Fresh Produce ©2009 Global Science Books

Influence of Preservatives, Thermal Treatment and Storage Time on the Carotenoid Content of Mangoes

Runu Chakraborty[1*] • Utpal Ray Chaudhuri[1] • Debjani Dutta[2]

[1] Department of Food Technology and Biochemical Engineering, Jadavpur University, Kolkata 700032, India
[2] Department of Biotechnology, National Institute of Technology, Durgapur 713209, India

Corresponding author: * **crunu@hotmail.com**

ABSTRACT

To retain the carotenoid content of mangoes (cvs. 'Himsagar', 'Langra' and 'Fajli'), they were preserved in sucrose (50° Brix), 5% NaCl or 1% citric acid solutions. In addition, some of these mangoes were thermally treated at 70°C for 30 min while others were cooked under pressure (1 atm) at 121°C for 10 min. They were then stored in a chest freezer at -18°C for 80 days. The carotenoid content was found to be higher in thermally processed mangoes but decreased in untreated mangoes and those preserved in citric acid. The carotenoid content initially increased during the first 10 days of storage when the mangoes were treated with sucrose and NaCl solutions, after which it decreased.

Keywords: citric acid, NaCl, sucrose

INTRODUCTION

Mango (*Mangifera indica* L.) is reported to be the second largest tropical crop, with the highest producing countries being India, China and Mexico, the leaders in the international trade being India, Mexico and the Phillipines (FAO 2000). Nevertheless, mango is scarcely commercialized when compared to the quantity produced due to the difficulties in post harvest management in the producing countries. There are more than thousand mango varieties in India. However, only about 30 varieties are grown on commercial scale in different states. The three varieties indigenous to the Eastern Indian states are 'Himsagar', 'Langra' and 'Fajli'.

Since the harvesting period of mangoes is limited to a few months, they are susceptible to a variety of disorders during post harvest handling and storage (Yahia 1998). The post harvest life of mangoes usually does not exceed 2-3 weeks and is limited by physiological deterioration of the fruit related to over ripening and by pathogen development leading to decay (Gonzalez-Aguilar 1997). To maintain the fruit quality for long periods, controlled temperature and atmosphere of storage are required, which is, in many cases, not available in producing countries. Limited storage life has resulted in the waste of huge amounts of this valuable fruit. Methods for extending the storage life even by a few weeks are urgently needed, not only to save a valuable food material from wastage but also to stabilize the economic life of the growers. Refrigeration is the most widely used method to preserve mangoes; however, the fruit can be susceptible to chilling injury.

Several studies have shown the presence or predominance of carotenoids and consequently high vitamin A activity of mangoes, although the values are likely to vary (Krisnamurthy *et al.* 1960; Fonseca *et al.* 1969; George *et al.* 1969; Morga *et al.* 1979). The demand for carotenoids has increased due to its reported anticancer (Sims *et al.* 1993; Halter 1989; Ziegler 1989), free radical quencher and other biological, e.g. antioxidant activities (Bendich and Olson 1989; Krimsky 1989). Mangoes are a good source of pro-vitamin A, containing an average total carotenoid content of 0.4–2.1 g/100 g, depending on the cultivar.

In this paper, the carotenoid content of three varieties of mangoes preserved in sucrose, NaCl and citric acid solutions was studied. The change in the carotenoid content with thermal treatment and subsequent storage at low temperature of the preserved mangoes were also studied.

MATERIALS AND METHODS

Three varieties of mango (cvs. 'Himsagar', 'Langra' and 'Fajli'), selected on the basis of similar degrees of ripening, were purchased from a local market. The skin was removed and two slices parallel to the stone were cut from each fruit. The mangoes were further cut in dimensions of $3 \times 2 \times 1$ cm^3 and approximately 10 mango slices of 10 gm each were soaked separately in sucrose (50° Brix), 5% NaCl and 1% citric acid solutions (250 ml) for 24 hr. The slices were removed from the soaking solution after 24 hrs and the surface moisture removed with tissue papers and the total carotenoid content was measured along with a set of control (untreated) mango slices. The treated mango slices along with the control was thermally treated by placing the mangoes in a beaker in a temperature controlled water bath at 70°C for 30 min and the other set of mangoes was cooked under pressure in a pressure cooker (1 atm) for 121°C for 10 min. Each temperature treatment was repeated at least three times. After removal, the samples were rapidly cooled (1 min in ice water) and the contents were immediately analyzed for carotenoid content. Then the thermally processed samples along with the control (no thermal treatment) were sealed in polypropylene bags and kept for storage at –18°C in a chest freezer for 80 days.

