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Efficacy of Some Plant Aqueous Extracts and Waxes in the Preservation of Some Fruits and Vegetables

A. Bukar[1*] and A. M. Magashi[1]

[1]Department of Microbiology, Bayero University, PMB 3011, Kano, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AB designed the study, performed the research, statistical analysis, wrote the protocol, and wrote the first and final draft of the manuscript. Author AMM supervised the research and also read and approved the final manuscript.

Research Article

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ABSTRACT

Aim: The preservative effect of waxes (paraffin and ester) in addition to buffers (pH 9 and 10) and aqueous extracts (*P. biglobosa* pod, *G. senegalensis* and *B. aeyptiaca* leaves) were studied on fruits and vegetables.
Methodology: The preservative effects of the waxes was determined by treating fresh ripe tomatoes, peppers and oranges with buffer (pH 9, 10) for 2 minutes and wax for 3 minutes using the dipping method and for extracts, washing daily with 5mg/ml or 10mg/ml for 3 minutes. Controls were untreated and unwaxed. Number of days taken for fruits and fruit vegetables to deteriorate was recorded and compared.
Results: Results showed waxing was highly effective on pepper (30 days), moderately effective on orange (26 days) and fairly effective on tomato (15 days). Among the waxes, paraffin was more effective (9 – 30 days) in increasing shelf life than ester (9 – 14 days) and the control (6-8 days). *P. biglobosa* extract application proved more effective (17 - 26 days) than *Guera senegalensis* (13 – 14 days), *Balanites aegyptiaca* (8 - 13 days) and the control (9-11 days) in extending the shelf life of the test fruits and vegetables. Statistically, significant differences ($P > 0.05$) exist between shelf life of tomatoes, oranges and peppers used as control and those subjected to treatments. Comparison of the preservative activity indicated paraffin wax > *P. biglobosa* > *G. senegalensis* > *B. aegyptiaca* > ester wax.

**Corresponding author: E-mail: al_amsak2004@yahoo.com;*

Conclusion: Application of waxes and plant aqueous extracts to preserve seasonally available fruits and vegetables could provide a cheap and economically viable method of preservation that could be adopted by farmers in Nigeria, where storage facilities for such products are insufficient.

Keywords: Efficacy; fruits; Nigeria; storage; wax.

1. INTRODUCTION

It is estimated that 20% of fruits and vegetables harvested for human consumption are lost through microbial spoilage [1]. The high water content of fruits and vegetables favours growth of spoilage bacteria, molds and yeasts [2].

Fresh fruits and vegetables offer the most rapid and lowest cost method of providing adequate supplies of vitamins, minerals, and fibre to man [3]. In the tropics, fruits and vegetables are abundant immediately after the early rains but become scarce late in the rainy season and more so in the dry season [4]. To improve availability year round, farmers resort to sun drying of fruits and vegetables, the consequences of which certain vitamins and minerals are lost (33 -50% of the thiamine, ascorbic acid and vitamin A in fruits and vegetables) [5]. Therefore, there is need to have a preservative method that will improve the availability of these vitamins and minerals in fresh fruits and vegetables - even for a short – duration.

In a preliminary investigation to determine the efficacy of plant extracts as preservatives, Bukar and Magashi [unpublished thesis] screened *Guera senegalensis, Lepidium sativum, Balanite aegyptiaca* and *Parkia biglobosa* used in ethnomedicine for preservative effect on tomatoes, leafy vegetables and fresh meat. The results indicate a preservative effect of a powdered suspension of *Lepidium sativum,* leaves of *Balanite aegyptiaca, Guera senegalensis* and pods of *Parkia biglobosa* on tomatoes and lettuce but not on the fresh meat.

