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REGULAR ARTICLE

Modified insulated punnets and conventional packaging films for retail storage of robusta banana fruits

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Abstract

The application of poor consumer packaging technology to Banana fruits can increase fruit susceptibility to diseases which affect quality and shelf-life. Understanding the use of appropriate consumer packages is crucial in developing packages for the fresh produce sector. In this study, four different consumer packages and Control Samples (CT) which included Perforated Insulated Punnet (PP), Non-perforated Punnet (NP), Perforated Films (PF) and Non-perforated Films (NF) were used. Fruits in packages were stored at 27°C for 7 days where rate of ripening, weight loss, total soluble solids, taste, pulp texture and consumer acceptance were assessed. The results demonstrated that the use of perforated punnets was better in reducing the rate of ripening. The changes in TSS was progressive in all the treatments but the control sample produced the highest Brix at 16% compared with Brix 15% for fruits in PP, NP. PF and NF. Weight loss was more pronounced in the control sample 11.7% compared with the least weight loss of 0.7% for fruits in NF. Except, Sweetness and TSS without dilution all the parameters assessed were statistically significant at $P \leq 0.05$. Based on the results obtained in this research, it can be shown that the use of insulation and perforations of punnets demonstrated appropriateness which offers a promise and can be adopted for consumer use in the fresh produce sector.

Key words: Robusta banana, insulation, punnets, colour, weight loss, TSS, acceptance

Introduction

Bananas are important as cash crops providing a source of income to rural population thus playing an important role in poverty alleviation. High postharvest losses of fresh banana are encountered at the retail point due to inadequate techniques in handling and packaging materials used at the retail point resulting in reduction of product quality as well as low income. Banana is cultivated in very small quantities in the Upper West Region but largely traded in the various markets when fruits are brought from the other parts of the country. Short shelf life of fresh banana fruits, resulting from poor packaging, low level of appropriate storage technology of fresh banana fruits, poor price offers to produce due to lack of value addition were the problems identified for this research. Different packaging materials have been applied over the years which produced inconsistent results. Appropriate packaging is required for efficiency in handling (Hailu et al., 2013) and modification of packages affects weight loss of produce (Abdul-Rahaman and Bishop, 2013) and green life (Osman, 2015). Jobling (2001) added that materials such as polyethylene film are excellent vapour barriers and help restrict the air movement around the produce to reduce the rate of water loss. Furthermore, packaging isolates the product from the external environment and helps to ensure conditions that reduce exposure to pathogens and

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contaminants thereby extends the shelf life of the produce (Mir and Beadry, 2004). It is therefore crucial for a research to be conducted to come out with appropriate and inexpensive technologies for preserving these perishable produce that is cultivated every year to ensure its availability to retailers and consumers. However, the study outlines ways that contribute to preservation of fruit qualities and ensure extension of shelf life. Postharvest techniques such as proper packaging can help reduce losses in banana fruits at storage. The research results can offer suggestions to address the physical and financial losses associated with banana storage. Also the insulated packages can be adopted as a reusable package for consumers at the household level. The main objective of this research was to determine the effectiveness of insulated punnets and conventional packages in extending the shelf life of banana fruits. The specific objectives were to determine how the packaging treatments affected fruit weight loss, colour changes, total soluble solids and consumer acceptance after a defined period in storage.

Materials and methods

Experimental design

The insulated punnet was constructed using PVC covers and a jute sack which provided an insulation to the inside of the punnet. A total of one hundred and thirty-five (135) fingers of Banana fruits were used for the experiment where each package contains five (5) fingers. The entire sample was divided into five to represent the treated and untreated samples. Where each division was replicated five times in Completely Randomized Design (CRD). The experiment was monitored for a period of seven (7) days at 27°C. Four replicates of each sample were used for the daily readings and a sample of each of the treatments was used for TSS.

Colour assessment

The colour of the banana fruits was inspected carefully on the first day before storage and for effective assessment of the peel colour, fruits in the packages as well as control sample were compared with a Commercial Standard Colour Chart and absolute figures of between 1 and 7 were scored each day for completely green to completely yellow.

