DR-1984
[1-8]

RESEARCH ARTICLE Asian Journal of Dairy and Food Research

Effect of Maturity Stages and Ripening Process on the Nutritive and β-carotene of Mango [*Mangifera indica* (L.) *var.* Manjeera]

Himani Joshi[1], Aparna Kuna[2], M. Sreedhar[3], A. Kiran Kumar[4]

10.18805/ajdfr.DR-1984

ABSTRACT

Background: Mango is one of the few fruits that is used at every stage of ripeness, from the very young, immature stage to the completely mature state. The concentrations of nutrients vary across different kinds according on the environmental factors, ripening processes and maturity stages. The process of ripening, which can be carried out either naturally or artificially, brings the fruit to maturity before it is consumed or processed. The best time for mango intake with the most nutrient and phytochemical potential can be determined rationally by new facts about mango consumption.

Methods: Materials utilized for the study were mangoes harvested at two maturity stages *i.e.* 7-9°brix and 9-11°brix and processed by three treatments methods *viz*, control, 100 ppm and 150 ppm ethylene treatment followed by 12 days storage. The samples were withdrawn periodically for analysis on 4th, 8th and 12th day of the storage. Nutritive composition and β-carotene analysis for the mangoes were done using the standard methods.

Result: According to the findings of the proximate analysis, the ash content was greater in the control on the 12th and 4th days, respectively, in the 9-11°brix TSS and 7-9°brix TSS. Mangoes harvested at 7-9°brix TSS had the maximum protein content on the fourth day, followed by mangoes treated with 150 ppm ethylene on the twelfth day. In all the treatments, the maximum levels of crude fiber and crude fat were found on day 12th and 8th, respectively, in mangoes harvested at 7-9°brix TSS and 9-11°brix TSS. On the fourth day, mangoes treated with 100 ppm ethylene and harvested at 9-11°brix TSS had the highest carbohydrate content. On the eighth day, all treatments had the most energy. 7-9°brix TSS harvested mangoes showed good nutrient content in control samples, showing that artificial ripening treatments had a substantial impact on the nutrient composition, according to the data.

Key word: Ethylene, Manjeera, Maturity stages, Nutrition, Ripening.

INTRODUCTION

A healthy diet should include plenty of fruit and vegetables, which can help prevent serious illnesses like cancer and cardiovascular disease. If fruit and vegetable consumption were adequately increased, it is projected that up to 2.7 million lives may be saved annually. In order to prevent chronic diseases like heart disease, cancer, diabetes and obesity as well as to prevent and treat a number of micronutrient deficiencies, especially in less developed countries, a recent report on the Joint FAO/WHO Expert Consultation on diet nutrition and the prevention of chronic diseases recommends consuming a minimum of 400 g of fruit and vegetables per day (excluding potatoes and other starchy tubers) (World Health Organization, 2003).

Mango is a member of the genus Mangifera and the family Anacardiaceae. Mangifera is a genus that has many species that produce palatable fruit. *Mangifera indica*, the most popular Mangifera species, is native to India and Myanmar (Bally, 2006). One of the most significant tropical fruits in the world, the mango is now grown for commercial purposes in more than 87 countries (Tharanathan *et al.,* 2006) and is currently rated fifth among the major fruit crops in terms of global production (Ravani and Joshi, 2013).

According to epidemiological research, eating fruits and vegetables helps reduce lung cancer (Yong *et al*., 1997), neurological illnesses (Joseph *et al.,* 1999) and cardiovascular diseases (Ye and Song, 2008). Contrarily, fiber is known to be essential for regular gastrointestinal function and high intakes of dietary fiber are also advised to reduce the risk of cardiovascular illnesses and coronary heart disease (Slavin, 2013), diabetes (Hopping *et al.,* 2010) and to maintain appropriate body weight (Slavin, 2008).

[1]Department of Foods and Nutrition, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar- 263 153, Uttarakhand, India.
[2]MFPI-Quality Control Laboratory, Professor Jayashankar Telengana State Agriculture University, Hyderabad-500 030, Telangana, India.
[3]Planning and Monitoring Cell, Professor Jayashankar Telangana State Agricultural University, Hyderabad-500 030, Telangana, India.
[4]Comptroller and Dean of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Hyderabad-500 030, Telangana, India.