Waxes serve as physical barriers to spoilage microorganisms and by preventing their entry increase the shelf life of fruit and vegetables [6]. Such waxes could be classified as 1) natural waxes, such as candelia wax, carnauba wax, Japan wax, rice oil wax, sugar cane wax, shellac wax, bees wax and paraffin wax, 2) chemically modified waxes (hard waxes), such as ester wax, sasol wax, hydrogenated jojoba wax, montan ester wax; and 3) synthetic waxes such as polyalkylene wax and polyethylene glycol wax [7]. Pao et al. [8] reported effective bactericidal activity of combined alkali and heat treatment on both glass and orange fruit surfaces. A five log reduction of *Escherichia coli* count was achieved by dipping in wax heated at 50ºC and pH of 10. Magashi and Bukar [9] reported that buffer at pH 9 and 10 and wax applied on the surface of fruits and vegetables sanitized them by significantly ($P > 0.05$) reducing the counts of both bacteria and fungi.

In another research by same authors, Bukar and Magashi [10] washing fruits and vegetables using aqueous extracts of *Parkia biglobosa* achieved sanitizing effect by reducing both bacterial and fungal counts on their surfaces. Bukar et al. [11] also reported that extracts of *P. biglobosa* possessed antimicrobial activity against food – borne pathogens and food spoilage causing microorganisms. It is in view of the above findings that the present research was set up to evaluate the preservative activities of some selected waxes together with buffers at pH 9 and 10 and plant aqueous extracts with a view to discovering their potentials in extending shelf life of fruits and vegetables.

2. MATERIALS AND METHODS

2.1 Collection and Processing of Plant Materials and Wax

The leaves of *Guera senegalensis, Balanites aegyptiaca* and Pods of *Parkia biglobosa* were collected fresh from their parent plants around Old campus, Bayero University, Kano. Paraffin and Ester waxes were purchased from Toteil Nigeria Limited, Kano.

The plants were first identified at the field using standard keys and descriptions of Dalziel [12]. The plants were further confirmed and authenticated in a Herbarium of the Department of Biological Sciences, Bayero University, Kano, Nigeria. The plant materials were air dried and ground into powder using mortar and pestle in the laboratory as described by Mukhtar and Tukur [13].

2.2 Sourcing of Test Fruits and Vegetables

For the purpose of this research, Oranges, peppers and tomatoes were used as test fruits and vegetables. Arrangement was made with a fruit seller to purchase the fruits and vegetables before their bags were opened and before they were washed, as washing will reduce or eliminate the microorganisms on the surface of the fruits and vegetables. Visually unbruised fruits were sorted out and transported in sterile polythene bags to the laboratory for investigation as set out by Refai [14]. All the fruits and vegetables brought to the laboratory for the research were sorted into ripe ones [which were red in colour, except for oranges which were yellow] and unripe ones [which were green in colour, except for orange which was not used in the research].

2.3 Preparation of Aqueous Extract of Plant Materials

The aqueous extracts were prepared using the procedure described by Olamifihin [15]. Fifty grams (50g) of each of the dried, powdered leaves of *Guera senegalensis, Balanites aegyptiaca* and pods of *Parkia biglobosa* was percolated in 500ml of sterilized distilled water at 60ºC in a 1-litre capacity round bottom flasks. The flasks were corked, shaken for 1 minute and left to stand for 7 days with shaking at regular intervals. The solutions were filtered using Whatman N0. 1 filter paper. The filtrates were evaporated in a hot oven at 40ºC to obtain aqueous extracts of the various test plants. The extracts were stored in a refrigerator at 4ºC for future use.

2.4 Preparation of Different Concentrations of Aqueous Extracts

Concentrations of the aqueous extracts (5mg/ml and 10mg/ml) were prepared by placing 5 or 10 gram into sterilized bottles containing 1000ml of sterile distilled water [16]. The solutions of the extracts were then kept in a refrigerator for daily use.

2.5 Buffer Preparation

Buffers of pH 9 and 10 were prepared for fruit and vegetable treatment prior to wax application. Buffer solution of pH 9 was prepared by dissolving 2 sachet of pH 9 powder into

200ml of sterilized distilled water. One hundred millilitres (100ml) of this buffer (pH 9) was dispensed into a separate conical flask, which was adjusted to pH 10 by adding more 1N NaOH with the help of pH meter Jenway model (UK).

2.6 Wax Preparations

The procedure for wax preparations was carried out according to the manufacturer's instructions on the packets. Paraffin wax (Raymond A. Lamb, London) was prepared by melting about 200g in a stainless steel container on a hot plate at 60ºC. When the wax had melted completely, the container was left on the hot plate to equilibrate at 50ºC prior to wax treatment on the fruits and vegetables.