Total soluble solid measurement

The measurement was done using both dilute and non-diluted methods as suggested by Laure (2001). A blender was used to blend the pulp to obtain the juice for measurement. A 100ml distill water was applied on the pulp to aid dropping sample on refractometer. This was measured using an analog refractometer with a range of 0 to 32 % brix for day 0, 2, 5 and 7 of the experimental period.

Weight loss

Weights of fruits in the packages were taken daily using an electronic weighing scale. The weight loss in percentage of the fruits were determined using the difference of initial weight and weight after storage on initial weight by one hundred.

Assessment of taste

Five and three points hedonic scales were developed purposely for this experiment on the last day. Thirteen (13) panelists were invited to assess the sweetness, texture and overall acceptance with a score key designed specifically for the work: evaluation of overall acceptance include: 9 = Excellent, to 1 = Poor. But a 3 point hedonic scales were used for both sweetness and texture which respectively describe good taste fruits to poor and firm to soft.

Data analyses

Data obtained from weight loss, TSS, colour were analyzed based on daily readings from the experiment as well as taste test on the last day. The analyses of the data were done using Mini Tab version 16. The single factor ANOVA was used and significant difference claimed at $p \leq 0.05$. Means separation was done using the individual Fishers' error rate.

Results

Colour changes

The results obtained from the data for changes in colour indicated that Robusta banana fruits stored at 27°C in both perforated and non-perforated punnets were at colour stage 2 with green colour and only a trace of yellow for the first two days of the experimental period. Fruits stored in both perforated and non-perforated plastic films showed more ripeness colour than the punnets with averages of 2.5 and 3 respectively but less than the control sample which showed more ripeness with an average colour of 3.5 progressing to more yellow than green. As storage proceeds to day 4 the ripeness

colour pattern changed where the least colour was found with fruits in perforated insulated punnets and perforated films with averages of 3.5 and 3.7 that matched more yellow than green. However, fruits stored in Non perforated films and punnets showed more ripeness in colour stage 5 which indicated more yellow with a trace of green but control sample was at stage 6 where fruits colour were all yellow. The experiment was terminated on day 7 and all the treatments progressed to colour stage 7 with fruits turned all yellow with traces of speckles except fruits in perforated punnets which ended in stage 6 (Fig. 1). Significant differences were observed among the treatments during the storage period at $p \leq 0.05$.

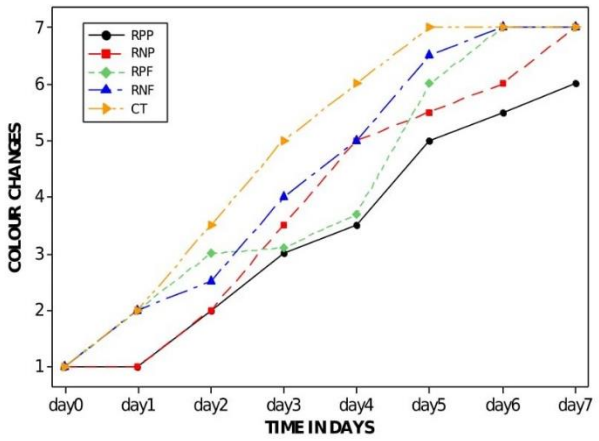

Fig. 1. Colour changes on robusta banana fruits in Perforated Punnet (PP), non perforated punnet (NP), perforated plastic films (PF) non perforated films (NF) and control sample stored for seven days.

