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Effect of Different Waxing Materials on the Quality and Shelf Life of Mysore Banana Variety

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Authors' contributions

This work was carried out in collaboration among all authors. Authors KSK and PK designed the study, performed the statistical analysis, wrote the protocol. Author KSK wrote the first draft of the manuscript. Authors PK and Author PKT managed the analyses of the study. Author PKT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Banana is a climacteric fruit with a short shelf life. As a result, huge losses are incurred during handling in the value chain. The need to develop means of extending the shelf life and concomitantly maintaining the quality of the fruit after harvest has become very important. This study was conducted to determine the effects of two different edible waxing materials (beeswax and cassava starch) used as coatings on the quality and shelf life of Mysore banana. The study was conducted in the laboratory at the Department of Horticulture, Kwame Nkrumah University of Science and Technology–Kumasi. The experiment was laid out in a simple completely randomized design (CRD) and replicated three (3) times with three treatments (beeswax, cassava starch and a control). Parameters studied were: fruit weight loss, firmness, peel colour, pulp-to-peel ratio, moisture content (MC), dry matter content (DMC), total titratable acidity (TTA), total soluble solids (TSS), pH, green life and shelf life. The results showed beeswax and cassava starch had no significant effect ($P>0.01$) on peel colour, fruit firmness, TTA, TSS, DMC, MC and green life. Beeswax, however, kept weight loss minimal, and reduced TSS and the pulp-to-peel ratio of the fruits during storage. We conclude that beeswax was the best treatment in terms of waxing Mysore banana fruits to maintained its quality and ultimately prolonged its shelf life by about four (4) days more than the control.

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Keywords: Beeswax; physicochemical quality; cassava starch; Musa spp.

1. INTRODUCTION

Banana (Musa spp.) is a crop belonging to the family *Musaceae.* According to FAO [1], banana is cultivated in more than 135 countries and territories worldwide with tropical countries like Ecuador, Philippines, Costa Rica, Columbia, Guatemala, Ivory Coast and Cameroun producing and exporting megatons of the commodity annually. Banana fruit is of importance to humans as well as animals. Banana is a good source of a wide range of nutrients and it is predominantly rich in Vitamins (Pyridoxine, Ascorbic acid and Vitamin A), Carbohydrates, Fibre and Minerals (Potassium, Magnesium, Phosphorus and Iron), all of which are important for the proper growth and development of the human body [2]. Banana fruits contain certain antioxidants (e.g. dopamine and catechin). These are substances which aid in alleviating the risk of heart related diseases as well degenerative illness [3]. Dried banana peels are incorporated in the formulation of feed for livestock in animal production. Like other crops, losses in Mysore banana do occur along the production chain right from harvesting through to packaging and marketing. Such losses do occur mainly as a result of respiration and rapid ethylene production which is mostly induced by poor handling and microbial attack. The aforementioned factors are highly favoured in the tropics where harvested fruits are mostly exposed to ambient conditions during storage and transit. Consumer awareness in recent times on the nutritional importance of banana has increased its consumption and heighted the demand for the commodity but due to its short shelf life, this demand is not met. This is normally due to unavailability of storage facilities coupled with lack of alternative product development technologies.

According to Ahmed and Palta [4], matured green bananas kept at room temperature ripen within 4-5 days after ethylene treatment. After this period, banana fruits can stay fresh on the shelf for up to three days after which fruits are deemed unsuitable for the market or unfit for human consumption. Banana fruits are delicate with a very short shelf life [5]. In view of this, many post-harvest treatments have been studied and applied to banana fruits in a bid to prolong the shelf life of the produce. The use of 1-methycyclopropene (1-MCP) was beneficial in maintaining fruit firmness during storage, colour changes in the peel of banana fruits during early stages of ripening [6]. Researchers have also studied the effects of refrigeration on the shelf life and overall acceptability of banana. A study conducted by Broughton *et al.,* [7], showed that refrigerated banana fruits ripen very slowly but under storage temperatures below 10^0C, fruits show signs of chilling injury. There is however dearth of scientific information on the use of wax in the improvements or preservation as qualities for a longer period. The objective of this study therefore was to determine the effect of beeswax and cassava starch on the physicochemical quality and shelf life of Mysore banana.

