62	7.43	6.55	5.58	5.32	9.00	7.15	6.18	5.49	5.26
T5	8.97	7.32	6.20	5.13	4.72	8.18	7.09	5.38	5.12	5.03
L.S.D at 5%	0.31	0.10	0.19	0.25	0.39	0.61	0.05	0.17	0.20	0.12
PAE concentrations										
Treatments	Weight loss percentage									
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	5.83	5.34	5.09	4.74	4.30	6.18	5.98	5.64	5.12	3.42

T2	5.19	4.80	4.66	4.40	3.77	5.83	5.50	5.03	4.30	3.21
T3	4.41	4.36	4.22	4.06	3.27	4.63	4.14	4.12	3.88	2.63
T4	4.18	3.94	3.78	3.38	2.68	4.06	3.83	3.71	3.49	2.10
T5	3.69	3.50	3.32	2.80	2.15	3.82	3.23	3.07	3.05	1.75
L.S.D at 5%	0.23	0.41	0.43	0.33	0.49	0.20	0.25	0.30	0.34	0.21
Length loss percentage										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	5.33	5.11	4.95	4.17	3.70	4.89	4.48	4.35	4.01	3.84
T2	4.69	4.50	4.66	3.76	3.47	4.37	4.26	4.13	3.65	3.53
T3	4.46	4.22	3.42	3.17	3.23	4.11	4.06	3.94	3.39	3.08
T4	4.21	3.44	3.21	2.75	2.70	3.87	3.57	3.23	3.13	2.39
T5	3.17	3.10	2.86	2.43	2.14	3.41	3.35	3.07	2.61	2.13
L.S.D at 5%	0.22	0.28	0.21	0.23	0.23	0.19	0.20	0.15	0.24	0.22
Diameter loss percentage										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	13.52	10.50	10.47	9.78	9.46	13.79	11.36	10.18	9.91	9.31
T2	11.53	9.80	9.03	8.41	9.26	13.42	9.95	9.56	9.50	8.72
T3	10.54	9.23	8.17	8.15	7.55	10.45	9.41	8.76	8.57	8.12
T4	9.62	8.62	7.82	7.40	7.35	9.00	8.91	8.07	8.00	6.70
T5	8.97	8.06	7.43	7.09	7.00	8.18	7.98	7.52	7.18	6.14
L.S.D at 5%	0.31	0.54	0.16	0.22	0.17	0.61	0.50	0.27	0.41	0.34

T1: Fruits produced from plants treated by tap water (control treatment); T2: Fruits produced from plants treated by PEE at concentrate 3%; T3: Fruits produced from plants treated by PEE at concentrate 6%; T4: Fruits produced from plants treated by PEE at concentrate 9%; T5: Fruits produced from plants treated by PEE at concentrate 12%.

3.2.2 Fruit chemical content

With regard to fruit chemical content expressed as TSS and ascorbic acid data in Table (7) showed that the gradient in the concentrations from 6% to 12% of PEE and PAE treatments were lead to a decrease in the percentage of TSS increases and loss of ascorbic acid in the end of shelf life period. In addition this effect becomes clear with fruits resulting from plants which were treated previously in the first experiment with high concentrate (12%) from this concern, the highest fruit content of TSS and loss percentage of ascorbic acid were obtained with control treatment (0 concentrate). Data also cleared that PEE at 12% was more efficient than PAE to lower increasing fruit content of TSS while PAE was superior and effective in detecting minimum loss of ascorbic acid in two seasons. These observations may be attributed to that fruit metabolites are continuing during post-harvest period due to the respiration processes therefore accelerates the deterioration of the fruits and losses quality [65] which conclude external quality, internal quality and hidden quality i.e., nutritional status and safety as reported by [66].