Total soluble solids (TSS) diluted with distil water (DW)

The results obtained from the data on the effects of different packages on total soluble solids (TSS) diluted with Distill Water (DW) revealed that TSS values were Zero for all the treatments for day zero and day 1. However, TSS of fruits sample in PP produced 11% Brix as the highest on day 2 compared with 10% Brix and 7% Brix values for NP and PF respectively (Fig. 2). The fruits sample in NF produced 1% Brix but the CT was still at zero. As storage proceeds the pattern in TSS changed on day 4. The fruits sample in PF and NF were found with same TSS of 10% Brix, but the fruits in NP produced 11.5% Brix whiles the CT increased sharply to 13% Brix. The inconsistent pattern of TSS as storage proceeds resulted in the fruits sample in NP produce 12%Brix compared with 11.5% PP. Fruit sample in PF, PF and CT produced 10% Brix when the experiment was terminated on day 7 (Fig. 2). It was clear that the highest Brix was found with fruits sample as control. The results produced significant difference among treatment means.

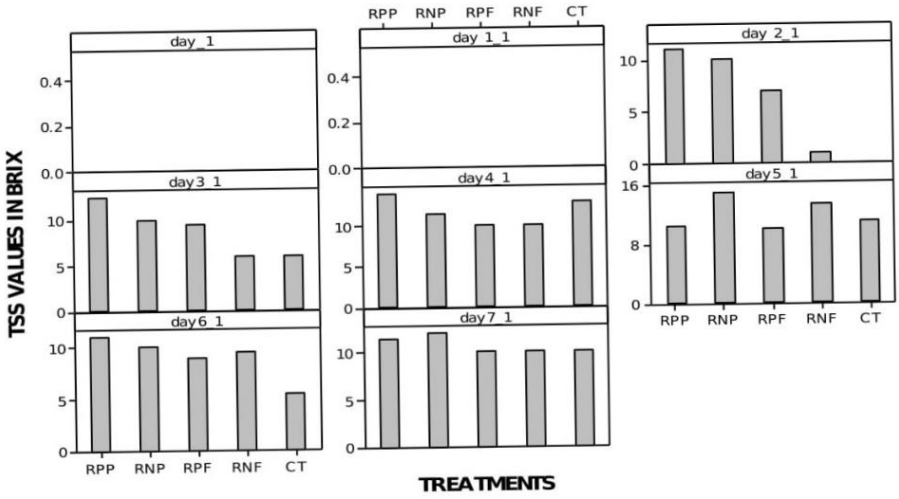

Fig. 2. Total Soluble Solid for robusta banana pulp with distill water in Perforated Punnet (PP), non perforated punnet (NP), perforated plastic films (PF) non perforated films (NF) and control sample stored at 27° for seven days.

Total soluble solids (TSS) without distil water (DW)

The results obtained from the data on the effects of different packages on total soluble solids (TSS) without Distill Water (DW) revealed that TSS values were Zero for all the treatments for day zero and day1.However, TSS of fruits sample in NP produced 15.4% Brix on day 2 compared with 15.2%, 15.1%, 5% and 3% Brix values for PP, NF, PL and CT respectively. As storage proceeds the pattern in TSS changed on day 4, The fruits sample in PP and CT were found with the same TSS of 18%Brix, while fruits in NP and NF were also found with same TSS of 17% Brix, and fruits sample in CT produced 17.3% Brix. The inconsistent pattern of TSS as storage proceeds resulted in the fruits sample in CT produce 16% Brix compared with fruits sample in PP, NP and PF having TSS of 15.5%. Fruit sample in NF, produced 15% Brix when the experiment was terminated on day 7 (Fig. 3). It was clear that the highest Brix was found with fruits sample in PP and CT on day 4 sample without dilution could not produce any significant difference.