Total carotenoid content was measured according to the method of Ranganna (1986) and Alasalvar *et al.* (2005) with slight modifications. Mango slices were homogenized in 125 ml of diacetone alcohol. The homogenate was filtered through a Whatman No 4 filter paper and washed until the residue was colourless. The filtrate was extracted with petroleum ether and further purified with diacetone alcohol, methanolic KOH and distilled water. The resulting solution was filtered with anhydrous sodium sulphate and read on a spectrophotometer at 450 nm against petroleum ether as a blank. All the analytical work was repeated three times.

Received: 28 November, 2008. Accepted: 6 July, 2009.

Original Research Paper

Data analysis

The experiment was conducted using a split plot design where 3 mango cultivars (r=3) served as whole plots, which consisted of a single way treatment structure. Two thermal treatments (a=2) (70°C for 30 min and 121°C for 10 min) were randomly assigned to the whole plots within each block. Each whole plot was divided into three split plots with the type of preservative added (b=3) (50° Brix sucrose solution, 5% NaCl solution and 1% citric acid) were randomly assigned within each split plot. Each split plot was further divided into sub-split plot and storage days (c=5) were randomly assigned. Statistical analysis was done using the software STATISTICA version 5.0. (StatSoft).

RESULTS AND DISCUSSION

Fig. 1 shows a significant difference in the carotenoid content in the three mango cultivars ($p < 0.05$).

Thermal treatment led to an increase in the carotenoid content of untreated mangoes (**Fig. 2**). It can be seen from **Fig. 2** that the increase was slightly more in mangoes cooked under pressure (1 atm) at 121°C for 10 min than for the thermally treated mangoes at 70°C for 30 min. The increase was about 59.429% in 'Himsagar', 94.26% in 'Langra', 38.92% in 'Fajli' in when mangoes are cooked under pressure (1 atm) at 121°C whereas in thermally treated mangoes at 70°C for 30 min. the increase was 53.626% in 'Himsagar', 78.88% in 'Langra', 28.40% in 'Fajli' as compared to the control. Thermal processing led to an increase in the carotenoid concentration, perhaps due to greater chemical extractability (Rodriguez-Amaya 1999) and loss of moisture and soluble solids. Heat treatment inactivated some oxidative enzymes with the rupture of cellular components that lead to higher carotenoid content (Howard *et al.* 1999; Vander Berg *et al.* 2000). But when mangoes were cooked under pressure at 121°C, it led to the removal of air, preventing the carotenoid from getting oxidized. As a result higher carotenoid content was observed in the mangoes cooked under pressure (1 atm) at 121°C for 10 min. Rodriguez-Amaya (2002) reported that high temperature short time processing is a better method for retention of carotenoids in fruits and vegetables.

Preserving the mango pieces in sucrose solution (50°

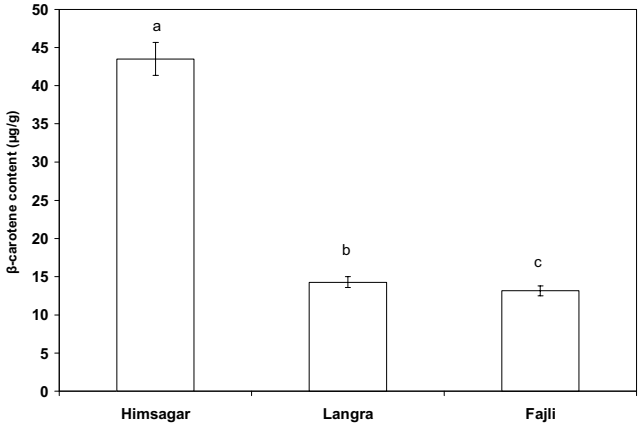

Fig. 1 β-carotene content in three varieties of mangoes. Means with different letters are significantly different (p<0.05).

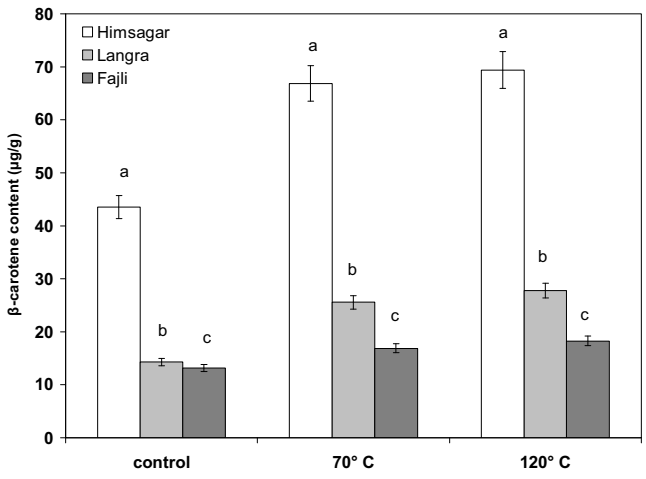

Fig. 2 Effect of thermal processing on the β-carotene content of mangoes. Means with different letters are significantly different (p<0.05).

