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Effect of Postharvest Application of Ethanol-extracted Propolis on the Storage Quality and Shelf-life of Mango (*Mangifera indica L.*) Varieties in Makurdi, Nigeria

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Abstract

Mango is a very important fruit based on the fact that it contains rich dietary source (carbohydrates, fiber minerals), antioxidants such as vitamin C, carotenoids, and phenolic compounds and has a general tendency of boosting the immune system of human beings. As such proper storage and extension of shelf-life of this prestigious fruit is very important. In this paper, the storage quality and shelf-life of two mango varieties (Mabrouka and Local) in relation to postharvest application of ethanolic extract of propolis (EEP) at 70, 80 or 90% were studied during 22 days of storage period at ambient conditions (temperature of 30.8^{0}C to 33.5^{0}C and relative humidity of 55% to 68%). It was observed that EEP, especially at higher rates (90% EEP), maintained the hardness/firmness of mango fruits, slowed the physiological loss in weight (g) and slowed changes in total soluble solids (TSS) and total titratable acidity (TTA) fruits, as well as delayed changes in the postharvest decay and increased marketability of the mango fruits. Hence the propolis (90% EEP) can be efficiently utilized to maintain postharvest quality and extend the storage life of mango fruits, particularly the Mabrouka variety, up to 21 days, whereas untreated mangoes could only be stored for 14 days at ambient storage conditions. In conclusion, EEP treatments at 90% kept the quality of mango fruits, particularly Mabrouka, during storage life, and it could successfully serve as a natural alternative to synthetic chemicals in postharvest handling and applications, notably in mango fruits.

Keywords: Propolis, Postharvest storage quality, shelf-life, Mango fruits, Makurdi.

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Introduction

With over 1000 identified varieties and commercial production in more than 87 countries (Kansci *et al.,* 2008), mango (*Mangifera indica* L.) is one of the most popular fruits consumed worldwide (Tharanathan *et al.,* 2006; Evans and Ballen, 2012). Mangoes are the world's fifth largest fruit production after bananas, grapes, apples, and oranges (Bally *et al.,* 2009; Okoth *et al.,* 2013). Mango is a valuable and popular fruit possessing rich dietary source (carbohydrates and fiber minerals), antioxidants such as vitamin C, carotenoids, and phenolic compounds which have shown various health benefits (Liu *et al.,* 2014; Gámez *et al.,* 2017). Various parts of the mango fruit (pulp, peel, and stone), leaves, and bark are rich sources of fiber and bioactive compounds (Rymbai *et al.,* 2013; Monribot-Villanueva *et al.,* 2019). The fruits are, specifically, rich in antioxidants known to reduce the risk of cardiac diseases with the potentials of anticancer and antiviral activities (Jash and Brahmachari, 2015).

Throughout storage life, a number of physiological and biochemical changes take place, such as an increase in weight loss, the breakdown of chlorophyll and polyphenols, the conversion of starch to sucrose, the release of degradable enzymes, and a decrease in vitamin C, titratable acidity (TA), and pulp firmness (Mattiuz *et al.,* 2015; Awad *et al.,* 2017; Al-Qurashi and Awad, 2018), thus, making the mango fruits vulnerable to high post-harvest losses (FAOSTAT, 2016). In Nigeria, these postharvest losses seem to be the bane of mango production. It has been reported that in Benue State, one of the highest producers of mango fruits in Nigeria, about 20 to 80 percent of mango fruits produced are subjected to post-harvest loss every year (State Ministry of Agriculture, 2015; Sambe *et al.,* 2021). The high post-harvest losses are because the fruit possesses a very short shelf-life (Akimbamowo, 2013; Sambe *et al.,* 2021). As a result of the seasonality nature of mango, the fruits availability during the period of the season is always above demand which leads to low market value and high post-harvest losses (Maloba *et al.,* 2017). The high post-harvest losses of mango fruits have adverse effects on the income of the farmers, as they incur huge economic losses from mango fruits production (Agyapong, 2013; Sambe *et al.,* 2021).

Numerous techniques that can be used to either lower post-harvest losses or maintain fruit quality have been described by a number of scientists. Some of these techniques are undesirable due to health implications. As a result, natural substitute preservatives are vitally needed to control mango ripening and preserve quality throughout storage. Propolis and other natural edible coatings are thought to be potentials way to delay ripening, minimize water loss and degradation, and increase the duration of time that different fruits may be stored and kept fresh (Bibi and Baloch, 2014; Mattiuz *et al.,* 2015; Passos *et al.,* 2016; Awad *et al.,* 2017). Hence, this study aims at evaluating the effect postharvest application of ethanol extracted propolis (EEP) on the shelf-life and storage quality of mango fruits in Makurdi, Nigeria.

