Influence of Indigenous Ripening Methods on Quality and Shelf Life of Bananas

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Abstract

A laboratory study was carried out at Midlands State University, Gweru, Zimbabwe. The main objective of the study was to determine the most effective indigenous method of ripening bananas. The parameters measured were number of days taken by the bananas to reach colour plate number 6, the Total Soluble Solids (TSS) after the ripening of bananas and shelf life. The indigenous methods used were acacia leaves, tomatoes, and ashes mixed with water, banana leaves and banana fingers taken from the bunch left to ripe naturally (untreated control). The conventional ripening, of the application of ethrel was used as a positive control. There were significant differences (P = 0.001) on the number of days taken to ripen bananas, and on the shelf life of bananas ripened using the different methods. Banana fingers from the untreated bunch had the highest total soluble solids percentage (11%) followed by bananas treated with ashes mixed in water with (10.167%). There were significance differences (P = 0.001) on banana colour using different indigenous methods. Considering the ripening colour, use of tomatoes and ethrel showed the best colour. It is therefore recommended that the use of ripe tomatoes be adopted by smallholder farmers. Ethrel treated banana fingers and the untreated banana fingers showed highest days for banana shelf life. The results of the study showed that ripened tomatoes can be used in ripening of bananas in as much the same way as ethrel.

Key words: Banana, ripening, quality, TSS, shelf life, indigenous

Introduction

Banana is one of the most common fruits in the world grown in tropical countries (Kachru *et al*., 1995) and is ranked as the fourth most important food crop in the world after rice, wheat and maize (UNCTAD, 2008). Almost all edible bananas were selected as natural, intra- or interspecific hybrids of two diploid species: *Musa acuminata* and *M. balbisiana (*Valmayor, 1991). The edible and wild bananas have different cultivars depending on their resistance to pests and diseases, morphological and phenological characteristics (Vuylsteke *et al.,* 1993). In Zimbabwe the common cultivars include the Dwarf Cavendish, Williams Grand Nain, Chinese Cavendish and Valery (Masimbe, 1997). These cultivars are mainly grown in Burma Valley mainly by Matanuska company, Chipinge, Zambezi, Shamva, Rusitu, Charara Estate near Kariba, Chimanimani, Chibuwe and Honde valley both commercially and communally. Commercially, bananas are sold either as greens or as ripe bananas. Fruit weight, pulp texture and Total Soluble Solids (TSS) content are among the most useful and reliable maturity indices for banana fruits (Patil and Shanmugasundaram, 2015) and quality in fruits as in vegetables is very critical.

Ripening in any fruit is a complex process that results in marked changes in colour, flavour, aroma and nutritional value (Giovannoni, 2004). These changes are physical, mechanical and chemical properties (Tapre and Jain, 2012) whilst the skin colour changes from green to yellow with decreasing firmness as the fruit is softened and starch is converted to sugar (Kajuna *et al*., 1997; Prabha and Bhagyalakhmi, 1998). The compositional changes that occur in bananas after harvest depend on several factors such as climate, cultivation practices, postharvest handling and storage conditions among others (Patil and Shanmugasundaram, 2015). Banana fruits are generally not left to ripen on the plant because of undesirable effects such as fruit peel splitting, uneven ripening, bad colour development and aroma; hence the marketable quality deteriorates (Khader *et al*., 1990). Banana fruit ripening is usually done artificially but small farm holders mostly use traditional methods as only a few can afford the artificial/ conventional methods (Adeyemi and Oladiji, 2009). The artificial methods involve the use of ethylene gas filled in the ripening room with bananas and to prevent ethylene loss the room should be properly insulated to ensure the control of temperature (Horlcroft and Kader, 1999). Ethylene plays an important role in the ripening of climacteric fruits where a massive production of ethylene commences at the onset of the respiratory climacteric period (Kim *et al*., 2003). Calcium carbide mixed with water reacts to give the end products which are calcium carbonate, acetylene and heat and the produced acetylene contains trace amounts of ethylene which are sufficient to induce fruit ripening (Hartshorn, 1931; Tasneem, 2004). Small holder banana producers in Zimbabwe face challenges in choosing the appropriate method for ripening bananas. It has been shown that bananas ripened by application of external ethylene lack that characteristic flavour and aroma of naturally ripened fruit. For these reasons, there is need for information on the quality of bananas ripened by different techniques. Therefore the objective of this study was to investigate the effects of different ripening methods on banana ripening and fruit quality.