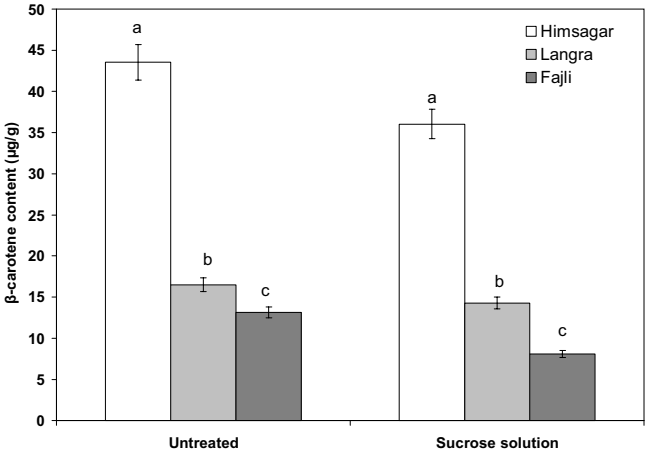

Fig. 3 Effect of sucrose solution (50° Brix) on the β-carotene content of mangoes. Means with different letters are significantly different (p<0.05).

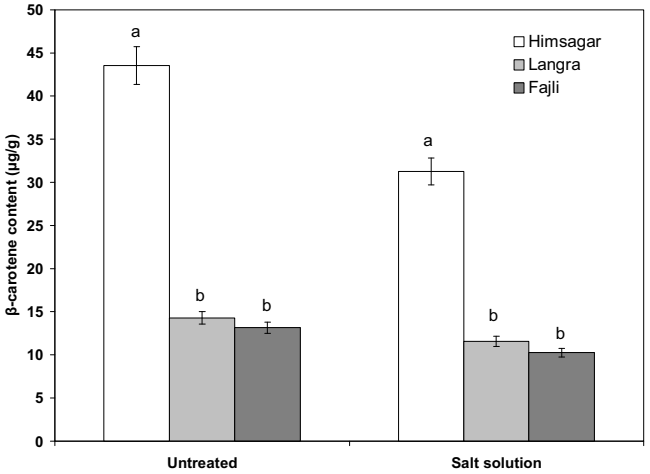

Fig. 4 Effect of NaCl solution (5%) on the β-carotene content of mangoes. Means with different letters are significantly different (p<0.05).

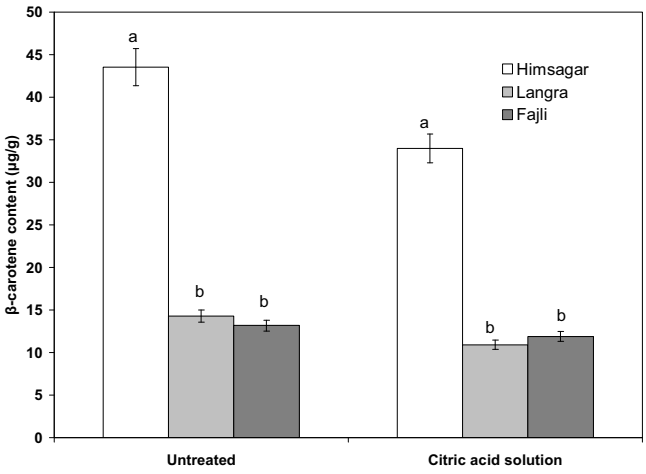

Fig. 5 Effect of citric acid solution (1%) on the β-carotene content of mangoes. Means with different letters are significantly different (p<0.05).

Brix) led to a decrease in the carotenoid content in all varieties as compared to the control (untreated) (**Fig. 3**). Probably, osmotic dehydration took place resulting in rapid removal of water with subsequent replacement of sugar in the vacuole. Ramakrishnan and Francis (1979) reported that water had a protective influence on the auto-oxidation of carotenoids. With the loss of water, the protective influence of water for carotenoid oxidation was not present leading to a loss of carotenoid.

The carotenoid content of mangoes soaked in 5% NaCl solution was less than the untreated ones (**Fig. 4**). However, mangoes soaked in NaCl solution after thermal treatment had a higher carotenoid value than the control. Thermal treatment lead to the removal of gases from the fruit surfaces and from intracellular spaces, resulting in enhanced extraction efficiency of carotenoid. It could be possible that the osmotic gradient induced by salt and followed by thermal treatment could promote the disassociation of carotenoid from the protein complex in the mango slices.

