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Evaluation of the Properties and Shelf life of Okra Preserved in Makurdi with Ethanol Extracted Propolis

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Abstract

The aim of this study was to evaluate the effect of different doses of ethanol-extracted propolis (EEP) on physicochemical changes and shelf-life of okra fruits during storage in Makurdi. The experimental treatments were done on two okra varieties (Clemson spineless and Stubby okra) and three concentrations of propolis (70% ethanol extracted propolis (EEP), 80%EEP and 90%EEP) and untreated fruits served as controls. Fruits of uniform size and free from dirt were dipped into EEP of varied doses (70% EEP, 80%EEP and 90%EEP) in order to uniformly coat the EEP onto the fruit surface. The untreated fruits (control fruit) were immersed simply in clean water. All of the fruit was air dried at ambient temperature before being stored for 16 days. Results revealed that that 90% EEP not only slowed down the metabolism process but also increased the biosynthesis of the physical and chemical components such as weight loss, total soluble solids, pH and titratable acids. However, 80%EEP showed promising outcomes with vitamin C and fruits firmness. The study concluded that, independent of okra variety, larger quantities of ethanolic extracted propolis can be employed to preserve and maintain the quality of okra fruits during storage in Makurdi.

Key words: Propolis, okra fruits, postharvest quality, shelf-life, Nigeria.

Introduction

The use of natural products for fruit and vegetable postharvest quality, shelf life and disease control have produced promising results, indicating the possibility of developing natural fungicides that are as effective as synthetic fungicides while being safer for humans and the environment (Arowora and Adetunji, 2014; Mvumi et al., 2017; Nande and Igoli, 2017). In the past decade, scientists are interested in the contents and biological consequences of propolis, a resinous chemical compound collected by bees from plant exudates from different location/sources (Sforcin and Bankova, 2011; Okhale et al., 2020; Ipav et al., 2022). The use of propolis, alone or in combination with other treatments, has been shown to enhance the quality and shelf life of fresh horticultural fruits (Yang et al. 2010; Noosheen et al. 2013; Aghel et al. 2014; Mattiuz et al. 2015; Franchin et al. 2016; Kahramanoglu et al. 2020; Moreno et al.

2020; Aparicio-García et al. 2021 and Ahmad et al. 2022).

Okra (*Abelmoschus esculentus* L. Moench), also known as Lady's finger, is a popular vegetable crop grown in most tropical and subtropical regions, as well as in Mediterranean climates (Singh et al., 2014; Al-Dabbas et al., 2023). Its origin had been reported to be Ethiopia and was cultivated by the ancient Egyptians by the 12th century B.C. Its cultivation spread throughout the world (Tindall, 1983). Okra is one of the most widely grown vegetable crops in the Tropics (Udoh et al., 2005) and the second most important vegetable in the West African market after tomatoes (Ubani and Okonkwo, 2011; Kelechi et al., 2013), as it is widely consumed and considered a staple food in many low-income, challenging nations (Al-Dabbas et al., 2023). The nutritional composition of okra comprises approximately 2% protein, 0.1% total fat, 7.0% carbohydrates, and 3.2% dietary fiber (USDA, 2021). More-so, okra contains insoluble fiber, several carbohydrates, minerals, and vitamins, all of which contribute significantly to human health and overall well-being (Duha and Yed, 1997; Al-Dabbas et al., 2023). Gemede et al. (2016; 2018) had revealed a wide range of potential health benefits of okra for cardiovascular diseases, type 2 diabetes, digestive disorders, and even certain cancers.

The estimated global production of okra exceeds 10 million tons annually (FAO, 2021). Nigeria is Africa's greatest producer and the world's second-largest producer of okra in terms of production output (Factfish, 2016; FAO, 2021). Loss of quality and short shelf life are key challenges when marketing fresh okra in Nigeria (Iorliam and Ugoo, 2023). According to Farinde et al. (2006), postharvest okra waste is approximately 38%. Similarly, fresh okra fruits have a short shelf life, lasting only 7 to 10 days even when stored at 70 to 10°C (Katende, 2006). Surface coating of okra with 1% N, O-carboxymethyl chitosan, for example, enhanced shelf life, slowed weight loss, and preserved the textural profile of the okra fruit (Wang et al., 2021), Ogbaji and Iorliam (2020) found that okra fruits coated with Neem and Moringa powders kept firmness and quality for 15 days, compared to 7 days for untreated fruits in Makurdi, Nigeria. Inhibiting fungi growth is crucial for postharvest fruit, but synthetic fungicide use has recently raised consumer concerns, and its use is becoming more limited due to health effects, residual toxicity issues, environmental pollution, microbial resistance, and high input costs (Marín et al., 2003; Rial-Otero et al., 2005). One of the alternate techniques is the use of propolis. The antifungal activity of propolis and extended shelf life of horticultural fruits have been evaluated by several scientists and abound in literatures (Ozdemir et al. 2010; El-Badawy et al. 2012; Wagh, 2013; Ali et al. 2014; Mattiuz et al. 2015; Franchin et al. 2016; Embaby et al. 2019).