Methods and Materials

Table 1: Table of treatments

Treatments	Description
1	Control (untreated bananas)
2	Ripened tomatoes
3	Banana leaves
4	Mixture of ashes with water
5	Acacia leaves
6	Ethrel

Methodology

Bananas of the same size harvested at colour stage 1 were randomly picked from a box. The experiment was setup in six treatments where each treatment had five banana fingers. Five banana fingers were placed in a perforated plastic bag and tied with a rubber band and this was the negative control. Five banana fingers with 1 ripe tomato were placed in a perforated plastic bag and tied with a rubber band. Five banana fingers were completely wrapped in banana leaves and placed in a perforated plastic bag and tied with a rubber band. Five banana fingers were dipped in 2.5litres of water mixed with 20g of ashes, left to dry and placed in a perforated plastic bag and tied with a rubber band. Five banana fingers were completely covered with acacia leaves and placed in a perforated plastic bag and tied with a rubber band. Five banana fingers were dipped in 2ml of ethrel mixed with 5 litres of water, then left to dry and tied in a perforated plastic bag using a rubber band and this was the positive control. The different banana treatments were placed in a wooden cabinet at a temperature range of between 20°C - 25°C. Readings and measurements were recorded at 24-hour intervals.

Data Collection and Analysis

Fruit colour

Fruit colour changes were recorded on the first day of the experiment. Thereafter, colour changes were observed and recorded on day 2, 4 and 6 according to a ripening key (Table 2).

Time to ripening

The assessment started soon after the fingers started to show stage two colour of light green with yellow until they were completely ripe. Each treatment was carefully examined for colour change and the days taken to complete ripening. The colour of the banana fruit was determined by the banana scale chart at regular intervals and pictures were taken. The best ripening method was determined by the number of fingers with the complete yellow skin colour achieved within the shortest time using the colour chart.

Shelf life

Shelf life was determined using the number of days taken by fruits to change from ripeness stage 6 to the stage when the banana fruit was covered by the black spots (Jiang *et al*., 1999).

Total Soluble Solids (TSS) content

Ten samples were randomly picked before and after ripening and the values of the TSS were recorded. A quarter from each of the randomly picked unripe bananas was mashed using pistol and mortar and mixed with 30mls of water. The suspension was left to settle for a night in a refrigerator, a dropper was used to collect the liquid from the suspension. A drop from each of the ten samples was mounted on the refractometer using distilled water to calibrate the refractometer (MASTER-53S, Atago series) after the test of each sample.

Table 2 Banana ripening key

Stages	Colour
1	All green
2	Green with a trace of yellow
3	More green than yellow
4	More yellow than green
5	Yellow with a trace of green
6	All yellow
7	All yellow with brown speckles

(The Chiquita banana colour guide, http://www.ediblegeography.com/spaces-of-banana-control/)

Results and Discussion

Effect of different indigenous ripening methods on banana fruit colour

There were significant differences (P = 0.001) among fruits ripened using different ripening methods from day 0 to day 6. On day 2, fruits ripened using ripened tomatoes had the most notable colour change and were not significantly different from the fruits ripened by ethrel. Fruits ripened using acacia leaves, ashes with water, banana leaves and the control showed the least colour change and were not significantly different from each other (Table 3). On day 4, bananas which were treated using ethrel showed a more yellow colour of ripening than those of tomatoes due to the higher ethylene production and also ethylene produced by the ripening bananas. There were slight colour changes in fruits ripened by acacia leaves and banana leaves although they were not significantly different from those ripened by ashes with water and the control. Fruits ripened by tomatoes exhibited the highest change in colour on day 6 and they were not significantly different from those ripened using ethrel. Fruits ripened using acacia leaves; ashes with water and banana leaves were intermediate in colour changes and were not significantly different from each other. Untreated fruits did not show any colour changes throughout the experiment.

Ethrel and tomatoes produced high trace amounts of ethylene which speeded up ripening on day 2 changing from green to more yellow than green as the after effect of chlorophyll corruption that unmasked carotenoid colours lying underneath in the unripe organic product (Mahajan *et al*., 2008). Amid aging the measure of chlorophyll in the organic product was diminished to zero (Von Loesecke, 1997), while the measure of carotenoid colours was lessened marginally with the real carotenoids found in yellow-ready banana (Gross *et al*., 1976). On day 4, bananas which were treated using ethrel showed a more yellow colour of ripening than those of tomatoes due to the high ethylene production and also ethylene produced by the ripening bananas. On the sixth day, the bananas which were dipped in ethrel started to show a sign of dying with brown areas on the peel, which is usually coupled with a rapid rise in ethylene production (Gross *et al*., 1976). The banana skin was oxidized by polyphenol oxidase since it contains phenolic compounds (Palmer, 1971). In addition, browning of the banana peel is a sign of senescence where the rate of enzyme activity becomes high resulting in more dark areas developing that would cover the entire fruits within a short period (Palmer, 1971).