2. MATERIALS AND METHODS

The experiment was conducted in the laboratory at the Department of Horticulture, Kwame Nkrumah University of Science and Technology (KNUST) – Kumasi.

2.1 Experimental Materials

In conducting the experiment, the following were used; pH meter (Elico digital pH meter, Version LI-617 - India), durometer (Shore C durometer - China), refractometer (Hanna HI 96801 - USA), top loading electronic balance (Accuris w3300 - 500, USA), oven, beeswax and cassava starch.

2.2 Source of Materials

Two (2) Mysore bunches harvested at an optimum stage of maturity were obtained at a banana farm in Effiduase in the Ashanti region of Ghana immediately after harvest at 9:16am. The harvested bunches were transported to the Department of Horticulture, Kwame Nkrumah University of Science and Technology (KNUST) – Kumasi. The bunches were packaged in a corrugated paper boxed for transportation to keep injuries minimal.

2.3 Preparation of Samples

The matured Mysore fruits borne on the peduncle were de-handed using a clean, sharp knife. Averagely, each hand consisted of thirteen (13) fingers. The hands were separated into fingers. Only uniformly sized and shaped fingers taken from the mid-section of the bunch were selected for the experiment. Fingers of uneven sizes and shapes borne on the extremes of the bunch were discarded. Each finger was washed gently under running water using soft foam to rid the fingers of dirt and also to remove their natural wax coatings. A total of two hundred and four (204) uniformly sized Mysore fingers were used for the experiment. One hundred and eighty (180) fingers were used for destructive analysis and twenty-four (24) fingers were used for non-destructive analysis.

2.4 Treatments

Ninety-three (93) Mysore fingers were waxed with beeswax, ninety-three (93) fingers with cassava starch and eighteen (18) fingers were set as control.

2.4.1 Preparation of beeswax

At room temperature, beeswax in solid. 2000g of solidified beeswax was melted by heating in a beaker at a temperature of 65C for 9 minutes. The liquid wax was allowed to cool to approximately 45C after which waxing was done using soft foam.

2.4.2 Preparation of cassava starch

Fresh cassava was purchased from the Ayeduase Market in the Ashanti Region of Ghana. 1600 g of cassava was weighed using the analytical balance and peeled using a sharp knife. The pulp obtained was washed under running water and cut into small pieces. Pieces were blended with half parts of water added to obtain coarse whitish paste and strained through a colander. Finally. a clean chiffon cloth was used to separate the whitish chaff from the starch-containing suspension. The resulting suspension was boiled at approximately 80^0C until a viscous jelly-like liquid was obtained (the suspension was continually stirred using a slender wooden ladle to avoid the formation of large lumps). The starch prepared was allowed to cool after which waxing was done using soft foam.

2.5 Experimental Design

The experiment was laid out in a simple Completely Randomized Design (CRD) consisting of two (2) treatments and a control. The experiment was replicated three (3) times.

2.6 Parameters Studied

2.6.1 Colour changes

The peel colour of the individual fingers was examined daily. Changes observed were recorded and characterized using the standard banana colour chart with seven (7) different colours at each stage of ripening viz.; All green, Green with trace of yellow, More green than yellow, More yellow than green, Yellow with green tips and green necks, All yellow and All yellow with brown flecks.

Plate 1. Melting of beeswax

Plate 2. Preparation of cassava starch

2.6.2 Fruit firmness

Firmness of the banana fruits was measured and recorded on daily basis throughout the span of the experiment. This was done using a durometer (Shore C Durometer, China). The durometer is an instrument which measures firmness by calculating the resistance of the sample to force applied in a non-destructive fashion. The indenter, which lies beyond the surface of the pressure foot, applies a force to the sample (material). The resulting resistance to the force applied is recorded as the firmness of the material. Three readings were taken for each sample and the average of the three values obtained was recorded as the firmness value.