For ester wax (BDH Chemicals Ltd, England), the same procedure for melting paraffin wax was applied, the only difference was the melting temperature used, at 80ºC.

2.7 Determination of Shelf Life of Wax and Plant Extract Treated Fruits and Vegetables

Tomatoes, peppers and oranges were divided into 3 groups each with a group consisting of both unripe and ripe fruits with replication; first group was dipped into buffer solution at pH 9 for 2 minutes, then treated with wax at 50ºC for 3 minutes, it was removed and allowed to dry. The second group was also dipped into buffer at pH 10 for 2 minutes, then dipped into wax at 50ºC for 3 minutes and allowed to dry and kept until it show signs of spoilage or deterioration. The third group which was the control was not treated with either the buffer or wax but was kept unwaxed in a cupboard. All the treatments were kept in open plastic containers in a cupboard. The number of days taken for the fruit and vegetable to spoil or decay was recorded.

For shelf life determination of extract treated tomatoes, peppers and oranges, they were also divided into 3 groups each with a group consisting of both unripe and ripe fruits with replication; first group was surface washed daily with the aqueous extract of 5mg/ml concentration for 3 minutes duration. The second group was also treated with the aqueous extract of 10mg/ml concentration for 3 minutes duration, dried and kept also in plastic containers in a cupboard for shelf life determination. The third group, which was the control was daily washed with sterilized distilled water for 3 minutes. All the treatments were kept in a cupboard until it spoilt or decayed. Fruits and vegetables were recorded spoilt or decayed on rating of 1(poor) on a visual eating quality rating of 4 (excellent), 3(good), 2(fair), 1(poor) and 0(very poor) [17]. This is in addition to observed microbial growth on the fruits and vegetables, which could render them unfit for consumption.

The room temperature was monitored daily.

2.8 Statistical Analysis

The results of the preservative effect (Shelf life) of the *P. biglobosa*, *G. senegalensis* and *B. aeyptiaca* extracts, paraffin and ester waxes on the test fruits and vegetables was statistically analysed using Analysis of variance (ANOVA) at 5% level of significance to determine whether significant difference exist among the various treatments applied. Means were separated using Least Significant Difference (LSD) [Zar, 18].

3. RESULTS AND DISCUSSION

Fig. 1 shows the result of shelf life determination of paraffin waxed and control tomato, pepper and orange. It can be observed that unwaxed unripe tomato, pepper (control) took 15 and 11 days to deteriorate. The paraffin waxed unripe tomato and pepper at pH 9 took 19 and 24 days to deteriorate while paraffin waxed unripe tomato and pepper at pH 10 took 30, 35 days to deteriorate respectively. For unwaxed ripe tomato, pepper and orange it took 8, 6, 6 days to spoil, paraffin waxed ripe tomato, pepper and orange at pH 9 took 9, 18 and 15 days to spoil , while paraffin waxed ripe tomato, pepper and orange at pH 10 took 15, 30 and 26 days to spoil respectively (Plate 1).

Fig. 2 shows the result of shelf life determination of Ester waxed and control tomato, pepper and orange. It was observed that unwaxed unripe tomato and pepper (control) took 15 and 11 days to deteriorate, the ester waxed unripe tomato and pepper at pH 9 took 12 days and 8 days to deteriorate, while ester waxed unripe tomato and pepper at pH 10 took 19 days and 15 days to deteriorate respectively. For unwaxed ripe tomato, pepper and orange it took 8, 6, 6 days to spoil, ester waxed ripe tomato, pepper and orange at pH 9 took 7, 6 and 10 days to spoil while ester waxed ripe tomato, pepper and orange at pH 10 took 14, 9 and 14 days to spoil respectively.