Corresponding Author: Himani Joshi, Department of Foods and Nutrition, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar- 263 153, Uttarakhand, India. Email: joshi.himanijoshi@gmail.com

How to cite this article: Joshi, H., Kuna, A., Sreedhar, M. and Kumar, A.K. (2022). Effect of Maturity Stages and Ripening Process on the Nutritive and β-carotene of Mango [*Mangifera indica* (L.) *var.* Manjeera]. Asian Journal of Dairy and Food Research. doi: 10.18805/ajdfr.DR-1984.

Submitted: 07-07-2022 **Accepted:** 19-12-2022 **Online:** 30-01-2023

MATERIALS AND METHODS

The research study, Effect of maturity stages and ripening process on the nutrient and bioactive composition of mango [*Mangifera indica* (L.) var. Manjeera], was carried out between January to June, 2016 at Department of Foods and Nutrition, Post Graduate and Research Center and MFPI-Quality Control Laboratory, Professor Jayashankar Telangana State Agricultural University.

Mangoes were harvested at two maturation stages (7-9°brix TSS and 9-11°brix TSS) at the Fruit Research Station, SKLTSHU, Sangareddy. Sixty mature, green, undamaged and healthy fruits of the Manjeera cultivar were gathered. After harvest, the fruits were left to dry for an hour before having their skins cleaned with a towel and being washed with a mild, neutral detergent (Sandovit - 0.5 ml/litre). After drying in the shade, the fruits were brought for an ethylene treatment. At the Fruit Research Station, SKLTSHU, Sangareddy, two ethylene ripening treatments (100ppm and 150ppm ethylene dosages) were performed. Fruits were removed from each treatment on days 4, 8 and 12 to be evaluated for their nutritional makeup and β-carotene concentration. Fig 1 contains a flow chart showing the various mango research treatments that were applied.

Moisture: (IS: 1155-1968 reaffirmed 2010)

5 g of dried sample was placed in dried and weighed porcelain dish was kept in electric oven at 105±1°C for 2 hours.

Ash: (IS: 1155-1968 reaffirmed 2010)

5 g of dehydrated mango pulp was dried for 1 hour and then kept in muffle furnace between 550 to 600°C to finish ashing. The weight of grey ash was recorded.

Protein: (AOAC 992.23; 32.2.02.)-generic combustion method; (Leco FP-528 nitrogen analyzer)

0.2 g of EDTA and dehydrated mango pulp and kept in aluminium foil cups. Blank of 0.5 g was entered to calibrate instrument. To determine the percentage of protein, sample id and weights were entered and added one at a time to the crucibles.

Crude fiber (AOAC 962.09-2007)

1 g sample was kept in weighed empty fiber bag and a blank fiber bag and weighed, bags were filled with glass spacers. Bags were placed in the sample carousel's and placed axially on hot plate and Fibertherm programme was initiated. Once programme was finished fiber bags were dried for 2 hours at 102°C and then weighed. After digestion and drying, the weight of the crucible and fiber bags alongwith blank fiber bag. Crucibles were then heated to 600°C in a muffle furnace. After burning, the weight of the crucible+blank fiber bag was taken.

Crude fat (AOAC 922.06-2006)

Dehydrated mango pulp was measured and wrapped in filter paper, kept in thimbles and then fitted in fat extraction beaker. N-hexane was added to beaker and placed into slots in soxtherm. The sample portion containing thimble was submerged in the boiling solvent. The sample portion was further extracted in the second phase by a continuous flow of condensed solvent for one hour and 20 minutes while the thimble was raised above the solvent. Condensation was used to recover the solvent after it had evaporated. After drying, the resultant crude fat residue was quantified. To get rid of moisture, extraction cups were dried at 102°C±2°C in a hot air oven for 30 minutes. The defatted sample (F) was weighed to the nearest 0.1 mg after cooling in a desiccator (F).