2.6.3 Weight loss

A top loading electronic balance (Accuris w3300 - 500, USA) was used to measure the weight of the individual fruits daily. The difference in the initial and the final weights of the Mysore fingers was recorded as weight loss and expressed as percentage. The formula below was used to calculate the percentage of weight loss;

$$\text{Weight loss } (\%) = \frac{a - b}{a} \times 100$$

a = initial weight of finger
b = final weight of finger in subsequent days

2.6.4 Pulp-to-peel ratio

To determine the pulp to peel ration of the samples, selected fingers were peeled using a sharp knife. The pulp was distinctively separated from the peel. The pulp as well as the peel was weighed on an analytical balance. The values obtained were then recorded. The pulp to peel ratio is expressed as:

$$\text{Pulp to peel ratio} = \frac{\text{Weight of pulp}}{\text{Weight of peel}}$$

2.6.5 Total Soluble Solids (TSS)

The total soluble solids (TSS) of the fruits was measured in ^{o}Brix using a Digital Refractometer (Hanna HI 96801 Refractometer - USA) with an accuracy of $\pm 0.2\%$. The fruit was first peeled. 30g of the pulp was weighed using an analytical balance and blended with 90ml of distilled water. Using a filter paper, filtration was carried out and the filtrate obtained was emptied into a 100ml beaker. Calibration of the refractometer was done using distilled water until a zero (0) reading was obtained. Four drops of the filtrate were placed on the prism surface of the refractometer using a plastic dropper and the reading displayed was recorded. The procedure was repeated three (3) times and the average of the three readings taken was recorded as the TSS value in ^{o}Brix. Standardization of the refractometer was done before use using distilled water and the prism surface was cleaned with distilled water between readings.

2.6.6 Total Titratable Acidity (TTA)

In determining the total titratable acidity (TTA) of the samples, the fruit were first peeled. 30g of the pulp was weighed using an analytical balance and blended with 90ml of distilled water.

Using a filter paper, filtration was carried out and the filtrate obtained was emptied into a 100 ml beaker. 10 ml of the filtrate was pipette into a conical flask and diluted to about 80 ml with distilled water.

Three (3) drops of phenolphthalein was then added to the solution and titrated against 0.1 M Sodium Hydroxide (NaOH) solution until a pale pink colour (persisting for at least 15 seconds) was observed. The total titratable acidity (TTA) of the pulp was expressed as percentage malic acid and was calculated using the formula below:

$$\text{Percentage of malic acid (\%)} = \frac{V_B \times M_B \times M_{Eq}}{g_s} \times 100$$

V_B = Volume of base (NaOH) used.
M_B = Molarity of base (NaOH) used.
M_{Eq} = Milliequivalent factor of malic acid in pulp.
g_s = Mass of sample in grams.

2.6.7 pH

The pH of the samples was determined at each stage of ripening using a pH meter (Elico digital pH meter, Version LI-617 - India). 30 g of the pulp was weighed using an analytical balance and blended with 90 ml of distilled water. Using a filter paper, filtration was carried out and the filtrate obtained was emptied into a 100 ml beaker. The pH meter before use was calibrated using three (3) buffer solutions of known pH values. The electrode of the pH meter was dipped in the filtrate. The displayed reading when stabilized, was recorded as the pH of the sample.