Fig. 3 shows the result of shelf life determination of aqueous extract of *Parkia biglobosa* treated and control tomato, pepper and orange. Untreated unripe tomato and pepper (control) took 18 and 13 days to deteriorate, the *Parkia biglobosa* treated unripe tomato and pepper at 5mg/ml took 26 days and 19 days to deteriorate while *Parkia biglobosa* treated unripe tomato and pepper at 10mg/ml took 32 days and 23 days to deteriorate respectively. For untreated ripe tomato, pepper and orange it took 9, 10, 11 days to spoil, *Parkia biglobosa* treated ripe tomato, pepper and orange at 5mg/ml took 20, 15 and 11 days to spoil while *Parkia biglobosa* treated ripe tomato, pepper and orange at 10mg/ml took 24, 17 and 26 days to spoil, respectively (Plate 2).

Fig. 4 shows the result of shelf life determination of aqueous extract of *Guera senegalensis* treated and control tomato, pepper and orange. It can be observed that untreated unripe tomato and pepper (control) took 18 and 13 days to deteriorate, the *Guera senegalensis* treated unripe tomato and pepper at 5mg/ml took 18 days and 16 days to deteriorate while *Guera senegalensis* treated unripe tomato and pepper at 10mg/ml took 28 days and 19 days to deteriorate respectively. For untreated ripe tomato, pepper and orange it took 9, 10, 11 days to spoil, *Guera senegalensis* treated ripe tomato, pepper and orange at 5mg/ml took 11, 10 and 10 days to spoil while *Guera senegalensis* treated ripe tomato, pepper and orange at 10mg/ml took 14, 13 and 14 days to spoil respectively.

Fig. 5 shows the result of shelf life determination of aqueous extract of *Balanites aegyptiaca* treated and control tomato, pepper and orange. It can be observed that untreated unripe tomato and pepper (control) took 18 and 13 days to deteriorate, the *Balanites aegyptiaca* treated unripe tomato and pepper at 5mg/ml took 22 days and 14 days to deteriorate while *Balanites aegyptiaca* treated unripe tomato and pepper at 10mg/ml took 32 days and 16 days to deteriorate respectively. For untreated ripe tomato, pepper and orange it took 9, 10, 11 days to spoil, *Balanites aegyptiaca* treated ripe tomato, pepper and orange at 5mg/ml took 10, 9 and 14 days to spoil while *Balanites aegyptiaca* treated ripe tomato, pepper and orange at 10mg/ml took 8, 13 and 18 days to spoil respectively. Result of temperature monitoring indicated it to be within the range of 19ºC to 32ºC with mean of 23ºC.

There were statistically significant differences ($P > 0.05$) between treated tomatoes, peppers and oranges and the control.

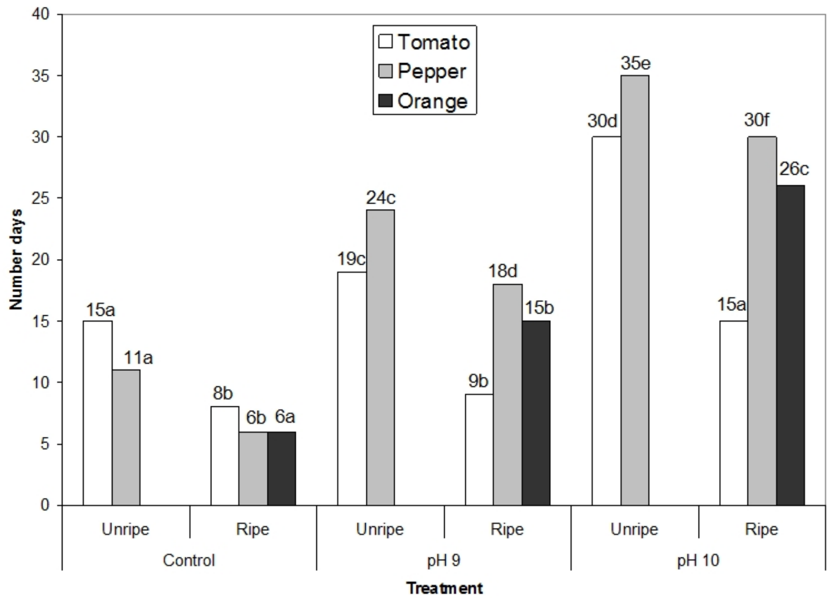


Fig. 1. Comparison of shelf life of paraffin waxed and unwaxed, ripe and unriped (control) fruits and vegetables

