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Effect of irradiation and refrigeration storage on the vitamin c content of kent and keitt varieties of Fresh-Cut Mangoes (FCM), (*Mangifera indica* L) in Ghana

Emmanuel K. Gasu[1,*], Josephine Nketsia-Tabiri[2] and Victoria Appiah[3]

[1]Biotechnology and Nuclear Agriculture Research Institute; Radiation Technology Centre, Ghana Atomic Energy Commission, P.O. Box LG, Legon Ghana.

[2]Biotechnology and Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Ghana, P.O. Box LG 80, Legon.

[3]Graduate School of Nuclear and Allied Sciences, Ghana Atomic Campus, University of Ghana, Legon.

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ABSTRACT

The quest for ready-to-eat fruits has resulted in cut-fruits such as pawpaw, watermelon, mangoes and pineapples in the local market. Many people eat fruits because of the vitamins they contain. Mango (*Mangifera indica L.*) fruits are consumed among other reasons, for their pleasant flavour. They are rich sources of vitamins A, B6 and C. Mango fruits are being increasingly process into ready-to-eat products such as fresh-cut slices. This study determined the effects of irradiation and refrigeration storage on the vitamin C content of fresh-cut mango products. Well matured half-ripe with peel of green and a little yellow intact fruits were sampled for laboratory analysis using 2x2x5 factorial experiment. The fruits were sanitized, peeled and sliced into cubes, packaged in 30 PET jars, and were subjected to various radiation dose levels (1.0, 1.5, 2.0 and 2.5) kGy and a control. The treated cut-mangoes were stored at 6°C and 10°C for 15 days and samples were taken at 3 days interval for analysis of vitamin C. The data was analyzed using ANOVA. Irradiation did not have significant ($p>0.05$) effect on the vitamin C content measured. However, there were significant varietal differences ($p<0.05$) between irradiated Kent and Keitt mangoes. Storage time has significant effect ($p<0.05$) on the vitamin C. There was significant ($P<0.05$) increase in vitamin C content during storage at 6 °C.

Introduction

It is common of late to see on the streets of some cities of Ghana where hawkers carry already cut-fruits wrapped in polyethylene for sale. Some of these cut-fruits include pawpaw, watermelon and pineapple. These products are patronized by a large part of the population throughout the day. They are easy to find and buy but the safety and quality are questionable. The difficulties encountered with fresh-cut fruits as a result of the process operations (i.e. cutting, splicing and mixing) include tissue softening, browning, bacterial/yeast/mould contamination, loss of flavour and colour, fermentation and reduction in Vitamin C content, production of undesirable volatiles and this may affect the physico-chemical properties thus markedly reducing their shelf-life (Chien *et al*, 2007).

Mango reaches its respiration peak of ripening process on the third to fourth day after harvesting when stored at ambient temperature (Narayana *et al*, 1996). The shelf-life of whole mangoes which is dependent on the variety and storage conditions ranges from 4 to 8 days at room temperature and 2 to 3 weeks in cold storage at 13 ºC (Carrillo *et al*, 2000). The short shelf life limits the long distance commercial transport of the fruit (Gomer-Lim, 1997).

The ripening of mature green whole mango fruits after harvesting takes 9 - 12 days (Herianus *et al*, 2003). The ripening process involves a series of biochemical reactions, resulting in increased respiration, ethylene production, changes in structural polysaccharides, tissue softening, degradation of chlorophyll, developing pigments by carotenoids biosynthesis and conversion of carbohydrates into sugars, organic acids, lipids, phenolic and volatile compounds (Herianus *et al*, 2003). The ripened fruit in its optimum state has a characteristic colour, texture and aroma which meet consumer acceptance. Subsequently it undergoes rapid deterioration, which limits its storage, handling and transport potential and marketing.

Mangoes are sensitive to low temperature storage (Hoa *et al*, 2002). Storage methods such as the application of modified atmosphere (MA) or controlled atmosphere (CA) have the potential to extend the shelf-life beyond 4 to 8 days at room temperature. Although CA storage has been shown to extend the shelf-life (Bender *et al*, 2000; Noomhorm and Tiasuwan, 1995), it is cost prohibitive. MA storage was also reported to delay mango ripening but was often accompanied by high carbon dioxide (CO_2) content and off flavour (Gonzalez-Aguilar *et al*, 1997).