Determination of total carbohydrates (IS 1656:2007 Reaffirmed 2012)

After calculating the percentage of moisture, total protein, total fat and total ash, total carbs were determined as follows. Total carbohydrates, including sucrose dextrose and dextrin, maltose or lactose, percent by mass= 100-(A+B+C+D)

Where
A= Percent by mass of moisture.
B= Percent by mass of total protein.
C= Percent by mass of fat.
D= Percent by mass of total ash.

Estimation of energy content by Atwater general factor system method

Energy content was estimated by multiplying protein, fat and carbohydrate values obtained from analysis by 4, 9 and 4 respectively.

RESULTS AND DISCUSSION

The results for the nutritive composition have been presented in Table 1 below.

Results for moisture content

The data (Fig 2) show that control mangoes harvested at 7-9°brix TSS had a moisture content that increased significantly ($p<0.05$) up to day 12. The moisture content of mangoes treated with 100 ppm and 150 ppm decreased substantially ($p<0.05$) from day 4 to day 8 and then dramatically ($p<0.05$) increased till twelfth day.

The moisture level in the control group of mangoes collected at 9-11°brix TSS fell somewhat over the course of day 4 to day 8, before considerably rising ($p<0.05$) till day 12. In mangoes treated with 100 ppm, moisture content increased significantly ($p<0.05$) from day 4 to day 12, whereas in mangoes treated with 150 ppm, there was a slight decrease in moisture content from day 4 to day 8, before declining significantly ($p<0.05$) to day 12. While Brito and Narain (2002) noted a drop in moisture content in sapota fruit, Mahmood *et al.* (2013) discovered a considerable increase in moisture content in cherry fruit during the various ripening stages. However, according to Opara *et al.* (2012), the moisture content of cherry fruits fluctuates between being lower and higher during various stages of ripening.

Results for ash content

The data show that there are different amounts of ash in the 7-9°brix TSS harvested mangoes for each of the three treatments. In 9-11°brix TSS harvested mangoes ash content in control and100ppm treated mangoes decreased significantly ($p<0.05$) from 4th day to 8th day of storage and then there was a significant ($p<0.05$) increase from 8th day to 12th day of storage, whereas in 150ppm ethylene treated mangoes there was a significant ($p<0.05$) increase in the ash content from 4th day to 8th day of storage and there was no increase in ash content from 8th day to 12th day (Fig 3).

While Sharma *et al.* (2014) discovered that the ash content of wood apples decreased and increased over the ripening process, Mahmood *et al.* (2013) discovered that the ash level in cherry fruits decreased from the unripe stage to the semi-ripe stage and decreased significantly to the fully-ripened state. The ash content of the native pawpaw variety significantly altered from the unripe to the semi-ripe stage and then again from the semi-ripe to fully ripe stage, according to a study by Wurochekke *et al.* (2013). The changing capacity for absorption of the minerals at different phases of growth, according to Adeyemi and Oladiji (2009), may be the cause of differences in ash.

Results for protein content

The protein content of control mangoes harvested at 7-9°Brix TSS and 9-11°brix TSS decreased from the fourth to the eighth day of storage then increased from the eighth to the twelfth day, according to the protein estimation results (Fig 4).

The protein content of the pawpaw types Kapoho Solo and Solo Sunrise decreased from the unripe to the semi-ripe stage and then increased up to the ripe stage of the fruit, according to Wurochekke *et al.* (2013). In a study on cherry fruit, Mahmood *et al.* 2013found that as the fruit ripens, the protein concentration increases. The amount of protein in blackberry fruit reduces as it ripens, according to Tosun *et al.* (2008).

Results for crude fat

According to the data (Fig 5), the crude fat content of both the 7-9°brix and 9-11°brix TSS harvested mangoes was maximum on the eighth day in all treatments. Our findings concur with those of Opara *et al. (*2012), who found that the

Table 1: Nutritive Composition in all treatments of Mangoes *var*. Manjeera harvested at different maturity and ripening stages.