Key: means with same letters not significantly different for the same fruit or vegetable under different treatments

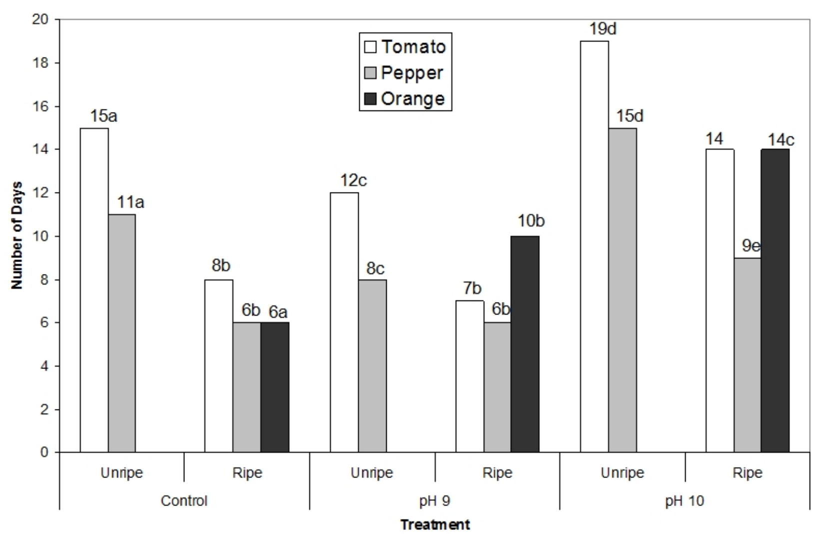


Fig. 2. Comparison of shelf life of ester waxed and unwaxed, ripe and unripe (control) fruits and vegetables

Key: means with same letters not significantly different for the same fruit or vegetable under different treatments

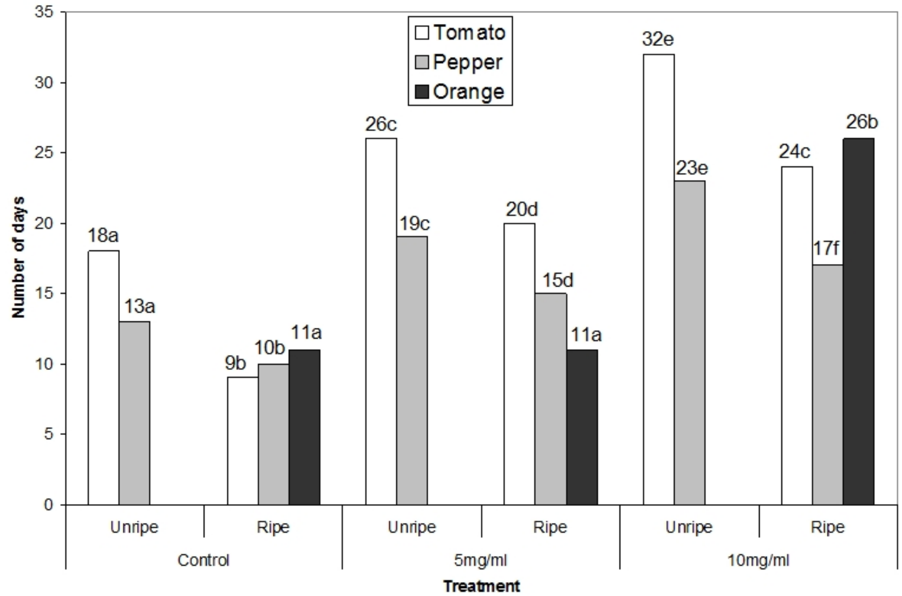


Fig. 3. Comparison of shelf life of *Parkia biglobosa* extract treated and untreated, ripe and unripe (control) fruits and vegetables

Key: means with same letters not significantly different for the same fruit or vegetable under different treatments