Films and edible coatings have been used traditionally to improve appearance and to conserve food products. The most common examples are the waxing of whole fruits (use of chitosan), which were reportedly used in China as far back as the 12th century (Dalal *et al*, 1971).

Irradiation was found to delay ripening and may extend the shelf life of certain whole fruits. The shelf life of irradiated fruits is 3 to 5 days longer than fruits chemically treated (Maxie and Kader, 1966). Gamma irradiation at 0.3kGy delayed ripening of whole mangoes by inhibiting respiration and

Tele:
E-mail addresses: ekgasu@gmail.com

ethylene production during storage at 10°C; starch, sugars as total soluble solids (TSS), total titratable acid (TTA) and carotenes were found not to be affected by irradiation (Farzana, 2005).

Fresh-cut mangoes (FCM) are considered as minimally processed fruits. According to the International Fresh-cut Produce Association (IFPA), fresh-cut products are fruits (or vegetables) that have been trimmed and/or peeled and/or cut into usable product that is bagged or pre-packaged to offer consumers high nutrition, convenience, and flavour while still maintaining its freshness (Lamikanra, 2002). Minimally processed fruits are characterized by a shorter shelf-life because of higher susceptibility to increased respiration rate and ethylene production, which is stimulated by wounding of the tissue. In addition, they may pose a food safety risk because they are consumed raw. The aim of this study was to determine the effect of irradiation and refrigeration storage on the Vitamin C of fresh-cut Kent and Keitt mango varieties.

Materials and methods

Preparation of raw materials

Freshly harvested Kent and Keitt mango varieties were sampled from three farms at Somanya in the Eastern Region of Ghana. The samples were transported in plastic crates to the laboratories for preliminary analysis and processing. The fruits were washed in 10% chlorine water (sodium hypochlorite solution whose pH was adjusted to 7 with citric acid) and stored in a pre-cooled room at a temperature of 15 ^{0}C to reduce the field temperature until the fruits have ripened.

Well-matured and undamaged fruits of Kent and Keitt mango varieties were selected, weighed and then washed in clean, cold chlorinated water of neutral pH for 10 minutes and sanitized in 10% solution of a food grade sanitizer for 10 minutes after which they were allowed to drain dry.

The fruits were peeled, deseeded, cubed and immediately placed in anti-browning solution. The flesh of the fruits was cubed using the Berg HOFF Germany stainless steel knife. The mango cubes were immediately placed in anti-browning solution.

Experimental Design

A factorial design of 2x2x5 (2 varieties x 2 temperature regimes x 5 doses) in 5 replicates for each variety was used in packaging the samples for irradiation.

Packaging of Fresh-Cut Mango (FCM)

The mango cubes were packed in 300 polyethylene terephthalate (PET) jars for each variety of mangoes. Each jar was packed with 15 cubes and was firmly covered (Fig.1a) and labelled accordingly for irradiation at selected doses: 1.0, 1.5, 2.0 and 2.5 kGy. Each dose was replicated five times and stored at 6°C or 10°C over a period of 15 days. Control samples were kept for comparison.

Irradiation And Storage Of Fresh-Cut Mango (FCM)

Irradiation of the samples was done at 0, 1.0, 1.5, 2.0 and 2.5 kGy immediately after packaging at the semi-commercial ^{60}Cobalt gamma irradiation facility of the Ghana Atomic Energy Commission at a dose rate of 2.419kGy/h and a dose uniformity ratio of 1.1499. The absorbed dose was determined by using SUNNA Dosimeter. The irradiated samples were stored in IGNIS (Model: RWN130) 130 L storage volume capacity Refrigerator set at 6°C and at 10°C (Fig. 1b). The samples were analyzed every 3 days for Vitamin C.

Fig 1a. Packaging of fresh-cut mango fruits

Fig. 1b Refrigerator storage of fresh-cut mango fruits

Determination of Vitamin C By Iodine Titration

Vitamin C content of the fruits was determined using an oxidation-reduction reaction; a redox titration involving an iodometric method, (AOAC 967, 1975). A standard Vitamin C solution was prepared by dissolving 0.250g of standard ascorbic acid in 250ml distilled water. Ten (10) ml of the standard solution was pipetted into a 250ml conical flask, and 1ml of 1% freshly prepared soluble starch, and 1ml of distilled water added and titrated against standardized iodine solution until a blue-black coloration was developed indicating the endpoint of the iodine – ascorbic acid reaction. The volume of iodine required to reach the end-point was recorded. Twenty (20) mL of the mango juice was measured and titrated with the standard iodine solution using 1ml of 1% freshly prepared soluble starch solution was added as an indicator. A blue-black coloration of the solution was indicative of the end-point of the iodine-ascorbic acid reaction.