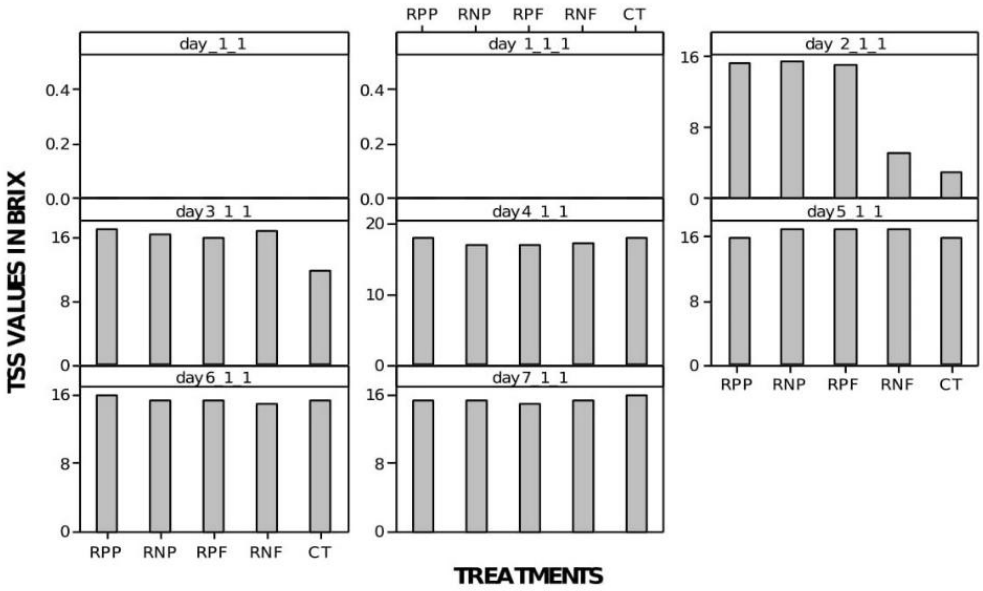

Fig. 3. Total Soluble Solid for robusta banana pulp without distill water in Perforated Punnet (PP), non perforated punnet (NP), perforated plastic films (PF) non perforated films (NF) and control sample stored for seven days.

Percentage weight loss of robusta banana fruits

The results obtained from the data on the effects of different packages on weight loss revealed that fruits stored in PP loss weight of 0.5% on day 2, fruits in NP loss weight of 0.7%, fruit in PF had a weight loss value of 1.3% while fruits sample in CT losses weight by 4.0%. However, weight loss of fruit samples on day 4 indicated that fruits sample in CT increase in weight loss by 7.4% as the highest on day 4 compared with 3.1%, 1.6%, 1.4% and 0.4% for PF, NP PP and NF respectively. As storage proceeds the pattern in weight loss on day 7 (Fig. 4), the fruits samples in CT were found with the highest weight loss value of 11.7% as compared with 4.5%, 3.0%, 2.3% and 0.7% for PF, NP, PP and NF respectively. It was clear that the highest weight loss value was found with fruits sample in CT and the lowest weight loss value was recorded by NF at the end of the experimental period (Fig. 4) Highly significant differences were observed between treatments.

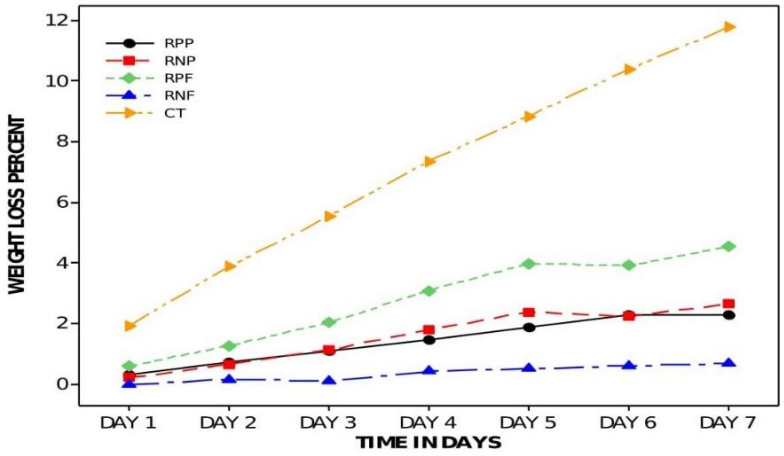

Fig. 4. Percentage weight loss of robusta banana fruits in Perforated Punnet (PP), non perforated punnet (NP), perforated plastic films (PF) non perforated films (NF) and control sample stored for 27°C for seven days.