Review of Related Studies

The impact of propolis extract on the quality and preservation of fruits and vegetables has been the subject of several investigations. Propolis can be included into food recipes or coated to the surface of fruits (Pobiega *et al.,* 2019). Furthermore, it has been documented that propolis application can enhance fruits shelf life and inhibit lipid oxidation (Bankova *et al.,* 2016; Yang *et al.,* 2017).

On mango fruits, propolis inhibited the growth of anthracnose on mango fruit (variety Kent) (Mattiuz *et al.,* 2015) and resulted in increased pulp firmness and decreased soluble solids in 'Hindi-Besennara' mango (Al-Qurashi and Awad, 2018). When applied as a bio-coating to tomatoes, propolis decreased the rate of weight loss while maintaining fruit firmness (Putra *et al.,* 2017). Furthermore, using propolis as a coating agent can improve the shelf life of cherry tomatoes while also delaying sensory degradation (Liu *et al.,* 2019). A recent study demonstrated that pullulan film combined with an ethanol extract of propolis inhibited the development of bacteria in cherry tomatoes. The overall quality of tomatoes coated with propolis was observed to be extremely high, perhaps leading to high customer approval (Pobiega *et al.,* 2020).

Fungal decay, weight and acidity losses, softening, stem browning, and color changes are all significant issues for sweet cherry and other fruits. According to Yang *et al.* (2020), propolis applications can significantly minimize sweet cherry weight loss and respiration while also delaying soluble solids, titratable acid, and sweet cherry firmness. In a similar vein, it was reported that an edible coating containing chitosan nanoparticles and 10, 20, or 30% propolis improved the antioxidant activity and shelf life of strawberries while having no effect on the sensory qualities of the fruit (Martínez-González *et al.,* 2020). Propolis is a natural, renewable product, so using it in more applications is both necessary and inevitable in the future. To the best of the researcher's knowledge, there has been no research published on the usage of Nigerian propolis as a coating material to extend the storage and shelf life of Mabrouka and Local mangoes fruits. As a result, the current study was designed to assess the effect of an ethanol-extracted of propolis (EEP) on the physicochemical changes and shelf life of Mabrouka and Local mangoes fruits during storage in Makurdi, Nigeria.

Materials and Method

Experimental Location

The study was conducted at the advanced pathology laboratory of the Benue State University, Makurdi, Nigeria. Makurdi, the capital of Benue State, lies 98 m above sea level and in Nigeria's Southern Guinea Savannah Agro-ecological zone. Annual rainfall is 1,290 mm and temperature ranges from 30.8^{0}C to 33.5^{0}C

Source of Materials

Crude Nigerian propolis was obtained from the Phytochemistry Research Group, Department of Chemistry, University of Agriculture, Makurdi. Two mango fruits varieties (Mabrouka and Local variety – Mangoutiv in Tiv) were collected from mango orchards. At each harvest time, 15 fruits were harvested from the tree using a cloth bag attached to a long pole. The fruits were immediately washed in cold water which was sanitized using 1% acetic acid for disinfection. Only uniform fruits were selected. Selected fruits from the mango tree were transported in a securely packed plastic crates to Benue State University Makurdi, Botany laboratory, for experimental set-up.

Preparation of Materials

Extraction of propolis was done by using ethanol at different percentages. 200 grams propolis was weighed ~~into~~ three equal portions and mixed with three concentrations of ethanol (70% ethanol extracted propolis (EEP), 80% EEP and 90% EEP), respectively, as outlined by Lu *et al.* (2005). The concentrations were allowed to stay in the sealed bottles for one week with vigorous shaking of the bottles every day, and sieved thereafter, and the extraction was used for the postharvest treatment of the mango fruits.

Experimental Design and Treatments

The experiment consisted of a 2 x 4 factorial combination of treatments, which were fitted in a fully randomized design (CRD) and replicated thrice. The experimental treatments were two mango varieties (Mabrouka and local variety) and three concentrations of propolis (70% EEP, 80% EEP and 90% EEP) and untreated fruits served as control.