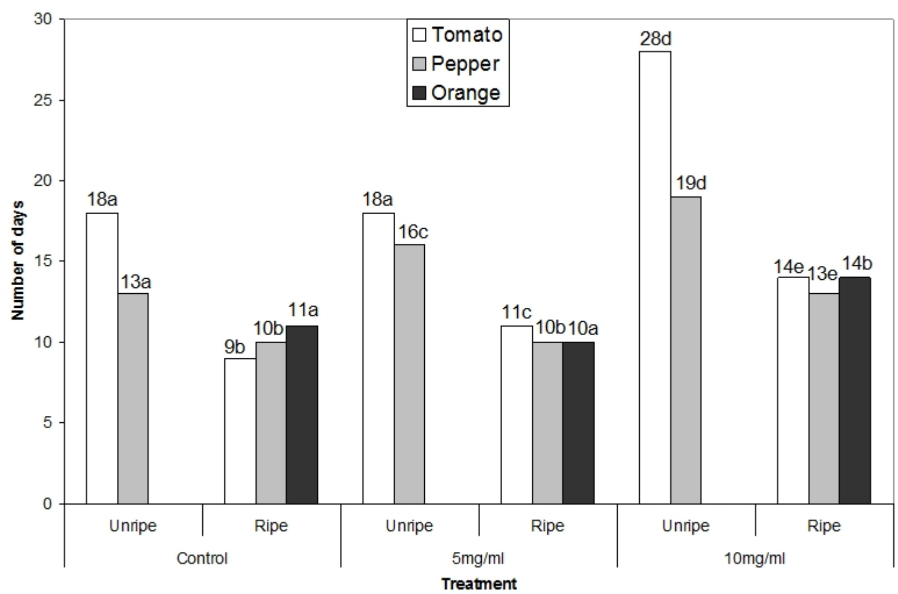


Fig. 4. Comparison of shelf life of *Guera senegalensis* extract treated and untreated, ripe and unripe (control) fruits and vegetables

Key: means with same letters not significantly different for the same fruit or vegetable under different treatments

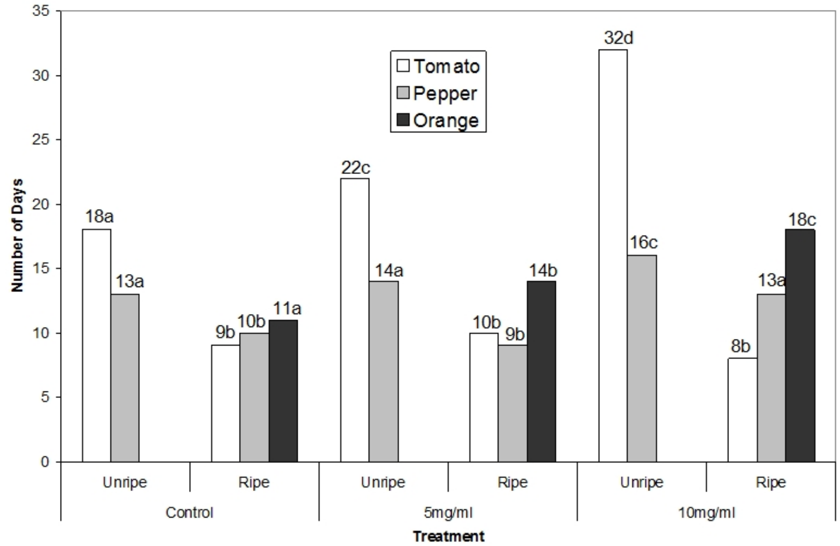


Fig. 5. Comparison of shelf life of *Balanites aegyptiaca* extract treated and untreated, ripe and unripe (control) fruits and vegetables

Key: means with same letters not significantly different for the same fruit or vegetable under different treatments