Analysis of Results

The results were subjected to statistical analysis using Minitab Version 14 for Windows, 2008. Pairwise comparisons were made using Tukeys and Bonferroni General Linear Model at confidence level of 95%, and the graphs plotted using the fitted means.

Results and Discussion

Effect of Irradiation and Refrigeration Storage on Vitamin C Content Of Fresh-Cut Mangoes

The plot for the main effects for Vitamin C indicates that vitamin C in Kent mango was higher than in Keitt. Vitamin C of both varieties of mango was higher at 6°C than at 10°C (Fig. 2.1a). As storage time increased, vitamin C content decreased but after 9 days of storage, it increased with increase storage time. There was a highly significant ($p < 0.01$) effect of fruit variety, storage time and storage temperature (°C), but not irradiation dose, on the vitamin C content of the fruits.

The varietal differences observed supported the observation by Kader and Lee, (2000) who concluded that the vitamin C content of fruits is affected by cultural factors and weather conditions (temperature). In mangoes, the varieties 'Pirie' and 'Haden' are only 'fair' sources of vitamin C, whereas other varieties such as Kent and Keitt are 'excellent' sources as found in this work.

The two varieties show highly significant differences ($p < 0.01$) in vitamin C content. Kent (Variety 1) had higher vitamin C content than Keitt (Variety 2). From the contour plots (Fig 2.1c and Fig. 2.1d) and the interaction plot (Fig. 2.1b) vitamin C content was dependent only on the storage time and the temperature.

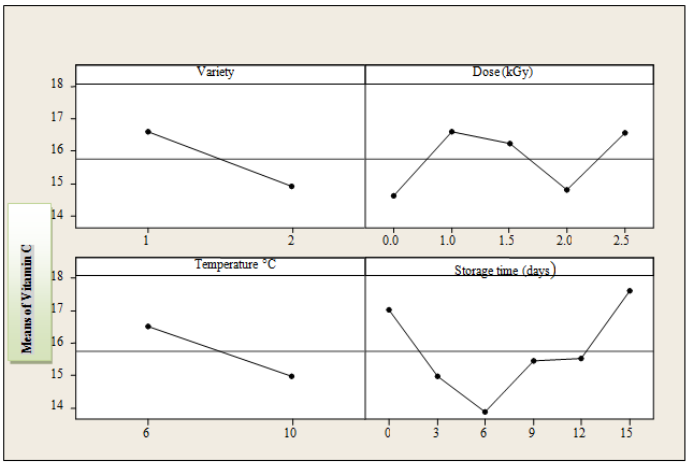

Fig 2.1a. Effects of irradiation, storage time and storage temperature on the vitamin C content of refrigerated fresh-cut mangoes

There were significant ($p < 0.05$) decrease in the vitamin C content during storage from days 0 to 6 and increase between days 9 to 12. However, the increase observed between days 9 to 15 was no significant ($p > 0.05$). Gil *et al* (2006) also reported the decrease in vitamin C content during storage. They reported loss of vitamin C in fresh-cut "Ataulfo" mango stored at 5 °C for 9 days.

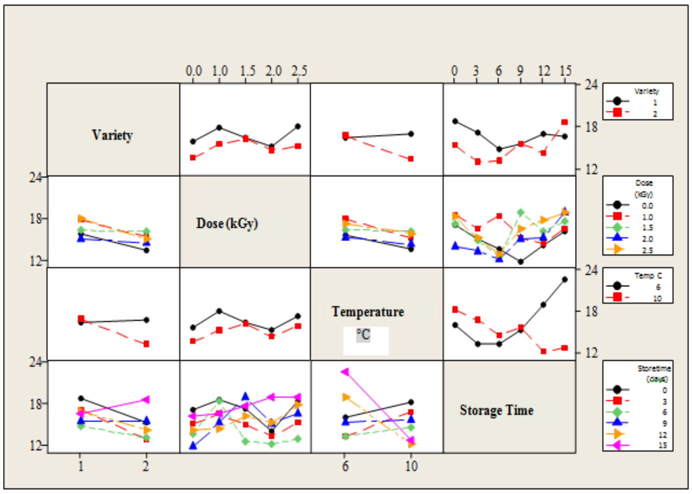

Fig.2.1b Interaction plot for Vitamin C content of refrigerated fresh-cut mangoes

A highly significant ($p < 0.01$) interaction was observed between storage days and variety, between storage days and dose and between storage days and storage temperature (Fig. 2.1b).