	Maturity stage						
Treatment/	7-9 brix			9-11 brix			Se
Day of storage	Control	100 ppm	150 ppm	Control	100 ppm	150 ppm	value
			Moisture (%)				
4th day	82.20±0.85^{bc}	84.70±0.14^{d}	85.20±0.11^{c}	83.40±0.00^{cd}	82.45±0.52^{bc}	86.50±1.55^{f}	1.48
8th day	81.90±1.55^{b}	82.30±0.99^{bc}	80.40±0.57^{a}	82.60±0.28^{bc}	84.40±0.28^{d}	86.20±0.28^{ef}	
12th day	84.80±0.00^{de}	90.80±0.57^{g}	85.20±0.57^{c}	91.67±0.30^{g}	87.52±0.00^{f}	84.58±0.48^{d}	
			Ash (%)				
4th day	0.42±0.03^{f}	0.40±0.00^{ef}	0.42±0.03^{f}	0.42±0.03^{f}	0.42±0.03^{f}	0.30±0.00^{ab}	0.04
8th day	0.37±0.00^{cde}	0.40±0.01^{ef}	0.37±0.01^{de}	0.28±0.00^{a}	0.36±0.01^{cde}	0.37±0.00^{cde}	
12th day	0.39±0.01^{def}	0.36±0.00^{cd}	0.33±0.02^{bc}	0.52±0.01^{g}	0.41±0.01^{f}	0.37±0.00^{cde}	
			Protein (%)				
4th day	1.92±0.00	1.48±0.06	1.19±0.00	1.36±0.49	1.14±0.07	1.64±0.40	0.65
8th day	1.37±0.03	1.49±0.31	1.22±0.07	1.15±0.06	1.48±0.52	1.11±0.00	
12th day	1.49±0.49	1.13±0.01	1.69±0.08	1.39±0.08	1.51±0.66	1.34±0.40	
			Crude fiber (%)				
4th day	1.96±0.03^{de}	1.93±0.03^{d}	1.83±0.02^{b}	1.73±0.01^{a}	1.92±0.02^{cd}	1.87±0.03^{bc}	0.06
8th day	2.08±0.04^{hi}	2.16±0.08^{j}	2.01±0.02^{efg}	2.06±0.05^{ghi}	2.00±0.01^{ef}	2.00±0.01^{ef}	
12th day	2.21±0.01^{jk}	2.17±0.03^{j}	2.26±0.06^{kl}	2.21±0.03^{jkl}	2.10±0.03^{i}	2.03±0.04^{fgh}	
			Crude fat (%)				
4th day	0.43±0.04^{ab}	0.45±0.07^{abc}	0.55±0.04^{bc}	0.49±0.04^{abc}	0.35±0.01^{a}	0.51±0.01^{bc}	0.16
8th day	0.99±0.13^{e}	1.03±0.01^{e}	0.96±0.03^{e}	1.94±0.20^{fg}	1.87±0.10^{f}	1.92±0.06^{fg}	
12th day	0.40±0.00^{ab}	0.80±0.00^{d}	0.90±0.14^{e}	0.40±0.00^{ab}	0.60±0.00 ^{c}	0.80±0.00^{d}	
			Carbohydrate (%)				
4th day	15.02±0.93^{h}	12.96±0.13^{efg}	12.63±1.05^{def}	14.32±0.48^{gh}	15.63±0.47^{hij}	11.04±1.97^{bcd}	1.62
8th day	15.36±1.39^{hi}	14.78±1.30 ^{h}	17.04±0.53^{ij}	14.03±0.42^{fgh}	11.88±0.16^{cde}	10.40±0.23^{bc}	
12th day	12.91±0.49^{efg}	6.90±0.57 ^{a}	11.87±0.52^{cde}	6.01±0.37^{a}	9.95±0.65^{b}	12.90±0.08^{efg}	

Note: All the values are expressed as mean±SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level.

fat content of the Isabella cultivar of tomato increased initially before declining.