Soaking mangoes in citric acid solution leads to a decrease in the β-carotene content. The loss in the β-carotene value in 'Himsagar' is around 22%, 24% in case of 'Langra' and about 10% in 'Fajli' as compared to the untreated (**Fig. 5**). Being highly unsaturated carotenoids are prone to isomerization and transformation from the *trans* to *cis* and this is enhanced with acid, heat treatment and light (Rodriguez-Amaya 2002).

Effect of storage at –18°C on the carotenoid content

As seen in **Fig. 6A-C**, the carotenoid content decreased in the untreated mangoes for all thermal treatments with storage. It is further seen from these figures that the decrease was lesser during the first 20 days of storage after which it

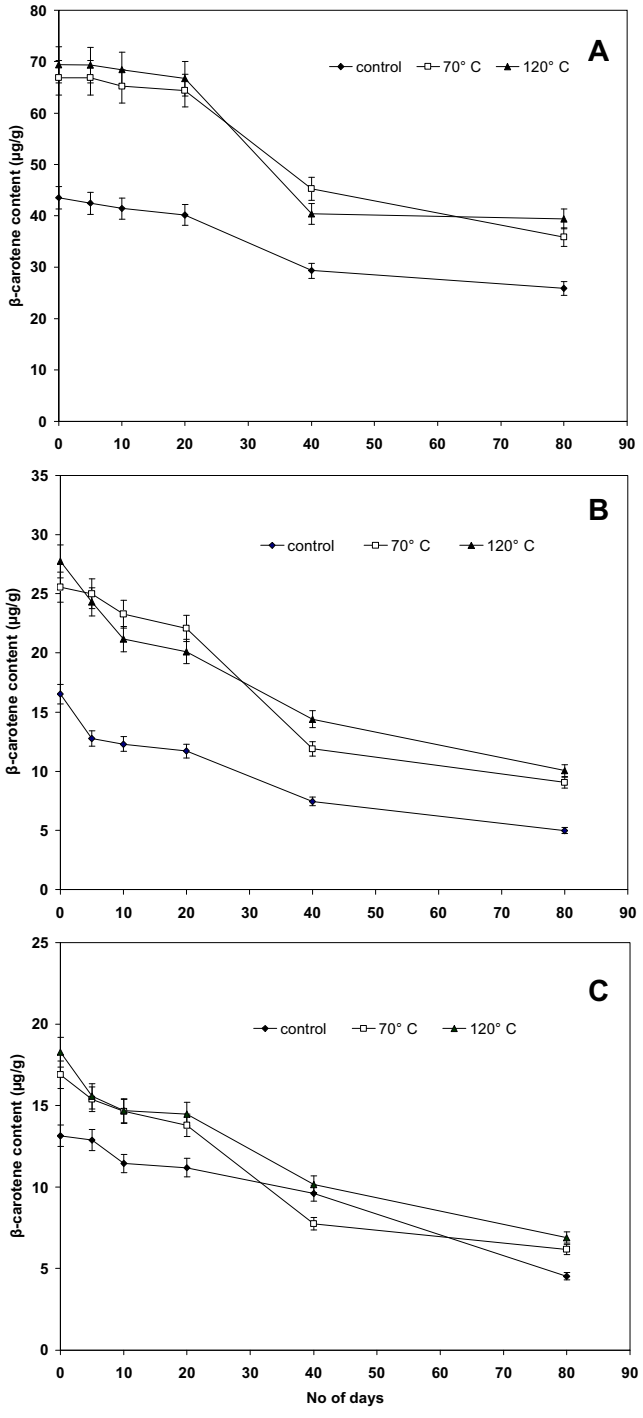

Fig. 6 Degradation of β-carotene in the untreated samples and kept for storage at -18°C for 'Himsagar' (A), 'Langra' (B) and 'Fajli' (C).