Table 3: Effects of ripening method on banana fruit colour

	Mean colour change		
Treatment	**Day 2**	**Day 4**	**Day 6**
Acacia leaves	1.000[a]	1.333[a]	1.667[b]
Ashes with water	1.000[a]	1.000[a]	1.333[b]
Banana leaves	1.000[a]	1.667[a]	2.000[b]
Ripened Tomatoes	3.333[b]	5.000[b]	5.667[c]
Ethrel	3.667[b]	6.000[c]	6.333[c]
Control	1.000[a]	1.000[a]	1.000[a]
P value	**0.001**	**0.001**	**0.001**
L.S.D	**0.5649**	**0.893**	**0.799**
C.V%	**17.9**	**19.6**	**15.6**
Grand mean	**1.789**	**2.58**	**2.89**

Key: Means followed by same letter in a row (superscripts) are not significantly different from each other

Effect of different indigenous ripening methods on TSS content

There were significant differences (P = 0.001) in TSS content in fruits ripened using different indigenous ripening methods. Fruits ripened using acacia leaves, ashes mixed with water and negative control had the highest TSS content and were not significantly different from each other (Table 4). Fruits ripened using ripened tomatoes had the lowest TSS content and were not significantly different from those ripened using ethrel. Fruits ripened using banana leaves were intermediate in terms of sugar content but they were also not significantly different from those ripened using ethrel. These findings concur with those observed by Palmer (1971) who highlighted that the longer the period taken by the treatments to ripen the bananas, the longer the anabolic and catabolic processes taking place (Palmer, 1971). Total carbohydrate decreases by 2-5% during ripening presumably as sugars utilised in respiration or used up during numerous anabolic and catabolic processes taking place in the fruit preparing it for senescence (Smith *et al.*, 1979). Among three treatments *viz*; the acacia leaves, control and ashes mixed with water, the TSS content of bananas ripened with ashes mixed with water was the highest due to the dehydration effect that ashes possess. The increase in TSS content during ripening resulted from an increase in concentration of organic solutes as a consequence of water loss (Ryall and Pentzer, 1982). A movement of moisture from the peel, solubilisation and starch degradation resulted in high moisture and TSS content in the banana flesh (Siriboon and Banlusilp, 2004). This also applies to fruits ripened using banana leaves which had a reasonably high TSS content due to the presence of leaves which resulted in high temperatures thereby increased moisture in the banana peel. Fruits ripened using tomatoes and ethrel had the lowest TSS content because the ethylene production is high in both treatments resulting in few days taken to ripen bananas.

Table 4: Effects of ripening method on Total Soluble Solids of banana fruits

Treatment	**Total Soluble Solids (%)**
Acacia leaves	9.967[c]
Ashes with water	11.10[c]
Banana leaves	8.300[b]
Ripened Tomatoes	6.267[a]
Ethrel	7.467[ab]
Control	10.167[c]
P value	0.001
L.S.D	1.627
C.V%	10.1
Grand mean	8.8

Key: Means followed by same letter in a row (superscripts) are not significantly different from each other

Effect of different indigenous ripening methods on ripening time of banana fruits

There were significant differences (P = 0.001) in time to ripening among banana fruits ripened using different indigenous ripening methods. Fruits ripened using tomatoes had the least ripening period (4.000 days) and they were not significantly different from those ripened using ethrel (2.333 days) (Table 5). Fruits ripened using the negative treated control took the longest time to ripening followed by those ripened using ashes with water which were followed by those ripened using acacia leaves.