Results for crude fiber

According to the crude fiber analysis (Fig 6), the amount of crude fiber in 7-9°brix TSS harvested mangoes increased from the fourth to the eighth to the twelfth day of storage in control mangoes and in mangoes treated with 150 ppm ethylene. In 9-11°brix TSS harvested mangoes, there was a significant ($p<0.05$) increase in fiber content from 4th day to 12th day of storage in control as well as 100 ppm and 150 ppm treated mangoes.

According to research by Brito and Narain (2002), Wurochekke *et al.* (2013) and Mahmood *et al.* (2013), the crude fiber content of cherry, sapota and pawpaw fruit reduced as the fruit ripened. However, the findings of our analysis are at odds with those of other studies because we discovered a consistent rise in the amount of crude fiber in manjeera mangoes.

Results for carbohydrate content

According to the data (Fig 7), the maximum carbohydrate content was discovered on the eighth day in mangoes harvested with TSS at 7-9°brix and on the fourth day in control and 100 ppm-treated mangoes harvested at 9-11°brix. In 9-11°brix TSS harvested mangoes, there was a significant ($p<0.05$) decrease in carbohydrate content from the fourth to the eighth day in all treatments. According to a study by Wurochekke *et al.* (2013), the amount of carbohydrates in the kapoho solo and solo dawn varieties of pawpaw increased during the ripe stage after first increasing during the semi-ripe stage. After fruit is harvested,

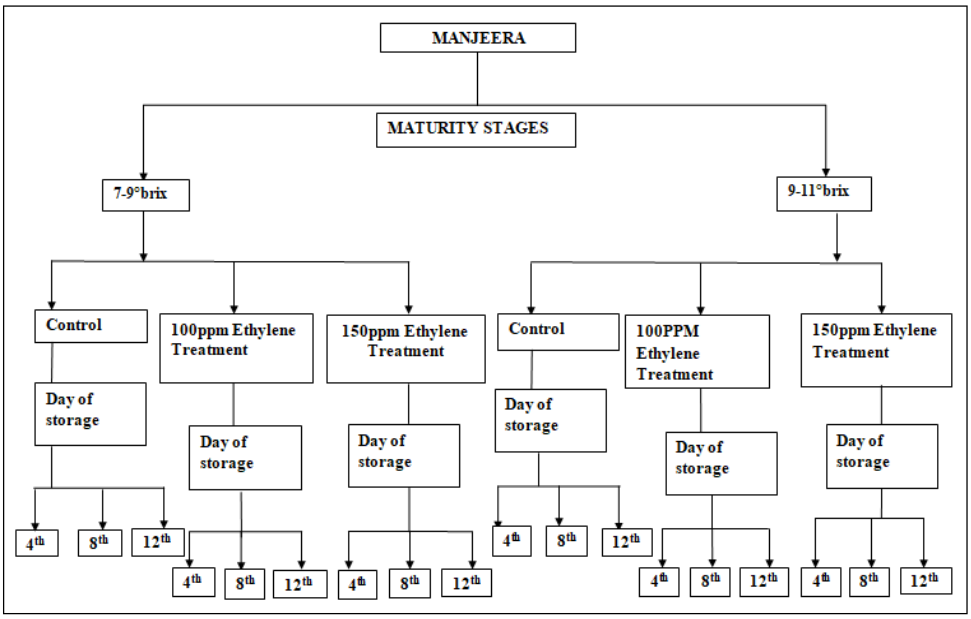

Fig 1: Flow chart depicting the treatment of mangoes for nutrient and β-carotene analysis during storage.