Related Literatures

Propolis application on horticultural fruits forms a semipermeable and biodegradable coating on the fruit surface, regulating the circulation of gasses and water into and out of the food tissues, so maintaining cell turgidity and firmness of the fruit. Numerous researches have confirmed this understanding regarding the preventative properties of propolis for fruit firmness, such as in mangos, papayas, bananas, dragon fruits, oranges, and sweet cherries (Gong *et al.,* 2020; Kahramanoglu *et al.,* 2020).

Moreno *et al.* (2020) in their study observed that edible gelatin coatings containing an ethanolic extract of propolis (EEP) had significant antifungal efficacy against the tested fungus, with a stronger inhibitory impact on *P. digitatum* and *B. cinerea*. The use of EEP improved antifungal activity in raspberries during cold storage. Furthermore, this proof-of-concept study demonstrated the effectiveness of the encapsulating technique in reducing infection incidence in raspberries held at refrigerated temperatures for an extended length of time. Aparicio-García *et al.* (2021) revealed that figs treated with the coatings maintained their normal ripening process during the 12-day storage, and were subject to reduced weight loss; furthermore, antioxidant capacity increased. Also, the coatings reduced the development of *A. flavus*, fungus under controlled laboratory and semi-commercial conditions, and aflatoxin production reduced remarkably. Ahmad *et al.* (2022) reported that propolis coating successfully reduced the fungal activity of *C. gloeosporioides* on bananas during storage. Finally, bananas treated with an 11% concentration of propolis coating are promising for increasing the color, total soluble solid content, and titratable acidity, and can suppress artificially anthracnose disease caused by *C. gloeosporioides* on a banana. Nefzi *et al.* (2023) also obtained a confirmation that the antimicrobial efficacy of propolis which could be proposed as a suitable bio preservative to ensure safety and improve the quality of food after 7 days of storage.

There has been no research published on the usage of Nigerian propolis as a coating material to extend the storage life of okra 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 okra 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 98m above sea level and in Nigeria's Southern Guinea Savannah Agro-ecological zone. Annual rainfall is 1,290mm and temperature ranges from 22.50C to 400C (Clement, 2013).

Source of Materials

Crude Nigerian propolis was obtained from the Phytochemistry Research Group, Department of Chemistry, University of Agriculture, Makurdi. Two okra fruits varieties (Clemson spineless and stubby okra) were collected from the College of Agriculture's Yandev okra farm in Gboko and transported to Benue State University Makurdi Botany laboratory.

Preparation of Materials

Propolis was extracted using varied amounts of ethanol. 200gram 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 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. It was sieved after one week and the extraction was used for the treatment of the okra fruits.

Experimental Design and Treatments

The experiment was a 2 x 4 factorial combination of treatments, fitted in a completely randomized design (CRD), replicated three times. The experimental treatments were two okra varieties (Clemson spineless and Stubby okra) and three concentrations of propolis (70% ethanol extracted propolis (EEP), 80%EEP and 90%EEP) and untreated fruits served as controls. Okra fruits of uniform size and free from dirt were dipped into EEP of varied doses (70% EEP, 80%EEP and 90%EEP) in order to uniformly coat the EEP onto the fruit surface. The untreated fruits (control fruit) were immersed simply in clean water. All the fruit were subjected to air drying at ambient temperature followed by storage for 16 days.