To evenly coat the EEP onto the fruit surface, fruits with uniform sizes and no defects were dipped into EEP at several concentrations (70%, 80%, and 90%). Control fruit were dipped in distilled water only. Every fruit was allowed to air dry at room temperature of (30.8^{0}C to 33.5^{0}C) before being stored for a total of 22 days.

Data Collection

Weight loss, fruit firmness, total soluble solids (TSS), titratable acidity (TA); vitamin C content and pH were collected. Marketability (%) was based on descriptive quality attributes such as level of visible lesion, shriveling, smoothness and shininess of fruit. The percentage of marketable fruits during the storage period were calculated using the formula reported by Mohammed *et al.* (1999):

$$\%\text{Marketability}=\frac{\text{Number of marketable fruits}}{\text{total number of fruits}} \times 100$$

The decay percentage of treated and untreated fruit was calculated using the formula provided by El-Anany *et al.* (2009), and the shelf-life of fruit was evaluated using the formula provided by Liamngee *et al.* (2018).

Statistical Analysis

Data collected from the study was subjected to Analysis of variance (ANOVA) using GENSTAT statistical software (2017). Fruit treatment and control means were compared using the F-LSD test ($P \leq 0.05$).

Results and Discussion

Weight of mango fruits increased during storage time and was significantly lower at medium and high rates of EEP than low rate of EPP and control (Table 1). Variety significantly showed difference on the fruit weight of mango during storage life as Mabrouka had higher fruit weight as compared to the local variety. EEP at 90% recorded higher fruit weight as compared to the other levels and the control and the difference was on significant at the last days of storage life. However, untreated fruits (control) obtained the lowest fruit weight throughout the storage period (Table 1). Mangoes, generally, show high metabolic activity with a relatively short postharvest life at ambient conditions being a climacteric fruit and as such the varietal difference might be due to the genetic build of the varieties evaluated as noted by Iorliam and Ugoo (2023) when they performed similar experiments on okra. In this study, EEP treatment as a neutral edible coat was evaluated for its impact on mangos. Propolis extract hydrophobic composites have the ability to create a biodegradable semipermeable coating on fruit surfaces, which may prevent some fruits from losing water and from releasing gases. In confirmation, Mattiuz *et al.* (2015) reported that propolis treatment reduced the weight loss of "Kent" mangoes during storage. El-Badawy *et al.* (2012), Zahid *et al.* (2013) and Passos *et al.* (2016) working on oranges, dragon fruits and bananas obtained similar works as reported by this current study.

Table 1: Effect of Variety X EEP on the Fruit Weight (g) of Mango fruits during Storage

	Fruit Weight (g)							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22 (Days)**
Mabrouka	457.90	437.40	420.30	406.30	397.80	383.80	370.20	358.30
Local	251.90	240.70	231.40	222.20	217.10	207.40	195.00	182.30
F-LSD (P≤0.05)	33.13	32.04	29.41	27.99	27.49	26.83	26.33	26.43
EEP (%)								
70	343.50	330.00	318.40	308.90	303.10	293.40	283.80	271.00
80	367.90	352.20	339.00	328.40	321.70	310.00	298.20	287.70
90	364.00	351.20	336.70	328.10	322.30	312.90	303.80	290.70
Control	344.10	322.70	309.10	291.60	282.60	265.90	244.50	231.60
F-LSD (P≤0.05)	NS	NS	NS	NS	NS	NS	37.23	37.38

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Table 2: Effect of Variety X EEP on the Firmness of Mango fruits during Storage

	Firmness (N/cm^2)							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22DAYS**
Mabrouka	8.24	8.09	7.78	7.28	6.79	6.23	5.76	4.98
Local	7.23	7.18	6.71	6.23	5.70	5.05	4.22	3.43
F-LSD (P≤0.05)	0.18	0.16	0.2	0.23	0.21	0.27	0.26	0.22
EEP (%)								
70	7.67	7.55	7.13	6.63	6.27	5.67	5.07	4.43
80	7.75	7.67	7.27	6.87	6.47	5.90	5.30	4.60
90	7.82	7.72	7.50	7.07	6.57	6.13	5.48	4.88
Control	7.70	7.60	7.07	6.45	5.68	4.85	4.10	2.92
F-LSD (P≤0.05)	NS	NS	0.29	0.33	0.3	0.38	0.37	0.31