The propolis mechanisms to prevents fruit from reaching to deterioration stage is due to its hydrophobic composites and high phenolic concentration which provides a capability to form a semipermeable and biodegradable barrier around fruit therapy prevents the movement of water and gasses through fruit surface, which in turn reduce the transpiration and respiration which improve fruit shelf life [67]. In our results both of PEE and PAE at different levels were delayed peak of fruit chemical content expressed as TSS and ascorbic acid in treated fruits which indicated that different coatings could inhibit the senescence and the PEE was most effective in this regard, but the high rate fruit content of TSS in control treatment may be returned to rapid loss of water from fruit surface, firmness loss and

conversion of complex polysaccharides and pectin substances into sugars [68] compared to treated fruits with varied levels of PEE and PAE.

Table 7 Effect of PEE and PAE at different concentrations on total soluble solids increasing percentage and ascorbic acid loss percentage of pepper fruits content after shelf life period in the seasons of 2019 and 2020

Treatments	1st Season					2nd Season				
	TSS increasing percentage									
	PEE concentrations									
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	13.40	10.83	9.01	7.38	4.91	13.74	10.05	7.40	6.92	4.39
T2	12.90	9.27	7.62	6.40	4.21	13.27	9.37	6.89	6.45	3.55
T3	12.38	8.51	7.33	6.15	3.45	12.81	7.76	6.47	6.00	3.23
T4	11.88	7.79	6.53	5.82	2.41	11.98	7.33	5.87	5.45	2.64
T5	11.22	7.56	5.22	1.64	1.50	10.54	6.52	5.46	4.57	2.10
L.S.D at 5%	0.48	0.19	0.28	0.20	0.23	0.34	0.40	0.36	0.42	0.17
PAE concentrations										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	13.40	10.21	8.49	5.48	5.19	13.74	10.15	8.60	6.42	6.10
T2	12.90	9.43	7.49	4.93	4.69	13.27	7.97	8.20	6.05	5.67
T3	12.38	6.82	6.35	4.37	3.89	12.81	6.08	6.51	4.29	4.67
T4	11.88	5.22	5.50	3.08	3.23	11.98	4.93	5.15	3.70	3.21
T5	11.22	3.73	3.66	2.51	1.77	10.54	3.70	4.12	3.05	2.25
L.S.D at 5%	0.48	0.64	0.59	0.31	0.19	0.34	0.21	0.39	0.26	0.40
Ascorbic acid losses percentage										
Treatments	PEE concentrations									
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	14.30	9.52	6.75	6.24	5.69	16.89	10.07	8.80	7.41	5.45
T2	13.68	7.23	6.23	5.03	4.32	14.41	7.87	7.81	5.90	4.05
T3	12.90	6.70	5.32	4.52	3.91	13.80	7.34	7.21	5.26	3.41
T4	12.18	6.18	4.64	4.00	3.55	12.87	6.74	5.76	4.39	2.49
T5	10.15	5.11	4.09	2.69	2.95	10.76	6.31	4.73	3.59	1.43
L.S.D at 5%	0.61	0.45	0.50	0.38	0.32	0.56	0.35	0.49	0.62	0.30
PAE concentrations										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	14.30	11.28	8.45	8.78	5.68	16.89	9.69	8.03	7.80	5.31
T2	13.68	10.45	8.00	7.15	4.33	14.41	8.90	6.86	7.25	4.26
T3	12.90	9.09	7.31	5.84	1.75	13.80	8.36	6.46	6.35	2.52
T4	12.18	7.81	6.48	5.36	1.51	12.87	7.08	5.80	5.27	1.98
T5	10.15	4.48	3.20	2.41	1.27	10.76	4.35	3.68	2.33	1.16
L.S.D at 5%	0.61	0.73	0.43	0.26	0.20	0.56	0.45	0.40	0.54	0.38

T1: Fruits produced from plants treated by tap water (control treatment); T2: Fruits produced from plants treated by PEE at concentrate 3%; T3: Fruits produced from plants treated by PEE at concentrate 6%; T4: Fruits produced from plants treated by PEE at concentrate 9%; T5: Fruits produced from plants treated by PEE at concentrate 12%.