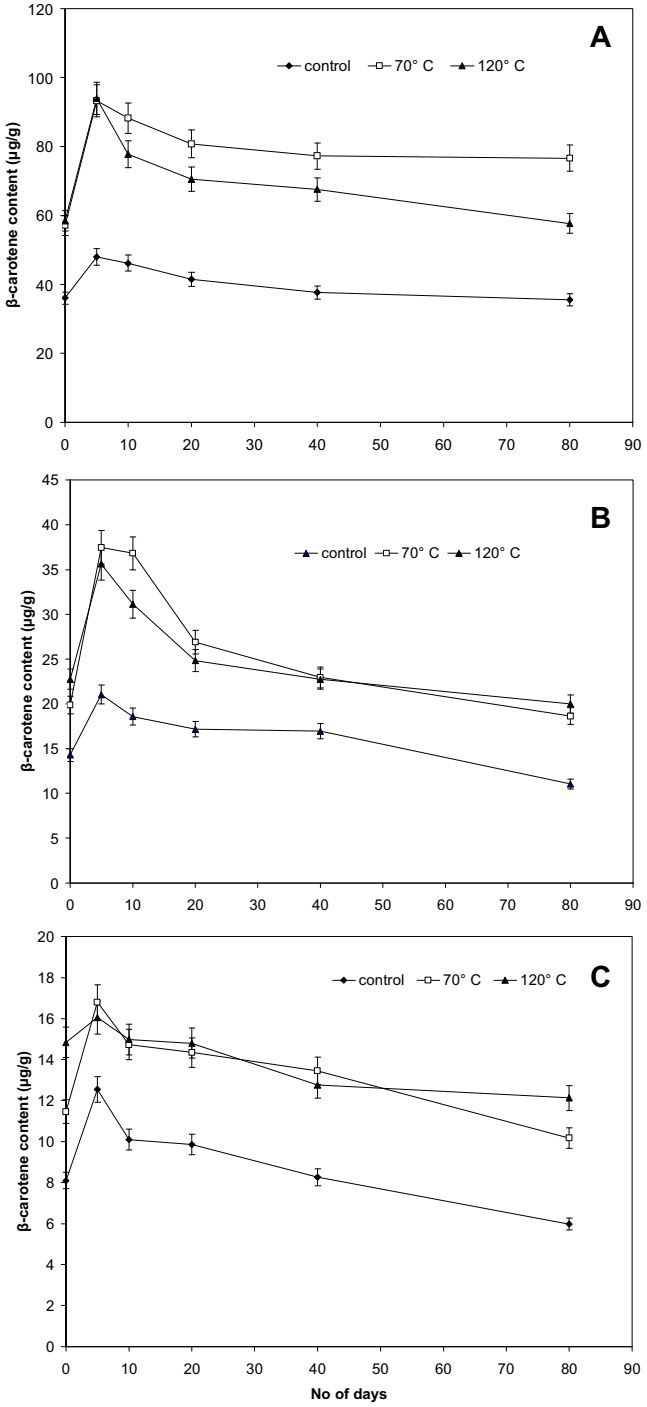

Fig. 7 Degradation of β-carotene in the samples treated with sucrose solution (50°Brix) followed by thermal treatment and kept for storage at -18°C for 'Himsagar' (A), 'Langra' (B) and 'Fajli' (C).