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

One of the most important fruit quality attributes is firmness, which is typically lost as a result of softening tissue. Ripeness reduces firmness during handling and transportation, leading to lower quality and more mechanical damage incidents. The firmness of the mango fruit was influenced by variety and the postharvest application of EEP varied at various levels. Maboruka variety was firmer than the local variety at the end of the storage period. At the postharvest application of EEP, the mango firmness increased with increased rate of EEP, as 90%EEP obtained firmness fruits as compared to other levels of the EEP (Table 2). This action in the study may have resulted from the propolis extracts' composite nature, which forms a semipermeable firm on fruit surfaces to prevent gas exchange and water loss in different fruits and keep them firmer for longer periods of storage. Similar findings have been obtained by Ozdemir *et al.* (2010); Zahid *et al.* (2013); Passo *et al.* (2016) on grapes, dragon fruits and bananas respectively. Putra *et al.* (2017) working on tomatoes reported that propolis reduced the rate of weight loss and maintained fruit firmness (tomatoes) when applied as bio-coating, this affirms the findings of the current study.

Regardless of the variety or EEP treatment levels, the TSS rose over the storage time (Table 3). Mabrouka variety TSS increased throughout the storage period while the local variety attained senescence at day 13. The untreated fruits had the highest TSS, whereas fruits that were treated with 70% EEP had the lowest TSS. Fruits usually have an increase in total soluble solids when they mature. Fruit ripeness or maturity may be primarily determined by the amount of soluble solids in the fruit. The fruits' elevated TSS might have been caused by increased water flow and the starch's conversion to soluble sugar during storage. Vishwanath *et al.* (2022) in their study affirmed that TSS of mango fruits Cv Alphonso increases with increased period and they also obtained higher TSS of untreated fruits which is similar with the current study. The results of Jawandha *et al.* (2012), Bhat *et al.* (2014) and Gavri *et al.* (2016) who studied a variety of mango fruit types, are similarly consistent with the current study.

Table 4 suggests that slower starch-to-sugar conversion, decreased ethylene generation, and delayed ripening might be the reasons for the delayed rise in TSS and breakdown of titratable acidity concentration in mango fruits treated with 90%EEP. The results showed that compared to the control treatment, the propolis treatments showed a significantly reduced decline in titratable acidity content following storage. According to the results of the current study, propolis treatments appear to have had a significant effect on respiration, which may have caused respiration to slow down or cease completely while keeping levels of titratable acidity. According to this study, Yang *et al.* (2020) found that propolis successfully delays the formation of soluble solids, titratable acid, and the hardness (firmness) of sweet cherries, as well as reducing weight loss and respiration of the fruit. Comparable findings with mango fruits were also noted by Jawandha *et al.* (2012) and Vishwanath *et al.* (2022). The Mabrouka mango variety was shown to have a delayed TTA breakdown at the TSS, in contrast to the local variety, which ripens entirely in 13 days.

Table 5 showed that varietal difference was significant on the vitamin c content of mango fruits as Mabrouka had higher vitamin c content as compared to the local variety. Vitamin c content of mango fruits increased during storage time and with increased in EEP levels and the untreated fruits obtained the lowest vitamin c content (Table 5). Moreover, EEP treatments especially the high (90%EEP) and medium (80%EEP) rates retained higher vitamin c concentration during storage life than control. Al-Qurashi and Awad (2018) reported similar findings. Propolis's broad preservation properties as an antioxidant and antibacterial agent may be the cause of these outcomes (Sforcin and Bankova, 2011; Pastor *et al.,* 2011; Bibi and Baloch, 2014).

pH values increased during storage regardless of the varieties up to the 16^{th} day and decreased at further storage days. pH values were higher at lower rate of EEP than high rate of EPP and control (Table 6). Propolis coating on fruit surfaces may alter the interior environment, slow down respiration and metabolic processes, limit transpiration, and preserve the firmness and turgidity of the fruit's cells. The current study varies from previous research by Al-qurashi and Awad (2018), who found that lower pH values were achieved with greater rates of EEP. Instead, lower pH values were found in the current study with lower levels of EEP. The disparity may have resulted from the fruit varieties assessed and the research environment. Similarly, Salgotra and Chauhan (2023) affirms that under environmental changes, different crop varieties survive due to the presence of genetic variation, which enables the varieties to adapt.