2.6.8 Moisture and dry matter contents determination

To determine the moisture content of the samples, labeled aluminum dishes were first weighed on an analytical balance and the values obtained after weighing were recorded. The samples were then peeled and for each sample, two (2) grams of pulp was weighed. The weighed samples in their respective dishes were then placed in an electric oven at a temperature of 60°C for 48 hours. The samples were removed from the oven, placed in a desiccator and allowed to cool. The weight of each sample was recorded. The Moisture content and the dry matter content of the pulp was determined using the formulae below:

$$\text{Moisture Content (\%)} = \frac{b - c}{b} \times 100$$

$$\text{Dry Matter Content (\%)} = \frac{c - a}{b} \times 100$$

a=weight of empty dish b=weight of fresh pulp
c= weight of empty dish + dried sample

2.6.9 Shelf life

The shelf life of the Mysore fingers was determined by counting the number of days required for the individual fingers to reach the last stage of ripening (full ripening) but at a stage where the fruits remain fit for the market. Using the standard banana colour chart, this stage is represented by ‘stage 6’. The stage where the peel colour of the banana fruit was all yellow without any noticeable traces of green. Banana at stage 7 of ripening (yellow with brown flecks) was deemed unacceptable for marketing.

2.7 Analysis of Data

The data obtained were arranged in Microsoft Excel (2016) and subjected to analysis of variance (ANOVA) using STATISTIX (version 9.1). The differences between treatment means was separated at 1% (P=0.01) least significant difference.

3. RESULTS

3.1 Physical Properties

3.1.1 Weight loss

From the Table 1, there was no significant difference (P>0.01) between Mysore fruits coated with Cassava starch and unwaxed Mysore fruits (control); however, there was a significant difference (P<0.01) between Mysore fruits waxed with beeswax and Mysore fruits coated with cassava starch and between Mysore fruits waxed with beeswax and unwaxed Mysore fruits (control). Mysore fruits waxed with beeswax recorded the lowest mean for weight loss (7.81%) whereas the highest mean was recorded by unwaxed Mysore fruits (control) (18.76%).

Fig. 1. shows the cumulative weight loss in beeswax-coated, cassava coated and unwaxed Mysore fruits stored under ambient conditions (30°C and 59% RH). There was a gradual increase in weight loss for all treatments. There were sharp increases in weight loss after day 2 of storage in Mysore fruits coated with cassava starch and unwaxed fruits; however, weight loss increased steadily in fruits waxed with beeswax.

Table 1. Means of physical properties of waxed and unwaxed mysore banana stored under ambient conditions (30□C and 59% RH)

Treatments	Weight Loss (%)	Firmness (N)	Colour Changes	Pulp-to-Peel ratio
Beeswax	7.82[a]	53.90[a]	4.44[a]	1.56[a]
Cassava Starch	16.34[b]	48.41[a]	4.55[a]	1.87[b]
Control	18.76[b]	50.76[a]	4.36[a]	2.00[b]
CV	8.43	7.21	5.77	0.43
LSD (0.01)	3.65	11.14	0.78	0.24