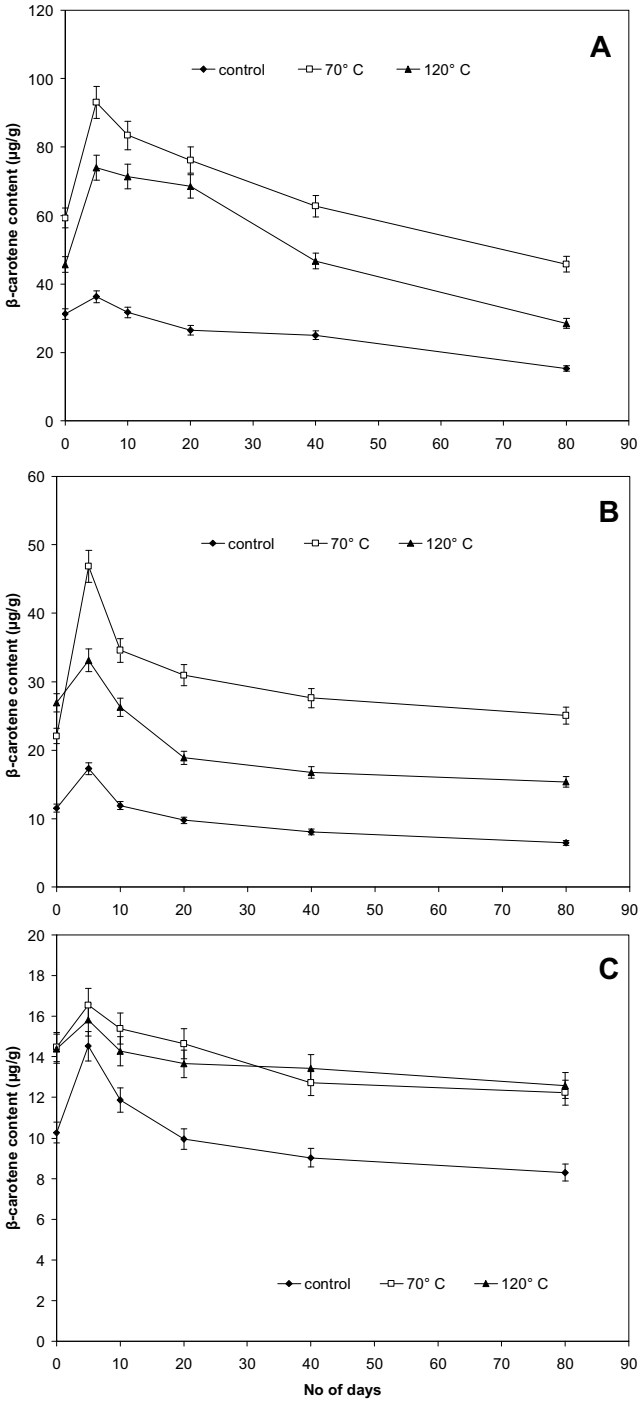

Fig. 8 Degradation of β-carotene in the samples treated with NaCl solution (5%) followed by thermal treatment and kept for storage at -18°C for 'Himsagar' (A), 'Langra' (B) and 'Fajli' (C).

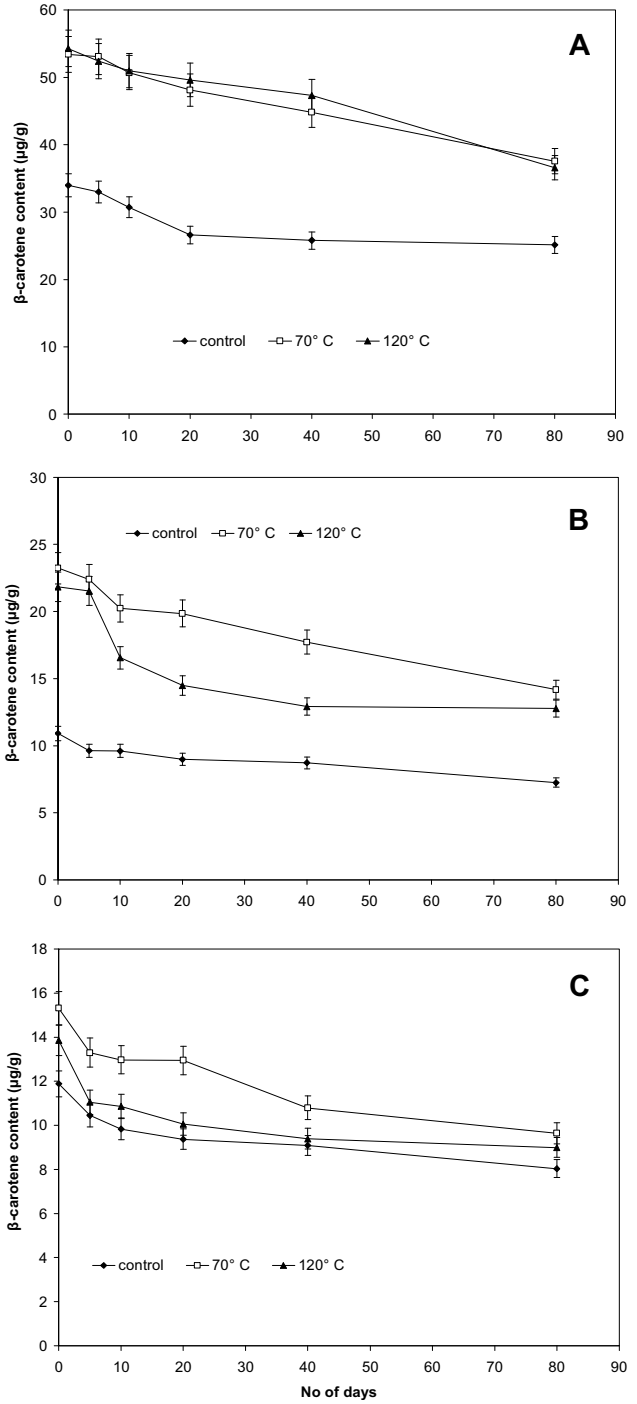

Fig. 9 Degradation of β-carotene in the samples treated with Citric acid solution (1%) followed by thermal treatment and kept for storage at -18°C for 'Himsagar' (A), 'Langra' (B) and 'Fajli' (C).

degraded drastically. The losses could be due to non-oxidative changes (*cis-trans* isomerization, epoxide formation or thermal degradation) or oxidative changes. Such a decrease in carotenoid content was also observed in the case of chopped green beans and intact pardon pepper when kept at -22°C for 12 months (Oruna-Concha *et al*. 1997).