Chantanawarangoon (2000) and Chonhenchob *et al* (2007) reported reduction in total vitamin C of fresh-cut Haiden, Kent or Keitt mangoes stored at 5 °C for 10 days. Findings of this current study confirmed the above observation; that there was a reduction in Vitamin C content with increase in storage time up to 6 days (Fig.2.1b).

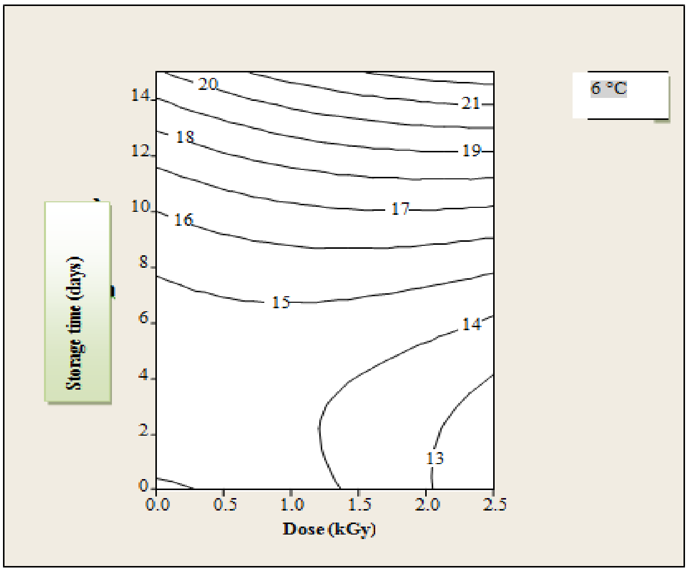

Fig. 3.1c Contour plots of the effects of dose (kGy) and storage time (days) on the Vitamin C of irradiated fresh-cut mangoes at 6 °C storage

At 6 °C (Fig. 3.1c) the rate of change of vitamin C with storage time is slow as shown by the wider spacing of the lines at all irradiation doses. This finding shows that lower storage temperature can enhance vitamin C content of mango fruits.

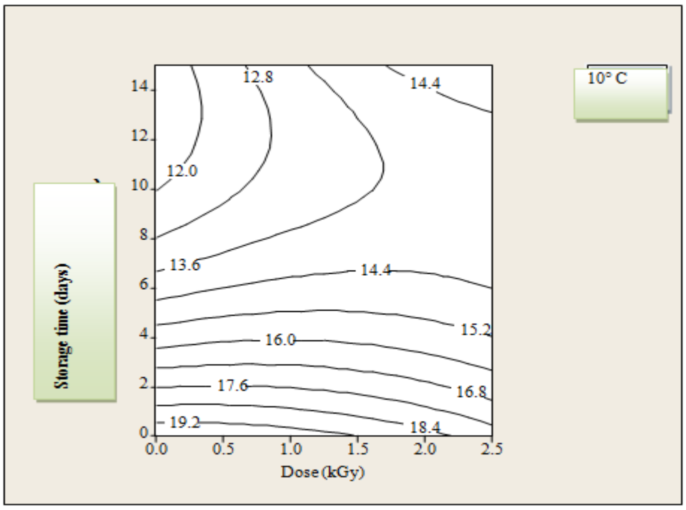

Fig. 3.1d Contour plots of the effects of dose (kGy) and storage time (days) on the Vitamin C of irradiated fresh-cut mangoes at 10 °C storage

At 10 °C the rate of change of vitamin C with storage time is faster than at 6 °C as shown by the narrow spacing of the lines at all irradiation doses. This shows that at a higher storage temperature vitamin C content of fruits could be negatively affected (Fig. 3.1d).

Conclusion

Generally, far more significant than ripening and storage effects on vitamin C was the effect of the variety of the fruit. The amount of vitamin C was higher in Kent than in Keitt. In this work the vitamin C content of the mangoes was dependent on the storage temperature and storage time. At 6 °C, the vitamin C content was about 19 mg/100g of fruits and this was maintained until the 14th day of storage. However, at 10 °C and the same time of storage the vitamin C recorded was 12 mg/100g. It is, therefore, advisable to store irradiated fresh-cut mangoes at 6 °C.

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