CV = Coefficient of Variation; LSD = Least Significant Difference

**Means in the same column followed by the same letter are not significantly different from each other at 1% LSD*

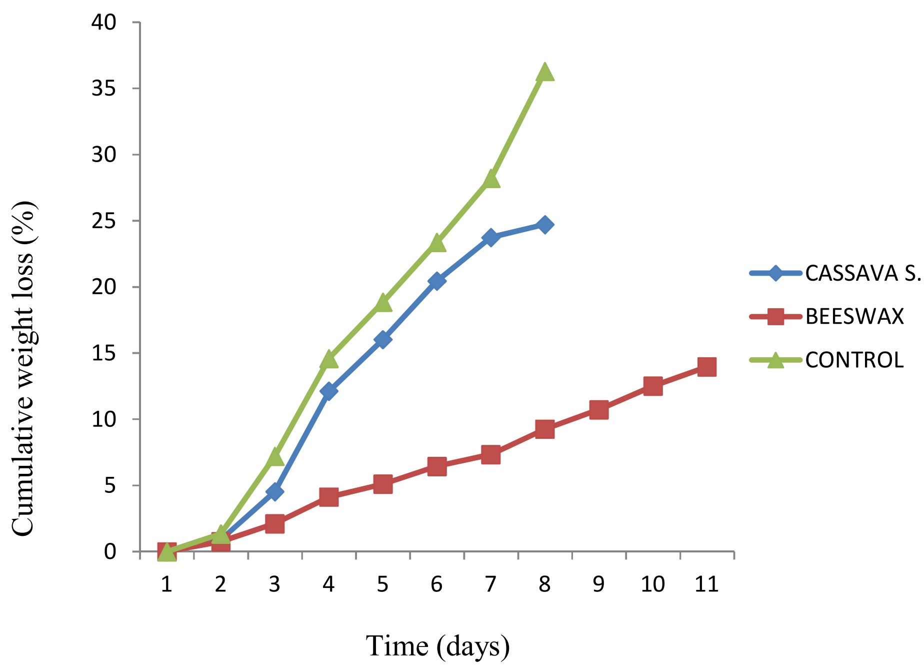

Fig. 1. Cumulative weight loss (%) of beeswax-coated, cassava coated and unwaxed Mysore fingers stored under ambient conditions (30^0C and 59% RH)

3.1.2 Fruit firmness and colour changes

Although Mysore fruits waxed with beeswax recorded the highest mean for fruit firmness (53.90N), statistically, there were no significant differences (P>0.01) among all the treatments. No statistically significant differences (P>0.01) were observed for colour changes among all the treatments.

Firmness dropped for all fruits irrespective of the treatment applied. Fig. 2 shows that there were sharper drops in firmness for fruits waxed with beeswax and fruits coated with cassava starch after day 3 of storage. Firmness dropped steadily and gradually for beeswax-coated fruits until the 11th day of storage.

3.1.3 Pulp-to-Peel Ratio

There was no statistically significant difference (P>0.01) between Mysore fruits waxed with beeswax and Mysore fruits coated with cassava starch as seen in Table 1; however, there was a statistically significant difference (P<0.01) between the means of unwaxed Mysore fruits (control) and Mysore fruits waxed with beeswax and between the means of unwaxed Mysore fruits and Mysore fruits coated with cassava starch. Unwaxed Mysore fruits recorded the highest mean value for pulp to peel ratio (2.00) whereas the least value was recorded by Mysore fruits waxed with beeswax (1.56).

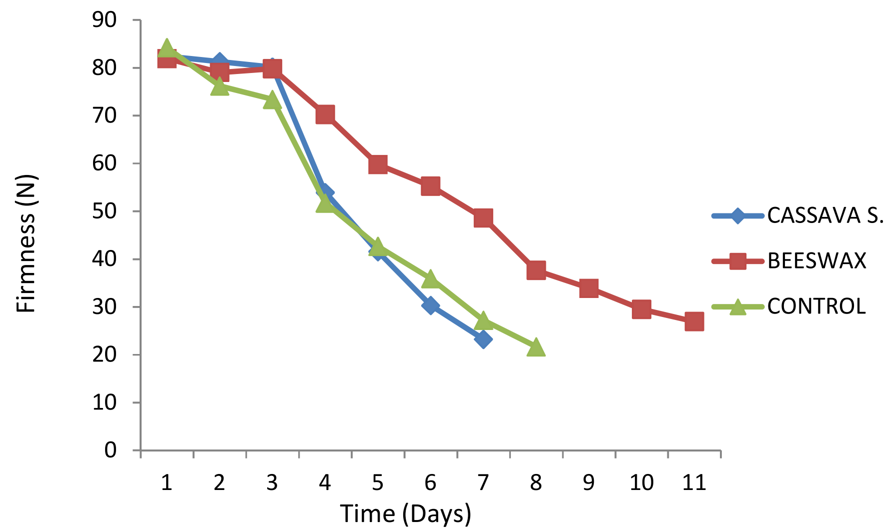

Fig. 2. Firmness (N) of beeswax-coated, cassava coated and unwaxed mysore fingers stored under ambient conditions (30^{0}C and 59% RH)