An initial increase in the carotenoid content was observed during the first five days of storage for the mangoes preserved in sucrose solution followed by thermal treatment (**Fig. 7A-C**). The heavy sucrose solution glazed the mango surface, protecting the mango slices from subsequent dehydration and exposure to oxygen. Similar results were observed by Chavasit *et al*. (2002) during preparation of candied fruits. With storage time, the carotenoid content gradually decreased, the decrease could be due to non-oxidative changes such as transformation and epoxide formation. Epoxide formation was reported by Godoy *et al*. (1987) during the processing of mango slices (cv. 'Tommy Atkins') and mango puree (cv. 'Golden').

Storing the thermally treated mango slices in 5% NaCl solution lead to an increase in the carotenoid content for the first 10 days of storage (**Fig 8A-C**). The increase might have resulted from certain changes in the mango tissue during salting, producing a higher release of carotenoid during the extraction process. Many researchers have mentioned similar changes (Poster *et al.* 1947; Oser *et al.* 1943; Park 1987; Hart and Scott 1995; Sungpang *et al.* 1999) while studying the carotenoid content in different vegetables. These studies indicated that the lower values of carotenoid found in raw vegetables was apparently due to the incomplete extraction of carotene from the stable lipoprotein complexes. Carotenoid might have been released from the lipoprotein complex during the salting process and this extraction continued for at least another 10 days. This is

Table 1 Results of the split plot analysis on the β-carotene content of mangoes.

Source of Variance	
Cultivar (r)	**
Processing Treatment(a)	ns
Preservatives added(b)	**
Storage days (c)	**
r × a	ns
a × b	ns
a × c	ns
b × c	*
r × a × b	**
a × b × c	ns

** :significant at $p < .001$
* :significant at $p < .05$
ns : not significant.

seen in **Fig. 7A-C**. From the 20th day to the 80th day, the carotenoid released from the lipoprotein complex led to auto-oxidation with the decrease in the carotenoid content.

The β-carotene content of the citric acid treated mangoes also decreased during the 80 days of storage period for all three varieties (**Fig. 9A-C**). The loss was in the range of 26-33% in the control samples, 20-31% for mangoes soaked in citric acid solution and thermally treated at 70°C for 30 min and 28-41% for mangoes soaked in citric acid and cooked under pressure (1 atm) at 121°C for 10 min in all three varieties. The decrease in β-carotene in mangoes soaked in citric acid solution was probably due to *cis-trans* isomerisation, which lowered the β-carotene content of mangoes. Chen *et al*. (1996) observed a reduction of lutein, α-carotene and β-carotene in acidified pasteurized carrot juice stored for three months, which increased with increase in storage temperature.

The split plot analysis yielded some significant interactions of the variety, thermal treatment, preservative used and duration of storage on the degradation of carotenoid (**Table 1**). There is a significant difference in the carotenoid values for cultivars, preservatives added and storage days ($p<0.001$). However, the two thermal treatments did not bring any significant difference in the carotenoid values. The interaction between the mango cultivars, thermal treatments and preservatives used were highly significant, implying that the carotenoid content in the mangoes were highly dependent on these factors ($p<0.001$). However, mangoes soaked in different soaking solutions (sucrose, NaCl, citric acid) had a significant effect ($p<0.05$) on the carotenoid content when stored for a period of 80 days. But when these processed mangoes were coupled with thermal treatment significant difference in the carotenoid content during storage was not observed. However, the decrease in the carotenoid values was more or less similar in all three varieties. There is a significant difference in the interaction between the mango cultivars, thermal treatment and the preservatives added.

REFERENCES

Alasalvar C, Al- Farsi M, Quantick PC, Shahidi F, Wiktorowicz R (2005) Effect of chill storage and modified atmosphere packaging (MAP) on antioxidant activity, anthocyanins, carotenoids, phenolics and sensory quality of ready-to-eat shredded orange and purple carrots. *Food Chemistry* **89**, 69-76

Bendich A, Olson JA (1989) Biological actions of carotenoids. *FASEB Journal* **3**, 1927-1932

Chavasit V, Pisaphab R, Sungpuag P, Jittinandana S, Wasantwisut E (2002) Changes in β-carotene and vitamin A contents of vitamin A-rich foods in Thailand during preservation and storage. *Journal of Food Science* **67**, 375-379

Chen BH, Peng HY, Chen HE (1996) Stability of carotenoids and vitamin A during storage of carrot juice. *Food Chemistry* **57**, 497-503