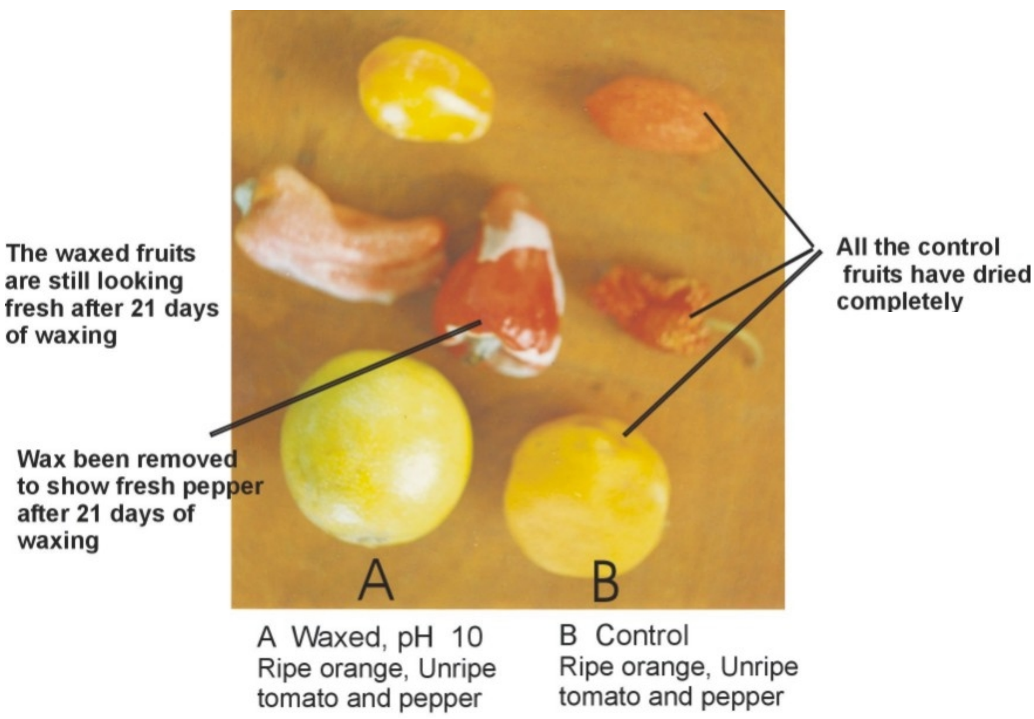
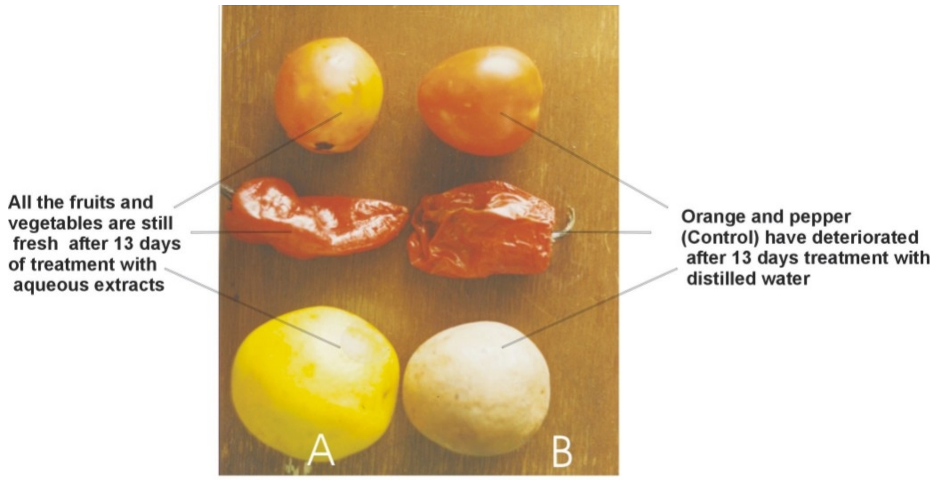


Plate 1. Paraffin waxed and unwaxed tomato, orange and pepper after 21 days of treatment



A Extract treated, 1000ug/ml
Ripe orange, pepper and unripe tomato

B Control
Ripe orange, ripe pepper and unripe tomato

Plate 2. *Parkia biglobosa* extract treated and unwaxed tomato, orange and pepper after 13 days of treatment

4. DISCUSSION

Results of shelf life determination of tomatoes, pepper and oranges showed that waxing is highly effective on ripe pepper (30 days), moderately effective on ripe orange (26 days) and fairly effective on ripe tomatoes (15 days). Among the waxes however, paraffin wax proved more effective (9-30 days) by increasing the shelf life than ester wax (7-14 days). This might be because ester wax was observed to inflate by trapping air and also had a crack, which might facilitate entry and proliferation in numbers and activities of the spoilage microorganisms [5]. Small amount of moisture was observed after peeling of ester wax from surface of the fruits and vegetables studied. On the other hand, this was not observed on surfaces of fruits and vegetables treated with paraffin wax rather they appeared fresh and glossy looking after peeling.