Moreover, in this experiment sweet pepper fruits have been spent the shelf life period under room temperature which was very high as shown in Table (2) as state by [69] temperature is the most effective tool in maintaining the quality and extending the shelf life of fresh horticultural crops such as sweet pepper from this concern we can say that availability of high temperature conditions was the reason in rise fruit respiration causes its progression towards deterioration represented by increasing both fruit TSS content and loss percentage of ascorbic acid in control treatment. Our results are in line with searches that approved PEE different treatment, especially at high concentrate delayed TSS increases in treated fruits [63,70] on tomato. Moreover, maintained quality and extended shelf life of different fruits such as cherry [71]. Vitamin C (ascorbic acid) is an important water soluble compound, easily oxidized [72]. The decrease in ascorbic acid could be attributed to the increased respiration, degradation during metabolic processes or through enzymatic oxidation of L-ascorbic acid to dehydro ascorbic acid by oxidizing enzymes like ascorbic acid oxidase, peroxidase, and catalase and polyphenol oxidase. [73,74]. Bio-coating application might have reduced oxidation of acids, thus resulting in higher values of ascorbic acid content [75]. In our experiment the loss is enhanced by PEE and PAE treatments, especially at high level 12% which retained lower loss percentage/or higher vitamin C concentrate during shelf life compared with the control treatment. This result is closely with that found by [58] who reported that minimum loss in ascorbic acid contents was obtained in bell pepper fruits treated with 12% of the bio-coating; the same results were summarized by [76]. Such effects might be due to the general preservative effects of propolis as an antioxidant [24], accordingly [53] the antioxidant activity of the fruits during storage is an important parameter and always needs to be at higher levels. Propolis treatments have a positive influence on the prevention of the antioxidant activity in fruit. Also, lead to modification of the internal atmosphere of fruit generated by propolis film surrounding the fruit surface [57]. The results in the Table (7) confirmed the superiority of propolis ethanolic extract PEE in reduce the increasing of TSS in treated fruits by level 12% compared with propolis aqueous extract PAE the possibility explain this result is that ethanol at concentrate 70% can dissolve approximately 50-70% of propolis active components i.e., flavonoid, phenols, terpenes, fatty acids, alkaloids, amino acids, antioxidants and other compounds [52]. However, propolis water extract contains less quantity of above active components [77] this is due to water's ability to dissolve a small part about 10% only of propolis constituents [78]. So a huge quantity of active components in PEE maintained fruit chemical content and delayed fruit deterioration thereby, preventing the increased TSS fruit content compared with PAE. On the other hand, the surpass of PAE at high level 12% to reduce V.C, ascorbic acid loss percentage compared to PEE in two seasons the reason in our result may be due to PAE have greater anti-oxidative effects and greater inhibitory activity against some enzymes than PEE and its constituents [79] and that causes modification of internal atmosphere of fruit as mentioned before by [57] which lead to lowering loss of ascorbic acid in treated fruit.