FAO (2000) Comite de problemas de productos basicos subgrupo sobre frutas tropicales. Pathaya, Thailand 25-28 May 1998. Available online: http://www.fao.org

Fonseca H, Nogueira JN, Marcondes AMS (1969) Teor de acido ascorbico e β-caoteno em frutas e hortalicas brasileiras. *Archivos Latino-americanos de Nutricion* **19**, 9-16

George LMI, Rivera AIC, Benero JR, Pennock W (1969) Pro-vitamin A and Vitamin C contents of several varieties of mango (*Mangifera indica* L.) grown in Puerto Rico *Journal of the Agricultural University of Puerto Rico* **53**, 100-105

Godoy HT, Rodriguez-Amaya DB (1987) Changes in indivual carotenoids on processing and storage of mango (*Mangifera indica*) slices and puree. *International Journal of Food Science and Technology* **22**, 451-460

Gonzalez-Aguilar GA, Zacarias L, Mulas M, Lafuente MT (1997) Temperature and duration of water dips influence chilling injury, decay and polyamine content in "Fortune" mandarins *Postharvest Biology and Technology* **12**, 61-69

Halter S (1989) Vitamin A: Its role in chemoprevention and chemotherapy of cancer. *Human Pathology* **20**, 205-209

Hart DJ, Scott KJ (1995) Development and evaluation of an HPLC method for the analysis of carotenoids in foods, and the measurement of the carotenoid content of vegetables and fruits commonly consumed in the UK. *Food Chemistry* **54**, 101-111

Howard LA, Wong AD, Perry AK, Klein BP (1999) β-carotene and ascorbic acid retention in fresh and processed vegetables. *Journal of Food Science* **64**, 929-936

Krimsky NJ (1989) Carotenoid and cancer in animal model. *Journal of Nutrition* **119**, 123-126

Krishnamurthy GV, Jain NL, Bhatia BS (1960) Changes in the physiochemical composition of mangoes during ripening after picking. *Indian Food Science* **9**, 277-279

Morga NS, Lustre AO, Tunac MM, Rahman AH, Soriano MR (1979) Physio-chemical changes in Philippine carabao mangoes during ripening. *Food Chemistry* **15**, 225-234

Oruna-Concha MJ, Gonzalez-Castro MJ, Lopez-Hernández J, Simal-Lozano J (1997) Effects of freezing on the pigment content in green beans and pardon peppers. *Zeitschrift für Lebensmittel Untersuchung und Forschung* **205**, 148-152

Oser BL, Melnick D, Oser M (1943) Influence of cooking procedure upon the retention of vitamin and minerals in vegetables. *Food Research* **8**, 115-122

Park YW (1987) Effect of freezing, thawing, drying and cooking on carotene retention in carrots, broccoli and spinach. *Journal of Food Science* **52**, 1022-1025

Poster T, Wharton MA, Bennett BB (1947) Evaluation of carotene content of fresh and cooked spinach. *Food Research* **12 (1)**, 133-141

Ramakrishnan T, Francis FJ (1979) Stability of carotenoids in model aqueous systems. *Journal of Food Quality* **2**, 177

Ranganna S (1986) Plant pigments. In: *Handbook of Analysis and Quality Control for Fruit and Vegetable Products* (2nd Edn), Tata McGraw Hill Publishing Co. Ltd, New Delhi, pp 83-104

Rodriguez-Amaya DB (2002) Effects of processing and storage on food carotenoids. *Sight and Life* **3**, 25-35

Rodriguez-Amaya DB (1999) Changes in carotenoids during processing and storage of foods. *Archivos Latino-americanos de Nutricion* **49**, 38S-47S

Sims CA, Balaban MO, Mathews RF (1993) Optimization of carotene color and cloud stability *Journal of Food Science* **58**, 1129-1191

Vander Berg H, Faulks R, Fernando-Granado H, Hirchberg J, Olmedilla B, Sandmann G, Southon S, Stahl W (2000) The potential for the improvement of carotenoid levels in foods and the likely systemic effects. *Journal of Science and Food Agriculture* **80**, 880-912

Sungpuag P, Tangchitpianvit S, Chittchang U, Wasantwisut E (1999) Retinol and beta-carotene content of indigenous raw and home prepared foods in North-east Thailand. *Food Chemistry* **64**, 163-167

Yahia E (1998) Modified and controlled atmospheres for tropical fruits. *Horticultural Reviews* **22**, 123-183

Ziegler RG (1989) A review of epidemiological evidence that carotenoids reduce the risk of cancer. *Journal of Nutrition* **119**, 116-122