Data Collection

Weight loss, fruit firmness, total soluble solids (TSS), titratable acidity (TA); vitamin C content, pH, and marketability were collected. The maximum penetration force (N) achieved during tissue breakdown was used to determine firmness using a standard probe. Firmness was determined by the force registered when a standard probe was penetrated to a specific depth (cm). The hardness of the okra fruits was measured using a penetrometer as described by Kumah *et al.* (2011)

The decay percentage of treated and untreated fruit was calculated using the formula provided by El-Anany *et al.* (2009) as follows;

$$\text{Decay (\%)} = \frac{\text{Number of Fruits decaying}}{\text{Total Number of Fruits in the plot}} \times 100$$

Shelf lives of okra fruits were evaluated by counting the number of days okra fruits were still acceptable for marketing and consumption. It was decided based on appearance and spoilage of fruits as provided by Liamngee *et al.* (2018). Marketability quality of fruits was assessed using Mohammed *et al.* (1999) scoring technique, with minimal modifications by the authors, on a 1-9 rating scale. Thus;

1 – 2.49 = unsalable
2.5 - 4.49 = saleable
4.5 - 6.49 = Good
6.5 - 8.49 = Very good
8.5 – 9.00 = Excellent

The marketable attributes were determined by observing colour, firmness, surface defects and signs of mold growth as visual parameters.

Statistical Analysis

Data collected from the study was subjected to Analysis of variance (ANOVA) using GENSTAT statistical software (2017). The F-LSD test (Pd"0.05) was performed to compare the means of treated and control fruit.

Results and Discussion

Table 1 indicates that okra fruit weight loss during storage was significantly influenced by variety and ethanolic extracted propolis (EEP) (Pd"0.05). Clemson spineless (small) lost more fruit weight than Stubby okra (large) on all days of storage, and the difference was statistically significant throughout the storage period. Regardless of the levels of the EEP, study shows that treated fruits lost less fruits weights as compared to the untreated fruits during the period of storage. At 16th day of the storage period, 90%EEP retained okra weight more while 70%EEP obtained the lowest weight of okra fruits during storage. The increased weight loss in untreated fruits compared to varying levels of EEP could be attributed to heat generation, which causes an increase in anaerobic respiration, followed by higher weight loss in the fruit. This could be that the hydrophobic composites of propolis extracts, with their high phenolic content, can create a biodegradable barrier on the fruit surface, preventing water and gaseous passage through the food surface (Zahid *et al.* 2013) thus recording less weight loss of treated fruits at higher concentration of propolis extracts. Similarly, Yang *et al.,* (2020) re-affirmed that propolis effectively reduced weight loss and respiration of sweet cherry and also delayed fruits deterioration by maintaining sweet cherry soluble solids, titratable acids and hardness during storage.

Variety and EEP showed significant difference at 1, 4 and 7days after storage. However, as the storage proceeds beyond the 7th day, variety and EEP showed no significant difference (P>0.05) on firmness of the okra fruit during storage. Clemson spineless (small) was firmer than stubby okra (big) and the difference was significant at 1, 4 and 7days but from 7th day onward, Clemson spineless was firmer although no significance was recorded. Regardless of the EEP levels, the treated okra was firmer than the untreated okra at the 16th day of the storage period (Table 2). However, 80% of EEP level gave the best firmness results as compared to 70% and 90% EEP levels. As a result, the EEP cannot alter the internal atmosphere of the fruit. Zahid et al. (2013) obtained similar reports working on dragon fruits, star ruby grapefruit (Özdemir et al., 2010) and table grape cv. Muscatel (Pastor et al., 2011). Putra et al. (2017) also reported that propolis reduced the rate of weight loss and maintained fruit firmness (tomatoes) when applied as bio-coating.

Table 1: Effect of Ethanol Extracted Propolis on the weight of okra fruits during storage in Makurdi

	Weight (g)					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS**
Stubby Okra	31.90	22.56	15.75	12.56	9.17	6.34
Clemson spineless	17.80	9.11	5.01	3.71	2.89	2.33
F-LSD($P \leq 0.05$)	4.47	3.93	3.29	3.01	1.23	1.94
EEP (%)						
70	26.20	15.33	8.90	6.51	4.37	2.77
80	22.20	13.73	8.57	6.51	4.58	3.06
90	28.20	22.31	17.35	14.70	11.83	9.09
Control	22.70	11.95	6.69	4.81	3.35	2.42
F-LSD($P \leq 0.05$)	NS	5.56	4.65	4.26	1.74	2.74

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

Table 2: Effect of Ethanol Extracted Propolis on the firmness of Okra Fruits during Storage in Makurdi