Table 3: Effect of Variety X EEP on the Total Soluble Solids (TSS) of Mango fruit during Storage

Variety	Total Soluble Solids (°Brix) 1	4	7	10	13	16	19	22 (Days)
Mabrouka	1.77	2.08	6.78	11.31	28.50	29.71	29.92	30.26
Local	2.23	3.03	15.57	17.94	18.00	0.00	0.00	0.00
F-LSD (P≤0.05)	0.14	0.08	0.02	0.08	0.10	0.04	0.24	0.09
EEP (%)								
70	0.00	2.45	11.77	14.32	23.50	14.87	14.93	15.02
80	0.00	2.35	10.75	13.77	23.50	14.92	14.97	15.07
90	0.00	2.15	9.08	13.20	22.50	14.75	15.10	15.10
Control	2.00	3.25	13.10	17.22	23.50	14.88	14.83	15.33
F-LSD (P≤0.05)	NS	0.04	0.03	0.10	NS	0.06	NS	0.12

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Table 4: Effect of Variety X EEP on the Total Titratable Acidity (TTA) of Mango fru during Storage

Variety	TTA 1	4	7	10	13	16	19	22 (Days)
Mabrouka	0.046	0.037	0.030	0.017	0.007	0.004	0.003	0.003
Local	0.016	0.007	0.007	0.004	0.005	0.000	0.000	0.000
F-LSD (P≤0.05)	NS	0.00	0.01	0.00	NS	NS	NS	0.00
EEP (%)								
70	0.000	0.021	0.018	0.009	0.005	0.002	0.002	0.002
80	0.000	0.023	0.020	0.011	0.005	0.002	0.002	0.002
90	0.000	0.025	0.022	0.013	0.007	0.005	0.004	0.003
Control	0.031	0.020	0.014	0.008	0.005	0.002	0.001	0.001
F-LSD (P≤0.05)	NS	0.00	0.00	0.00	NS	NS	NS	NS

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

In the current investigation, EEP treatments at medium and high rates reduced fruit degradation/decay (Table 7) and boosted marketability after 22 days of storage compared to the control (Tables 8). Among the varieties, Mabrouka recorded delayed decay with increased marketability as compared to the local variety during the 22days storage period. Increased in EEP levels delays in the postharvest decay and increased marketability of the treated fruits as to the untreated (control).

Table 5: Effect of Variety X EEP on the Vitamin C Content of Mango fruits d Storage

Variety	Vitamin C Content 1	4	7	10	13	16	19	22 (Days)
Mabrouka	5.79	3.43	3.58	3.33	3.38	3.50	3.46	3.42
Local	3.68	2.11	2.36	2.18	1.76	0.00	0.00	0.00
F-LSD (P≤0.05)	0.02	0.09	0.11	0.14	0.08	0.02	0.04	0.06
EEP (%)								
70	0.00	2.82	3.12	2.69	2.52	1.73	1.73	1.71
80	0.00	2.89	3.12	2.68	2.57	1.76	1.74	1.72
90	0.00	3.00	3.23	2.98	2.69	1.77	1.76	1.73
Control	4.74	2.38	2.41	2.66	2.50	1.74	1.70	1.68
F-LSD (P≤0.05)	NS	0.13	0.15	0.20	0.11	NS	NS	NS

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Table 6: Main Effect of Variety X EEP on the pH of Mango fruits during Storage

	pH							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22 (Days)**
Mabrouka	3.50	3.80	4.91	5.93	6.74	7.00	6.57	6.25
Local	4.77	5.78	6.87	7.00	7.46	0.00	0.00	0.00
F-LSD (P≤0.05)	NS	0.03	0.04	0.02	0.02	0.03	0.06	0.18
EEP (%)								
70	0.00	4.78	5.90	6.50	7.13	3.50	3.35	3.28
80	0.00	4.70	5.85	6.42	7.10	3.50	3.30	3.18
90	0.00	4.47	5.57	6.25	7.02	3.50	3.36	3.02
Control	4.13	5.22	6.23	6.70	7.15	3.50	3.13	3.02
F-LSD (P≤0.05)	NS	0.04	0.05	0.03	0.04	NS	0.09	NS

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Table 7: Main Effect of Varity X EEP on the Marketability of Mango fruits durin Storage

	Marketability (%)							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22(Days)**
Mabrouka	100.00	10000	100.00	100.00	98.30	94.20	90.00	87.50
Local	100.00	100.00	99.20	95.80	91.70	85.80	81.70	77.50
F-LSD (P≤0.05)	NS	NS	NS	3.60	4.20	6.50	4.70	4.50
EEP (%)								
70	100.00	100.00	100.00	100.00	96.70	91.70	88.30	83.30
80	100.00	100.00	100.00	100.00	96.70	93.30	90.00	90.00
90	100.00	100.00	100.00	100.00	100.00	96.70	93.30	93.30
Control	100.00	100.00	98.30	91.70	86.70	78.30	71.70	63.30
F-LSD (P≤0.05)	NS	NS	NS	5.10	6.00	9.20	6.70	6.40