Consumer acceptance

The results produced by the panelists on sensory assessment for sweetness of Robusta Banana fruits stored with PP, NP, PF, NF and CT, showed that Robusta Banana fruits stored in PP produced the highest average sweetness value of 3 compared with PF, CT, NP and NF which all produced averages of 2 (Fig. 5). It was clear that aside the fruits in PP panelist rated all the other treatments the same. Data could not produce any significant difference on sweetness. Based on results obtained from the panelist regarding pulp texture, it was found that fruits in NF were scored the highest value of 2.3 compared with fruits in NP and CT that produced the same values of 1.8. The fruits in PP scored lower than the preceding treatments with a value of 1.6 but higher than the fruits in PF which was found to be the least pulp texture with 1.5 (Fig. 5). Significant difference was found among the treatments means for pulp texture. The panelist also rated the fruits stored in NF as very good in overall acceptance been the highest compared with the fruits samples in PP, NP and CT which were all rated 5 to mean good fruits. The least accepted fruits were sample stored in NP with a value of 3 described as limit of marketability (Fig. 5). Significant difference was found among the treatments means for overall acceptance.

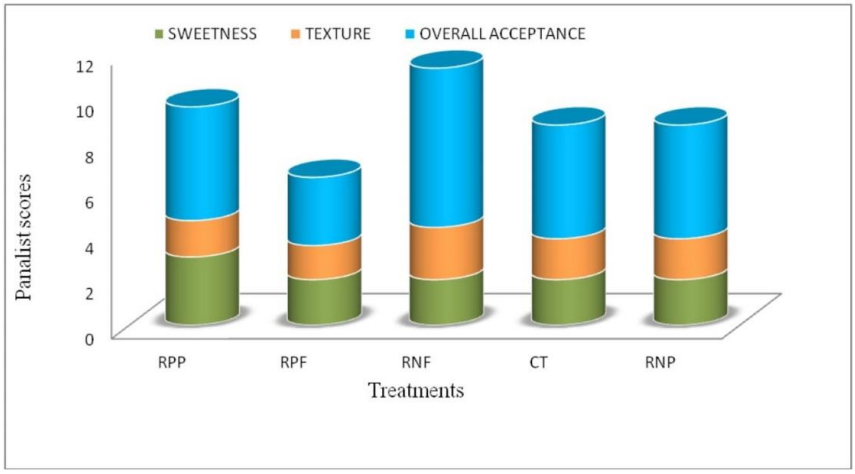

Fig. 5. Sensory evaluations on consumer acceptance base on texture, sweetness and overall acceptance of robusta banana fruits in Perforated Punnet (PP), non perforated punnet (NP), perforated plastic films (PF) non perforated films (NF) and control sample stored for 27°C for seven days.

Discussion

Colour changes

The results produced by the statistical analysis on colour changes of Robusta Banana fruits stored with PP, NP, PF, NF and CT demonstrated that significant difference were observed at $P \leq 0.05$ on colour changes of banana fruits during the experimental period where all the treatments progressed to colour stage 7 with fruits turned all yellow with traces of speckles except fruits in perforated punnets which ended in stage 6 on day 7 of the experimental period. The differences produced by the analysis on colour changes of Robusta Banana fruits stored in the different packages could be as a result of the insulation provided inside the packages. Combined effects of temperature and modified atmosphere packaging delayed colour development of banana stored at 14°C temperature and wrapped with non-perforated plastic bag (Hossain et al., 2013).

Prior research by Kader (2002) affirmed that, polyethylene film liners brought about a modified atmosphere and consequently postponed peel shading improvement in Banana. It has been demonstrated that bananas stuffed in polyethylene-lined boxes have a longer shelf-life than control. Likewise, Osman (2015) found that Banana held in place polyethylene bundles had the longest green-life, followed by those held in perforated ones and unpacked fruits had the most limited.