	Firmness(N/cm)					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	6.23	6.05	6.33	5.60	5.88	5.68
Clemson spineless	7.43	7.39	6.75	5.76	5.63	5.77
F-LSD($P \leq 0.05$)	0.42	0.61	0.17	NS	NS	NS
EEP (%)						
70	7.22	7.07	6.22	5.35	5.78	5.73
80	7.37	7.48	6.30	5.78	5.98	5.92
90	6.27	6.03	6.25	5.70	5.67	5.68
Control	6.47	6.30	7.38	5.88	5.60	5.57
F-LSD($P \leq 0.05$)	0.28	0.86	0.24	NS	NS	NS

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

Table 3 revealed that Clemson spineless (small) deteriorated faster than stubby okra (big) although the difference was not statistically significant. The EEP treated okra fruits preserved the okra fruits throughout the storage period while the untreated started decaying at 7th day onward and the difference was significant. Regardless of the levels of EEP, okra treated with EEP showed no decay of the fruits at the termination of the storage period (Table 3). On marketability, EEP treated okra were marketable even at the 16th day of the experiment while the untreated fruits decreased its fruits marketability from 7th day of storage up to the 16th day and the difference obtained was significant among the treatments. However, the varietal difference obtained no significant difference on the marketability of the okra fruits during storage (Table 4). This might be as a result that both varieties had higher resistance to environmental and pathogenic attacks during storage. The study revealed that untreated (Control) fruits declined faster in their marketable value compared to the treated okra fruits. This finding is in agreement with Sai et al., (2011) who reported a decrease in marketable quality of Chitosan coated tomato fruits during storage. They added that at the end of the storage period, marketability was found to be better in the coated fruits while the uncoated

Table 3: Effect of Ethanol Extracted Propolis on the Postharvest Decay (PD) of Okra Fruits During Storage in Makurdi

	Postharvest Decay (%)					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	-	-	0.83	1.67	3.33	4.17
Clemson spineless	-	-	0.00	0.83	1.67	3.33
F-LSD(P≤0.05)			NS	NS	NS	NS
EEP (%)						
70	-	-	0.00	0.00	0.00	0.00
80	-	-	0.00	0.00	0.00	0.00
90	-	-	0.00	0.00	0.00	0.00
Control	-	-	1.67	5.00	10.00	15.00
F-LSD(P≤0.05)			NS	0.35	3.50	3.20

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

Table 4: Effect of Ethanol Extracted Propolis on the Marketability of Okra Fruits During Storage in Makurdi

	Marketability (Days)					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	10	10	9.92	9.75	9.67	9.58
Clemson spineless	10	10	10.00	9.92	9.83	9.58
F-LSD(P≤0.05)	NS	NS	NS	NS	NS	NS
EEP (%)						
70	10	10	10.00	10.00	10.00	10.00
80	10	10	10.00	10.00	10.00	10.00
90	10	10	10.00	10.00	10.00	10.00
Control	10	10	9.83	9.33	9.00	8.33
F-LSD(P≤0.05)	NS	NS	NS	0.25	0.34	0.33

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

fruits lost marketable quality as observed in the current study. Similarly, untreated fruits showed visible signs of mould growth, blotchy ripening, loss of firmness and shrivelling which is in agreement with the findings of Liamngee et al. (2018). The ability of the propolis to maintain the marketability of the okra fruits may be due to the ability of the extracts to form a protective layer thereby preventing oxygen and moisture loss and inhibiting the action of microorganisms. Natural coatings using propolis have been shown to prevent loss of moisture and firmness, control respiratory rate (Aparicio-García et al. 2021; Ahmad et al., 2022; Nefzi et al., 2023).

Total soluble solids of the okra varieties showed that at the end of the storage period, Clemson spineless (small) recorded significantly higher TSS value than the stubby okra (big) variety. Although at some intervals during storage, significant difference wasn't recorded but stubby okra obtained higher values of TSS as compared to the Clemson spineless variety. The EEP treated okra fruits obtained higher TSS values than the untreated fruits and the difference was significant. At 7, 10, 13 and 16days after storage, increase in EEP revealed increased in the TSS values. At the final day of the storage period, 90%EEP recorded the highest TSS value while 70%EEP obtained the lowest TSS value among the EEP levels and the difference was significant (Table 5). The higher TSS levels in EEP-treated fruit could be due to the formation of a semi-permeable film around the fruit which suppressed ethylene production and restored TSS content in the fruit. In contrast, Ali et al. (2011) observed a slower evolution of total soluble solids in mangoes and papayas treated with chitosan. The difference observed between the two studies could be adduced from the environmental conditions of the study areas.