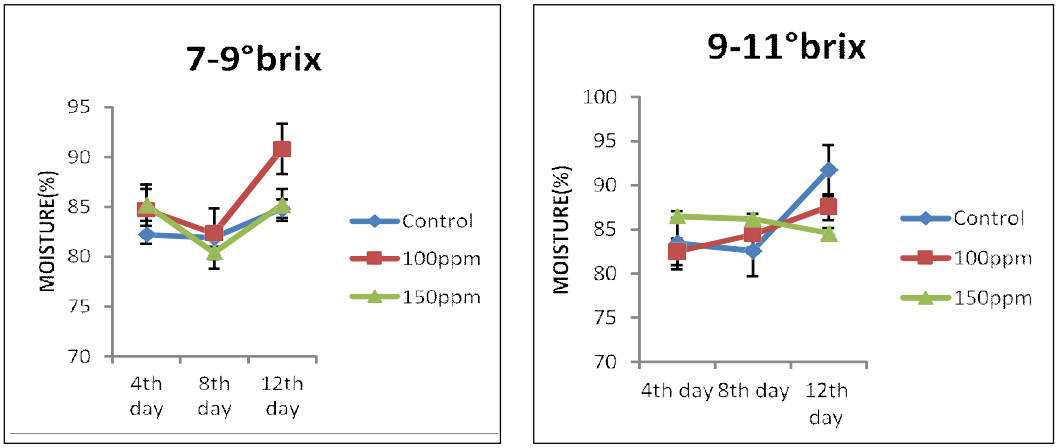

Fig 2: Moisture content (%) in all treatments of Mangoes var. *Manjeera* harvested at different maturity and ripening stages.

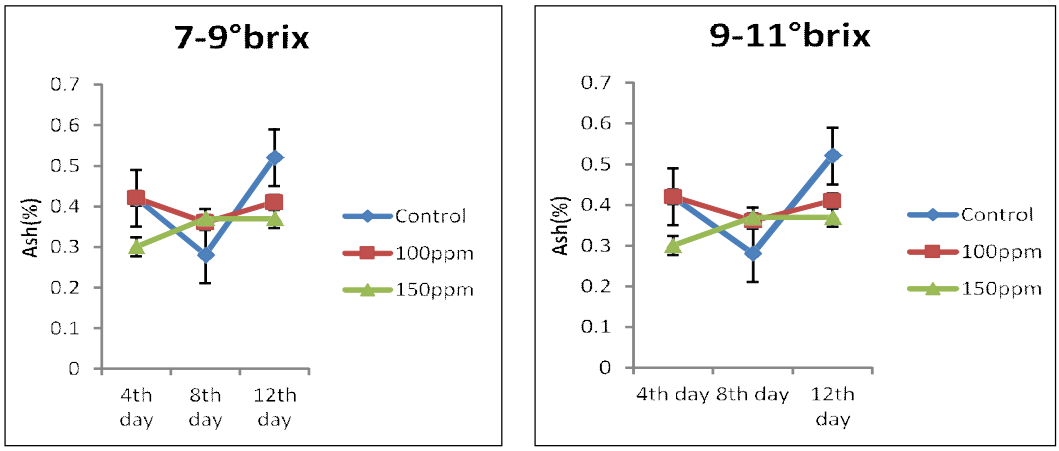

Fig 3: Ash content (%) in all treatments of mangoes var. *Manjeera* harvested at different maturity and ripening stages.

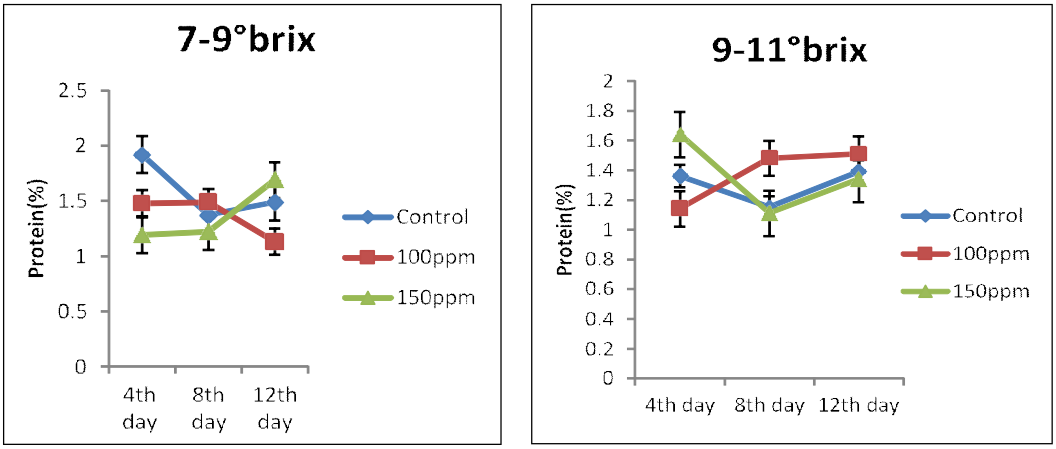

Fig 4: Protein content (%)in all treatments of mangoes var. *Manjeera* harvested at different maturity and ripening stages.