Buffers at pH 9 and 10 have been previously shown to possess sanitizing activity [9,10,19]. Waxing provide a barrier to further contamination by microorganisms and also prevents loss of moisture by fruits and vegetables [20]. The combination of the buffer and waxing may have provided a hurdle technology against the spoilage – causing microorganisms, thereby protecting the surface of the fruits and vegetables from microbial activities causing spoilage.

The surface washing of the tomatoes, pepper and oranges with the aqueous extracts was observed to be effective in extending their shelf life. This may be as a result of the antimicrobial components (alkaloids, tannins, saponins, etc) extensively reported to be present in plant tissues (roots, leaf, stem bark, etc) [12,19,20,21]. This finding agrees with the findings of Bukar and Magashi [unpublished thesis] who reported on the preservative effect of aqueous suspension of *Parkia biglobosa* pods, and leaves of *Guera senegalensis,* and *Balanites aegyptiaca* on tomatoes and oranges.

Other factors that might have aided in increasing the shelf life of aqueous extract treated tomatoes, pepper and oranges is the duration of treatment and the vehicle used in applying the extracts. In the present research, the fruits and vegetables were daily washed with 20 ml of the extracts for 3 minutes and then kept in containers with lid almost closed. The water on the surface of the fruits and vegetables might have helped in increasing the relative humidity, thereby reducing the temperature of the microenvironment on the surface of the fruits and vegetables [2], which helps to reduce transpiration and rate of enzyme activity that hasten ripening and decay [22].

On comparison, extract application at both 5 and 10mg/ml has proven to be more effective on ripe tomato (24 and 24 days), while paraffin wax at pH 9 and 10 was more effective on both pepper (18 and 30 days) and orange (15 and 26 days). The least effective of all is ester wax. Overall, in terms of increasing shelf life of fruits and fruit vegetables, paraffin wax > *Parkia biglobosa* > *Guera senegalensis* > *Balanites aegyptiaca* > ester wax.

The preservative effect of the buffer and aqueous extract does not increase significantly even when the pH was increased from 9 to 10 and the concentration from 5 to 10mg/ml, even though Ajaiyeoba [21] reported that increasing the concentration of extracts should naturally increase the antimicrobial activity.

The shelf life of unripe fruits and vegetables under investigation was observed to take longer time to spoil than the ripe ones. This might be because unripe fruits and vegetables take some days to ripe before actually starting to deteriorate [4] compared with ripe ones which are ripe already, therefore undergo deterioration only.

The average temperature of the room during the conduct of this research (23^{o}C) did not significantly affect the shelf life of the test fruits and vegetables as result show an increase of several days (in some cases up to 20 days) over the control despite the fact that fruits and vegetables have been reported to stay longer at temperature of below 10^{o}C and relative humidity of 95% [2]. Desrosier and Desrosier [23] reported that the generalized storage life of fruit and vegetables at 21ºC is 1 – 7. The treatment by both waxing and aqueous extract application can serve in increasing the shelf life of tomato, pepper and orange as well as reduce or eliminate on the surface potentially pathogenic and spoilage causing organisms.

5. CONCLUSION

The present research has shown that paraffin wax, ester wax and aqueous extracts of *Guera senegalensis, Parkia biglobosa* and *Balanites aegyptiaca* possess varying degrees preservative effects on tomatoes, peppers and oranges kept at room temperature compared to control test fruits and vegetables. This was achieved by shelf – life extension of treated fruits and fruit vegetables compared to the untreated.

RECOMMENDATION

Based on the results of this research, I suggest that further research should be carried out to corroborate the findings of this research so that the objective of the research will be achieved which is to make available waxes and plants extracts, which are available and cheap for preservation of fruits and vegetables at room temperature.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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