Table 5: Effect of Ethanol Extracted Propolis on the Total Soluble Solids (TSS) of Okra Fruits During Storage in Makurdi

	Total Soluble Solids (TSS)					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	1.64	1.45	1.62	1.65	1.69	1.24
Clemson spineless	1.59	1.47	1.63	1.68	1.67	1.27
F-LSD(P≤0.05)	NS	NS	NS	0.01	NS	0.01
EEP (%)						
70	0.00	1.45	1.63	1.72	1.69	1.16
80	0.00	1.40	1.66	1.74	1.79	1.44
90	0.00	1.38	1.68	1.83	1.83	1.72
Control	1.62	1.60	1.53	1.37	1.42	0.69
F-LSD(P≤0.05)	NS	NS	0.03	0.01	0.07	0.01

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

Table 6: Effect of Ethanol Extracted Propolis on the pH of Okra Fruits During Storage in Makurdi

	pH					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	7.50	8.00	7.23	7.38	6.52	6.33
Clemson spineless	7.60	8.25	7.12	7.41	6.70	6.38
F-LSD(P≤0.05)	NS	0.04	0.03	NS	0.04	NS
EEP (%)						
70	0.00	8.43	7.23	7.43	6.65	6.28
80	0.00	7.93	6.95	7.23	6.63	6.35
90	0.00	8.03	7.48	7.53	6.58	6.55
Control	7.55	8.10	7.02	7.38	6.57	6.22
F-LSD(P≤0.05)	NS	0.06	0.05	0.04	0.06	0.09

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

During storage, Clemson spineless (small) okra had a higher pH than stubby okra (large), and the difference was significant at 4, 7, and 13 days. Table 6 showed that pH of okra decreased as the days of storage increased. Okra fruits treated with EEP obtained higher pH than the untreated okra fruits. Increased in EEP level from 70% to 90% had a resultant increase in the pH of the okra fruits and the difference was significant from 4 to 16days of storage. A cursory look on Table 6 revealed that untreated okra fruits obtained the lowest pH while 90%EEP recorded the highest pH value of okra fruits at the 16th day of storage. This work collaborates the earlier works of Laila et al., (2018) who recorded a decrease of 1.02 % in pH by the twelfth week for okra coated with nanoparticle and chitosan as the present study followed similar pattern.

Vitamin C content of the stored okra varieties significantly decreased with increases in storage days. However, Stubby okra (big) significantly decreased faster as compared to Clemson spineless (Table 7). At the 16th day of storage, EEP treated okra retained more vitamin c content compared to the untreated okra, as 80% and 90%EEP showed higher vit C content at the end of storage with significant difference (Table 7). Similar trend was observed with the titratable acidity (TA) of the stored okra fruits. However, TA decreases from day 1 to 13 and increased at day16 of storage. 90%EEP had significantly higher TA as compared to other levels and the untreated okra fruits. However, stubby okra (big) obtained higher TA value as compared to Clemson spineless at the 16th day of the storage period (Table 8). The increase in ethylene synthesis during storage may be the cause of the decline in TA and vitamin C readings at higher concentrations. Fruit ripening is enhanced by a drop in acidity level since, generally speaking, TA decreases with an increase in respiration rate (El-Anany et al., 2009).

Table 7: Effect of Ethanol Extracted Propolis on the Vitamin C Content of Okra Fruits During Storage in Makurdi

	Vitamin C					
Variety	**1**	**4**	**7**	**10**	**13**	**16 (DAYS)**
Stubby Okra	0.53	0.45	0.26	0.24	0.18	0.06
Clemson spineless	0.43	0.30	0.20	0.30	0.17	0.16
F-LSD(P≤0.05)	0.01	NS	0.01	0.01	0.01	0.01
EEP (%)						
70	0.00	0.39	0.19	0.21	0.11	0.05
80	0.00	0.74	0.11	0.28	0.21	0.17
90	0.00	0.27	0.27	0.33	0.28	0.12
Control	0.44	0.27	0.35	0.25	0.10	0.09
F-LSD(P≤0.05)	0.02	0.02	0.01	0.02	0.01	0.01