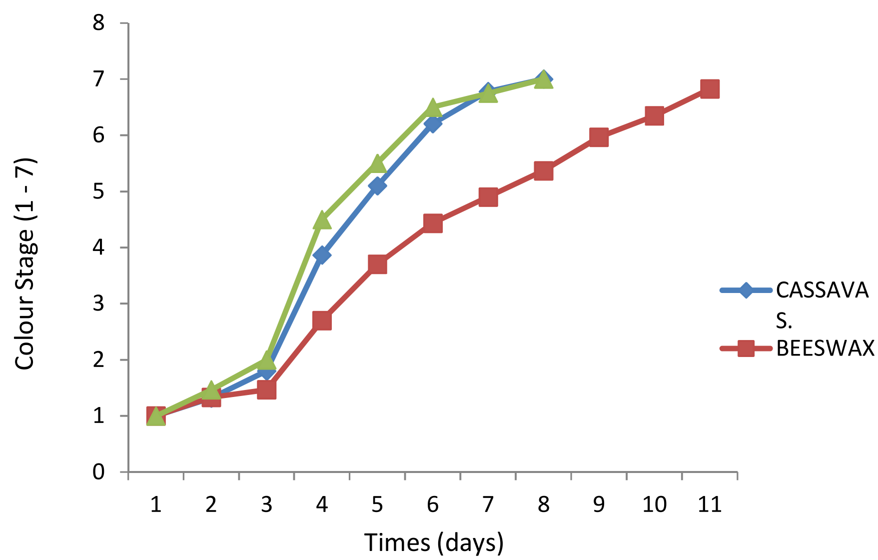

Fig. 3. Peel colour changes of beeswax-coated, cassava coated and unwaxed Mysore fingers stored under ambient conditions (30^{0}C and 59% RH)

3.2 Chemical Properties

3.2.1 Moisture content and dry matter content

From Table 2, statistically, there was no significant difference (P>0.01) among all the treatments for moisture content. The highest mean for moisture content was recorded by Mysore fruits waxed with beeswax (71.43%) whereas the lowest mean was recorded by unwaxed fruits (control) (69.15%). For dry matter content, there was no statistically significant difference (P>0.01) among all the treatments.

Table 2. Means of chemical properties of waxed and unwaxed Mysore banana stored under ambient conditions (30°C and 59% RH)

Treatments	Moisture content (%)	Dry matter (%)	Total titratable acidity (%)	Total soluble solids (°Brix)	pH
Beeswax	71.43[a]	28.24[a]	11.21[a]	0.11[a]	5.14[a]
Cassava Starch	69.15[a]	30.86[a]	13.81[b]	0.12[a]	5.17[a]
Control	69.18[a]	31.04[a]	13.37[b]	0.15[a]	4.91[a]
CV (%)	1.40	3.25	5.32	34.02	4.04
LSD (0.01)	2.96	2.96	2.06	0.13	0.62

CV =Coefficient of Variation; LSD =Least Significant Difference
**Means in the same column followed by the same letter are not significantly different from each other at 1% LSD (P=0.01)*

Table 3. Shelf life and green life of waxed and unwaxed Mysore banana stored under ambient conditions (30°C and 59% RH)

Treatments	Green Life (Days)	Shelf life (Days)
Beeswax	1.90[a]	10.47[a]
Cassava Starch	1.50[a]	6.70[b]
Control	1.40[a]	6.70[b]
CV (%)	17.31	2.22
LSD (0.01)	0.84	0.53

CV = Coefficient of Variation; LSD = Least Significant Difference
**Means in the same column followed by the same letter are not significantly different from each other at 1% LSD (P=0.01)*

3.2.2 Total soluble solids

There was a statistically significant difference (P<0.01) between beeswax-coated Mysore fruits and Mysore fruits coated with cassava starch and between Mysore fruits waxed with beeswax and unwaxed Mysore fruits (control); however, there was no statistically significant difference (P>0.01) between fingers coated with cassava starch and fingers waxed with beeswax used as edible films. The lowest mean for Total soluble solids (TSS) was recorded by beeswax (11.21).