Total soluble solid (TSS)

Statistical analysis obtained from the data on the effects of different packages on Total Soluble Solids (TSS) of Robusta Banana fruits without Distill Water (DW) and fruits diluted with Distill Water (DW) revealed that, no significant difference at $P \leq 0.05$ levels was found with samples without dilute but difference occurred in those dilution. The difference could be as a result of temperature, storage period and fruit ripeness level. The research was in line with Hailu et al. (2011) that reported that the total sugar of banana fruits showed an increasing trend during the storage and towards the end of the storage it became decreased. It was also observed that Packaging significantly at $P \leq 0.05$ affected the TSS content of banana fruits. Findings by Yadav et al. (2011) also indicated that TSS increased with storage periods irrespective of level of sugar and storage temperatures. Saeed and Sarhad (2007), also reported that Total soluble solids increased with ripening stage of the banana fruits.

Salvador et al. (2007) discovered a quadratic form of increase in soluble solids content of banana variety during ripening. They found soluble solids varied from about 5.5% Brix to 18% Brix. Similar values were found in the current research which confirmed the earlier research.

Weight loss

Significant difference at $P \leq 0.05$ was obtained from the statistical analysis on the percentage weight loss of Robusta Banana fruits stored in perforated and non-perforated punnets, perforated and non-perforated plastic films and control sample. The differences demonstrated by the banana fruits in the different packages on percentage weight loss could be attributed to the variance in moisture retention ability of the packages coupled with the gas permeability of the materials used. The current findings partially agreed with similar work conducted that revealed different packages produced significant difference in weight loss (Abdul-Rahaman and Bishop, 2013). In this research, the non-perforated plastic film was found to reduce weight loss better which supported the findings of Aharoni et al. (2007) that plastic film materials are known to reduce water loss during storage. The results however contradicted findings by Elkashif et al. (2005) that perforated films reduced fruits weight loss. The results of the current findings also demonstrated perforation and insulation could reduce weight loss which partially agreed with Wheeler et al. (2015) that insulated covers reduced weight loss of fresh amaranth.

Overall acceptance, Sweetness and Texture

The results obtained from the sensory assessment of taste test on sweetness level by the score of 13 panelists of Robusta Banana fruits stored with PP, NP, PF, NF and CT demonstrated that there was no significant difference at $P \leq 0.05$ on sweetness, but there was significant difference at $P \leq 0.05$ on the texture. The results also demonstrated that taste test on overall acceptance by the score of the 13 panelist indicated that there was significant difference at $P \leq 0.05$ on overall acceptance. The difference in both texture and

overall acceptance could be attributed to the temperature and nature of package used. This research support assertion by Elkashif et al. (2005), that banana fruits held in different packages and temperature were significantly different. Also, Appiah and Kumah (2009) discovered that, packaging improved the quality and the shelf-life of fruits and enhance consumer acceptance which was found in the current research. However, the non-significant difference on sweetness that was observed by the taste test panelist could be as a result of fruit ripeness level. This was in line with research by Saeed and Sarhad (2007) that, panelists could not differentiate between bananas in relation to their sweetness. The current results partially agreed with previous work by Abdul-Rahaman and Alhassan (2015) that differences were found in Banana fruits sweetness but not on texture after storage.

Conclusion

In this study, the perforated insulated punnet was beneficial in delaying the ripening after 7 days of storage at 27°C without detrimental effects on subsequent ripening, colour or eating quality. In addition, the reduced weight loss of the Robusta Banana fruits in the Non-perforated Plastic Films and Perforated insulated punnet confirms their suitability for consumer packaging. Therefore, based on the results obtained in this research, it can safely be suggested that the use of perforated insulated punnet offers a promise of successful extension of shelf life and can be adopted for consumer use and small scale commercial purpose at the fresh produce and retail sectors.

Authors' contributions

The preliminary survey of the retail sector as well as data collection were conducted by Leori Inusah. Pasenaa Peter also help in organizing experimental material. Abdul-Wahab Salifu was responsible for the design and construction of punnets and organizing the manuscript. Abdul-Rahaman Adams was responsible for the design of the experiment and data analysis, as well as compilation of the write-up.

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