The shortest ripening period in fruits ripened using tomatoes is related to a large increase in respiration, producing large amount of heat and ethylene production leading to the hastening of ripening of bananas (Masimbe, 1997). Respiration rate of about 20 mg $C0_2$ $kg^{-1}hr^{-1}$ in the hard green banana fruit may rise to about five times at the climacteric peak and then fall as the ripening advances (Salunkhe and Kadam, 1995) and there is also considerable water loss through transpiration after the initiation of ripening and water stress in fruits triggers ripening (Masimbe, 1997). Since banana is also a climacteric fruit, it exhibits a respiratory peak during ripening speeding up its ripening period (Ahmad, 2007). Just like banana leaves, on senescence of leaves, acacia leaves released ethylene gas to regulate the dying off of the leaves

(Thomas, 1987). The fingers from the bunch as the negative control, took the longest time to ripening due to a limited amount of ethylene since it relied on the ethylene produced by the banana fruits whilst other treatments had external sources. Bananas treated with ashes in water took longer time to ripening than bananas from other treatments and this contradicts to the findings by Nickel (1992), who highlighted that water stress in a fruit triggers ethylene production. This could be possibly due to the fact that there was a limited amount of ethylene and heat released during the ripening process which could have caused a delay in the ripening of the fruits.

Table 5: Effects of different indigenous ripening methods on ripening time of banana fruits

Treatment	**Ripening Time (days)**
Acacia leaves	11.000^{c}
Ashes with water	15.333^{d}
Banana leaves	6.667^{b}
Ripened Tomatoes	4.000^{a}
Ethrel	2.333^{a}
Control	20.000^{e}
P value	**0.001**
L.S.D	**1.747**
C.V%	**9.7**
Grand mean	**9.89**

Key: Means followed by same letter in a row (superscripts) are not significantly different from each other

Effects of ripening methods on shelf life of bananas

There were significant differences (P = 0.001) in the shelf life of bananas ripened using the six different banana ripening methods. Fruits ripened using ethrel had the longest shelf life (12.667 days) followed by those from the untreated control (9.000 days) (Table 6). Fruits ripened using tomatoes and acacia leaves were intermediate in terms of shelf life (6.000 days) and were not significantly different from each other. Fruits treated with ashes with water and banana leaves had the shortest and similar to each other in terms of shelf life (3.667 days) and were also not significantly different from each other. Most fruit soften during ripening and this is a major quality attribute that often dictates shelf life and the softening could arise from one of the three mechanisms which are loss of turgor, degradation of starch and breakdown of the fruit cell walls (Tucker, 1993; Turner, 2001). The short shelf life exhibited by fruits treated with banana leaves and ashes with water are likely to have been caused by the heat produced from respiration from the banana leaves treatment and moisture stress from the fruits treated with ashes and water. During ripening of bananas using ashes with water treatment, bananas had split peels which greatly reduced their shelf life as water stress of bananas leads to splitting of fruits (Kadam, 1995). Banana leaves produce heat leading to high respiration rate which accelerates rate of deterioration (Palmer, 1971) hence a shorter shelf life for the fruits. Moreover, exposing ripe bananas to higher temperatures and humid conditions than those in the ripening range accelerates softening and decaying, weakening the neck and peel and may cause poor fruit colour (Salunkhe, 1995). Fruits treated with ethrel had the longest shelf life possibly because there was no interference with relative humidity and high temperatures as in other treatments. Fruits in the untreated control were also not affected by temperature which hastens deterioration. For every increase of 10^{o}C above the optimum rate of quality deterioration increases two to three times (Masimbe, 1997). The shelf life of bananas in the control treatment was neither affected by temperature nor humidity because there was free air circulation (Nair *et al.,* 1992). Fruits from tomato and acacia leaves treatments came after ethylene and fingers from the banana bunch. Their shelf lives were lower possibly due to the high respiration rates of tomatoes and acacia leaves (Wills *et al.,* 1998) since respiration rate is known to be proportional to rate of deterioration. Water and heat energy were produced during respiration process contributing to deterioration of the banana fruit.

Table 6: Effects of different indigenous ripening methods on shelf life of banana fruits

Treatment	**Shelf life (days)**
Acacia leaves	6.000^{b}
Ashes with water	3.667^{a}
Banana leaves	3.667^{a}
Ripened Tomatoes	6.000^{b}
Ethrel	12.667^{d}
Control	9.000^{c}
P value	**0.001**
L.S.D	**0.939**
C.V%	**7.800**
Grand mean	**6.83**

Key: Means followed by same letter in a row (superscripts) are not significantly different from each other

Conclusions

From the results of the study, it can be concluded ripening of banana fruits using ripened tomatoes can be used as a fast and effective method for ripening bananas especially for small holder farmers where ethrel is not readily available and costly to them. Furthermore, it can be concluded that bananas ripened using indigenous methods like ripe tomatoes had a higher TSS content compared to those ripened using ethrel.

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