3.2.3 Total Titratable Acidity (TTA) and pH

From Table 2, it can be deduced that there were no statistically significant differences (P>0.01) among all treatments with respect to TTA. The highest mean for TTA was recorded by unwaxed Mysore fingers (control) (0.15%) whereas the lowest mean value was recorded by beeswax-coated Mysore fruits (0.11%). There were no significant differences (P>0.01) among all the treatments for pH.

3.3 Green Life and Shelf Life

From Table 3, there was no statistically significant difference (P>0.01) among all the treatments for green life although beeswax-coated Mysore fingers recorded the highest mean (1.90 days); however, for shelf life, there was a statistically significant difference (P<0.01) between fruits waxed with beeswax and fingers coated with cassava starch and between beeswax-coated fingers and unwaxed fruits (control) whereas between Mysore fingers coated with cassava starch and unwaxed Mysore fingers, there was no statistically significant difference (P>0.01). Beeswax-coated Mysore fingers recorded the highest mean for shelf life (10.47 days).

4. DISCUSSION

4.1 Physical Properties

4.1.1 Weight loss

Bibi and Baloch reported [8] that coating Mango, a climacteric fruit harvested at hard green stage of maturity with beeswax kept the rate of weight loss minimal. Weight loss increased for all samples irrespective of the treatment as ripening progressed. However, weight loss recorded for samples waxed with beeswax in subsequent days was significantly low relative to fruits coated with cassava starch and unwaxed fruits (control).

Highly crystalline edible waxes such as beeswax restrict the transport of water vapour between two surfaces [9]. This means that beeswax is less permeable to water vapour. In view of this it can be deduced that beeswax recorded the least mean for weight loss because, it restricted the outflow of water in the form of vapour to a larger extent, to its surrounding environment. Starch used as an edible waxing material is highly permeable to water vapour [10,11]. This means that cassava starch used to coat banana does not limit the outflow of moisture from the fruit to its surroundings. Coating banana fruits with cassava starch did not regulate loss of moisture in the form of vapour to the atmosphere; this could be due to the permeable nature of the starch film.

4.1.2 Firmness

Fruit firmness gradually declined as ripening progressed during the experiment. Smith *et al*. [12], reported that ripening is inversely related to firmness; in that as ripening progresses, fruit firmness drops. This was evident in the experiment conducted for all samples irrespective of the treatment applied.

4.1.3 Pulp-to-Peel Ratio

Beeswax applied as a waxing material on Mysore fruits had a pronounced effect on their pulp-to-peel ratio. Dadzie and Orchard reported [13] that the pulp-to-peel ratio of banana fruits keeps increasing as ripening progresses. The higher the value, the more advanced the ripening stage. In the experiment conducted, the pulp-to-peel ratio of all samples kept increasing; however, fingers coated with beeswax recorded a relatively lower value. The pulp-to-peel ratio gives an indication of the texture of the pulp. According to Palmer [14], the increase in the pulp-to-peel ratio of banana during ripening occurs as a result of accumulation of moisture in the pulp due to starch degradation and a corresponding movement of water from peel to pulp through osmosis. The movement of water from the peel to the pulp via osmosis may have increased the weight of the pulp relative to the weight of the peel for all fruits. Beeswax as reported by Martin-Polo et al. [9], serves as a barrier limiting the movement of water in its gaseous state to and fro the fruits' internal environment. It could be deduced from this that beeswax may have restricted the movement of O_2 (also a gas) into the fruit keeping the rate of respiration and ripening minimal. This slowed down ripening and the rate at which moisture was drawn from the peel by the pulp.