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

Table 8: Effect of Ethanol Extracted Propolis on the Total Titrable Acidity (TTA) of Okra Fruits During Storage in Makurdi

Variety	1	4	7	10	13	16 (DAYS)
Stubby Okra	6.67	3.17	2.92	2.75	2.33	3.02
Clemson spineless	5.67	3.42	2.42	4.50	2.00	2.74
F-LSD(P≤0.05)	NS	NS	0.26	NS	0.18	0.03
EEP (%)						
70	0.00	2.67	2.50	4.00	2.00	2.68
80	0.00	3.67	2.67	3.00	2.17	1.83
90	0.00	3.00	3.00	2.50	2.50	4.00
Control	6.17	3.83	2.50	5.00	2.00	3.00
F-LSD(P≤0.05)	NS	0.46	0.37	NS	0.25	0.04

EEP = Ethanol Extracted Propolis; F-LSD = Fishers' least significant difference at 5% level of probability

The reduction of titratable acidity in fruits is correlated, with few exceptions, with the decrease of organic acid levels during the ripening process by their oxidation through the Krebs cycle to form energetic reserves for fruits, (Kays, 1991; Mattuiz et al., 2015).

Okra varieties showed no statistical difference on the shelf life of the fruits during storage. The shelf life of EEP treated okra fruits was extended to 16days during storage while the untreated okra fruits shelf life terminated at day 10 of storage and the difference was significant at the end of the storage period (Table 9). The results of the present study revealed that propolis treated okra fruits showed no postharvest decay and their marketability was higher as well as the shelf life of propolis treated fruits was extended to 16 days while the untreated lasted only for 10 days. However, the results showed promising outcomes as the fruits can be extended beyond the 16th day of storage. The results of the present study are complementary with earlier findings of Alvarez et al. (2015) and Alvarez et al. (2017) in which they reported that fruits treated with propolis extended the shelf life and to also improve the visual quality of celery, leek and butternut squash fruits and fresh-cut mixed vegetables for soup. According to the study, Clemson spineless okra performed better in terms of the fruits' physical and chemical characteristics during storage than stubby okra. The genetic composition of the two types may make this feasible. This study complements the earlier findings of Ogbaji and Iorliam, (2020) and Iorliam and Ugoo (2023) which reported that when it came to physical and chemical quality and, consequently, shelf life when stored, spineless Clemson okra outperformed stubby okra.

Table 9: Effect of Ethanol Extracted Propolis on the Shelf-life of Okra Fruits During Storage in Makurdi

	Shelf-Life					
Variety	1	4	7	10	13	16 (DAYS)
Stubby Okra	1.00	4.00	7.00	10.00	13.00	16.00
Clemson spineless	1.00	4.00	7.00	10.00	13.00	16.00
F-LSD(P≤0.05)	NS	NS	NS	NS	NS	NS
EEP (%)						
70	1.00	4.00	7.00	10.00	13.00	16.00
80	1.00	4.00	7.00	10.00	13.00	16.00
90	1.00	4.00	7.00	10.00	13.00	16.00
Control	1.00	4.00	7.00	10.00	10.00	10.00
F-LSD(P≤0.05)	NS	NS	NS	NS	1.72	2.73

Singh, P., Chauhan, V., Tiwari, B. K., Chauhan, S. S., Simon, S., Bilal, S. and Abidi, A. B. (2014). An overview on Okra (*Abelmoschus esculentus*) and It's Importance as a Nutritive Vegetable in the World. *International Journal of Pharmacy and Biological Sciences, 4*(2), 227-233.

Conclusion

In conclusion, this study shows that 90% EEP not only slowed down the metabolic process but also enhanced the biosynthesis of the chemical and physical components, including pH, titratable acids, weight loss, and total soluble solids. But when it came to fruit firmness and vitamin C, 80%EEP exhibited encouraging results. The study confirmed that larger doses of ethanolic extracted propolis can be utilized to maintain the quality of okra fruits during storage, irrespective of the variety of okra. Propolis is a natural product that promotes the creation and use of natural fungicides that are just as effective as synthetic fungicides but safer for the environment and people. It is used to preserve fruit and vegetable postharvest quality, shelf life, and disease prevention. As a result, the current study recommends using propolis to preserve okra fruits in Makurdi.

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