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

These observations from the propolis treated fruits could be the presence of anti-oxidant, antifungal and antimicrobial agents of the propolis (Sforcin and Bankova, 2011; Pastor *et al.,* 2011). Moreover, Ali *et al.* (2014) confirmed that 1.5% EEP inhibited the mycelial development of *Colletotrichum gloeosporioides* and decreased the incidence of anthracnose and maintained the quality of the fruit. Mattiuz *et al.* (2015) also affirmed that postharvest application of propolis reduced the development of anthracnose on mango fruit (variety Kent) thus extending shelf-life during storage. EEP treatments especially 90%EEP delayed ripening and decay of mangos during storage in Makurdi.

Mango fruits treated with EEP, regardless of the levels, had the longest shelf life (21 days), whereas untreated mangoes had the shortest shelf life (14 days) (Table 9). Slow ripening was used to extend the shelf life of mango fruits treated with EEP. By delaying fruit softening, reducing weight loss, respiration rate, and the ripening/metabolism process, exogenous propolis application extended the shelf life of mangos without altering the fruit's organoleptic characteristics. Propolis extends the shelf life of fruits by regulating many physiological processes that occur during storage, owing to its anti-ethylene characteristics. Alvarez *et al.* (2015) in accordance to this study reported that propolis extends the shelf life and improves the visual quality of celery, leek and butternut squash fruits. Moreso, Liu *et al.* (2019) reported that propolis used as a coating agent can extend the shelf life of cherry tomatoes and delay the deterioration of their sensory traits. In terms of varietal differences, the local variety had a 16-day shelf life during storage, whereas Mabrouka had a 21-day shelf life. The genetic buildup maybe the reason for the physiological difference among the two varieties evaluated in this study.

Table 8: Main Effect of Variety X EEP on the Postharvest Decay (%) of Mango fruits dur Storage

	Postharvest Decay (%)							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22 (Days)**
Mabrouka			0.00	0.00	2.50	5.80	10.00	12.50
Local			0.83	4.17	8.33	13.30	17.50	22.50
F-LSD (P≤0.05)			NS	3.56	4.01	5.69	4.53	4.52
EEP (%)								
70			0.00	0.00	3.33	8.30	11.70	16.70
80			0.00	0.00	3.33	6.70	10.00	10.00
90			0.00	0.00	0.00	3.30	6.70	6.70
Control			1.67	8.33	15.00	20.00	26.70	36.70
F-LSD (P≤0.05)			NS	5.01	5.73	8.05	6.41	6.39

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Table 9: Main Effect of Variety X EEP on the Fruit Shelf-Life (Days) of Mango fruits during Storag

	Fruit Shelf-Life (Days)							
Variety	**1**	**4**	**7**	**10**	**13**	**16**	**19**	**22 (Days)**
Mabrouka	1.00	4.00	7.00	10.00	13.00	16.00	19.00	21.00
Local	1.00	4.00	7.00	10.00	13.00	16.00	16.00	16.00
F-LSD (P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS
EEP (%)								
70	1.00	4.00	7.00	10.00	13.00	16.00	19.00	21.00
80	1.00	4.00	7.00	10.00	13.00	16.00	19.00	21.00
90	1.00	4.00	7.00	10.00	13.00	15.00	19.00	21.00
Control	1.00	4.00	7.00	10.00	13.00	14.00	14.00	14.00
F-LSD (P≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS

EEP = Ethanolic Extracted Propolis; NS = Not Significant at 5% level of probability

Conclusion

Propolis extracted using ethanol, particularly at higher rates (90%EEP), can be used to preserve the firmness of the fruit, slowed physiological weight loss, and delay changes in TSS and titratable acidity of mango fruit. It can also be used to increase the marketability of mango fruits and maintain postharvest quality, extending the storage life of mango fruits, particularly the Mabrouka variety, for up to 21 days under ambient conditions (temperature of 30.8^{0}C to 33.5^{0}C and relative humidity of 55% to 68%).

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DECLARATIONS

Authors have declared that no competing interests exist.

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