4.2 Chemical Properties

4.2.1 Moisture content and dry matter

Analysis of results obtained for this study showed that, there were no significant differences among all the treatments for moisture content and for dry matter content of the Mysore samples. This implies that coating Mysore fruits with cassava starch or with beeswax had no significant effect on their moisture content and on their dry matter content.

4.2.2 Total Soluble Solids (TSS)

The total soluble solids content of banana generally increases as ripening progresses as reported by Dadzie and Orchard [13]. In the experiment conducted it was observed that TSS increased for all samples. The increase in TSS in the early stages of ripening (Stage 1-3) was generally dilatory; however, there was an abrupt rise in TSS from stage 4 to stage 6. At stage 7, no significant increase was recorded with the TSS remaining almost constant relative to the previous stage. Beeswax-coated samples recorded the lowest value for TSS and this implied that coating Mysore with beeswax generally rendered the pulp less sweet until fully-ripened. Beeswax delayed ripening and this could be as a result of its lower permeability to gases. The permeability of beeswax to vapour and other gases such as O_2 which stimulates respiration and ethylene synthesis as reported by Martin-Polo *et al.* [9] is low. Ultimately the breakdown of starch into sugar was also delayed. Cassava starch however had no pronounced effect on the sweetness of the banana pulp. Starch is generally permeable to atmospheric gases [10,11] and in view of this, ripening was highly facilitated in fingers waxed with cassava starch and this concomitantly increased the soluble content of the pulp.

4.2.3 Total titratable acidity and pH

Beeswax and cassava starch had no effect on the pH and TTA of Mysore fruits, per the results obtained for this study. No steady increasing or decreasing trends were observed for pH and TTA with the values obtained showing an irregular pattern. Dadzie and Orchard [13], reported that the patterns observed for changes in TTA and pH generally is hybrid-specific. For some hybrids, TTA increases whereas pH declines as ripening progresses whiles for others, no definite trend is observed for pH and TTA. The results obtained for this experiment for pH and TTA showed that Mysore is a member of the latter group as classified by Dadzie and Orchard [13].

4.3 Shelf Life and Green Life

According to Peacock and Blake [15], green life is defined as the period during which banana in its green state is able to retain its colour. The end of green life in banana indicates that ethylene production as well as respiration has peaked. Mysore fingers waxed with beeswax had the highest mean for green life (1.9 days) whereas the lowest mean was recorded by the unwaxed Mysore fingers (1.4 days); however, the differences in green life between beeswax-coated and unwaxed Mysore fruits could not be attributed to the treatment applied. The results for green life implied that beeswax and cassava starch had no effect on Mysore when used as edible coating.

Beeswax significantly prolonged the shelf of the Mysore Banana fingers as shown by the results of the study. Banana fruits approach the end of their shelf life as ripening advances. This means that in order to prolong shelf life in banana, ripening must be regulated. In climacteric fruits such as banana, ripening is characterized by a concomitant rise in respiratory rates and ethylene production [16]. The regulatory nature of beeswax which serves as a restrictive barrier to atmospheric gases (mainly O_2), may have slowed down the inflow of O_2 into the internal system of the fruit, retarding ripening to some extent.

5. CONCLUSION

Mysore fruits waxed with beeswax lost the least weight (7.81%) whereas the highest loss (18.76%) was recorded by the control (unwaxed) fruits. Mysore fruits waxed with beeswax recorded the highest mean for fruit firmness (53.90N). Unwaxed (control) Mysore fruits recorded the highest mean value for pulp to peel ratio (2.00) whereas the least was that of Mysore fruits waxed with beeswax (1.56). Beeswax conserved more moisture (71.43%) with the highest dry matter (28.24%) lesser acidic fruits (0.11%) and pH (5.14). Beeswax applied as a waxing material on Mysore banana, extended its shelf life by almost twice that of fingers waxed with cassava starch and unwaxed fingers. Beeswax was the best waxing treatment. Waxing Mysore banana fruits with beeswax maintained the quality of the fruits and ultimately prolonged their shelf life by up to four (4) days more than the control.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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