3.2.3 Deterioration fruits

Different results were obtained according to the both extracts PEE and PAE at different concentrations that reduced the percentage of deterioration fruits; however the highest level recorded the least percentage of this parameter as shown in Table (8). Generally, PEE at various levels was more effective to obtain the lowest percentage of fruit deterioration when compared to the aqueous extract PAE. The favorable effect of propolis on different extracts could be due to propolis having an important role in prevention of food loss and waste. It is composed of about 50% resin, 30% wax, 10% essential oils, 5% pollen, and 5% other substances [80]. It has a very rich chemical composition, specifically its phenolic compounds, which consider important phytochemicals to provide health-protective effects. Also have significant roles in the plants' defensive system against pests, diseases or abnormal environmental conditions [81].. In our investigation the fruits produced from plants sprayed with high levels 12% of PEE during vegetative growth obtained less percentage of fruit deterioration after dipping in the same level and continuous in healthy appears to the end of shelf life period, our finding were close with studies provident that inducement of the biosynthesis of the phenolic compounds in plants lead to preservation of the postharvest quality of fruit [53]. So presented of various chemical components of propolis have exceeded 250 as amino acids, enzymes, benzoic acid and its derivatives, fatty acids, sterols, sugar, hydrocarbons, vitamins, and waxy acids [55] resulting in keeping fruits with high quality and maintain its chemical content therefore, fruits treated with propolis extracts at high level 12% have the ability to spent its shelf life period without major losses (Table, 8). In addition propolis extracts have hydrophobic composites and high phenolic concentration which provides a capability to form biodegradable barriers on the fruit surface and prevents the movement of water and gasses through the fruits surface, which in turn reduce the transpiration and respiration. [82,83,84,85]. Furthermore, the capability of propolis to inhibit the pathogenic development, also application of propolis to the fruits was noted to enhance Cu/Zn-SOD and protect fruit cells, thus improving fruit resistance to the pathogens thereby, propolis extracts act as antimicrobial as confirmed in many studies [86,87,88], the antimicrobial efficacy of propolis extracts might be return to its indirect influence on the biochemical reactions of fruits which induce resistant against pathogens. From all these benefits of propolis it could say that propolis extracts reduce fruit physical disorder and losses of physical characters i.e., weight, length and diameters and keeping fruit chemical content. So, prevent fruits and reduce its rate of deterioration.

Table 8 Effect of PEE and PAE at different concentrations on fruit deteriorations percentage after shelf life period in the seasons of 2019 and 2020

Treatments	1st Season					2nd Season				
	PEE concentrations									
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	7.71	4.16	3.69	3.33	3.32	7.83	3.90	3.92	3.86	2.78
T2	6.77	3.70	3.30	3.10	2.22	6.90	3.60	2.52	2.21	2.06
T3	6.09	2.70	2.72	2.62	2.10	5.83	3.21	2.18	1.85	1.40
T4	5.53	1.74	1.77	1.73	1.27	4.66	2.40	2.00	1.53	1.08
T5	3.20	1.40	0.22	1.11	0.74	3.81	1.33	0.74	1.01	0.33
L.S.D at 5%	0.54	0.31	0.18	0.14	0.52	0.65	0.25	0.17	0.34	0.72
PAE concentrations										
	0%	3%	6%	9%	12%	0%	3%	6%	9%	12%
T1	7.71	6.16	5.99	5.46	4.64	7.83	7.12	5.95	5.74	5.48
T2	6.77	5.19	4.63	4.55	4.00	6.90	5.59	5.22	5.06	4.54
T3	6.09	4.45	3.68	3.51	3.40	5.83	5.23	4.46	3.83	3.28
T4	5.53	2.45	2.79	2.77	2.61	4.66	3.77	3.64	2.65	2.20
T5	3.20	2.11	2.57	2.36	1.47	3.81	2.15	2.59	2.11	2.03
L.S.D at 5%	0.54	0.34	0.13	0.30	0.37	0.65	0.31	0.34	0.60	0.13

T1: Fruits produced from plants treated by tap water (control treatment); T2: Fruits produced from plants treated by PEE at concentrate 3%; T3: Fruits produced from plants treated by PEE at concentrate 6%; T4: Fruits produced from plants treated by PEE at concentrate 9%; T5: Fruits produced from plants treated by PEE at concentrate 12%.

4. Conclusion

From this study it can be concluded that, PEE at concentrate 9% stimulated pepper vegetative growth except plant dry weight, total yield/feddan and fruit components i.e., fruit diameter, average fruit weight. The superiority values related to fruit chemical content, in terms of TSS and ascorbic acid were obtained with PEE at level 12%. With regard to shelf life investigation, high concentrate 12% of PEE and PAE was able to reduce loss percentage of fruit physical characters i.e., weight, length and diameter and decrease percentage increase of TSS and loss of ascorbic acid in fruit after the shelf life period. As for the percentage of deteriorated fruits, the high concentrate 12% of both extracts effectively prevent fruit after shelf life period and obtain less fruit decay especially in fruits produced from plants sprayed by high level 12% of PEE in two seasons.

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