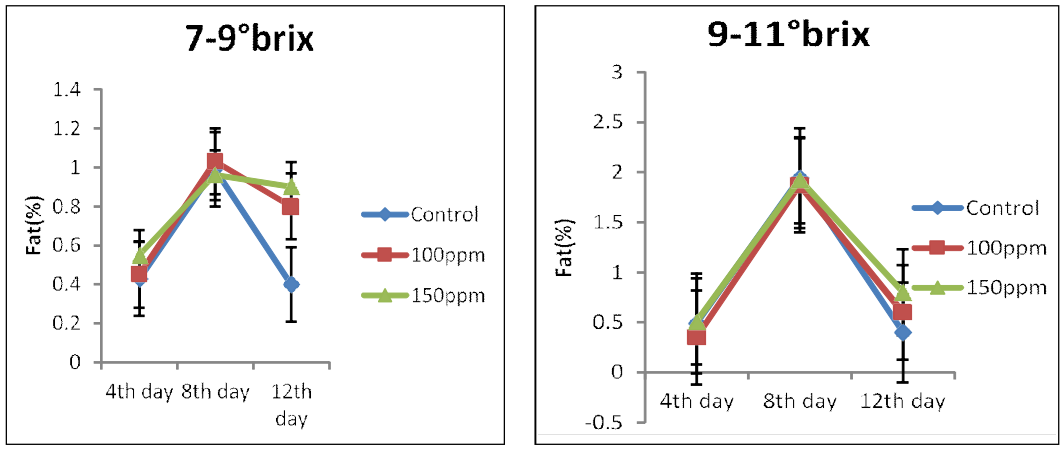

Fig 5: Crude fat content (%) in all treatments of mangoes var. *Manjeera* harvested at different maturity and ripening stages.

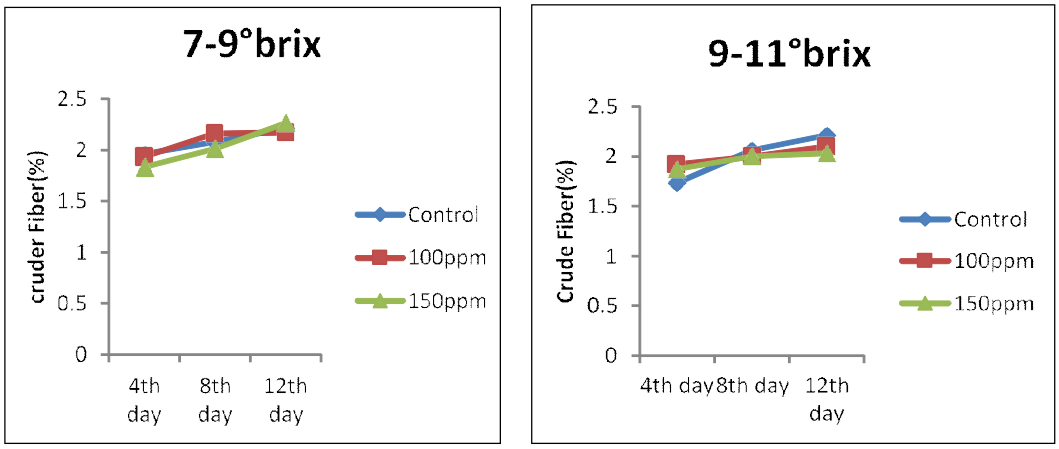

Fig 6: Crude fiber content on 4th day, 8th and 12th day in mangoes for all treatments at 7-9 and 9-11°brix TSS.

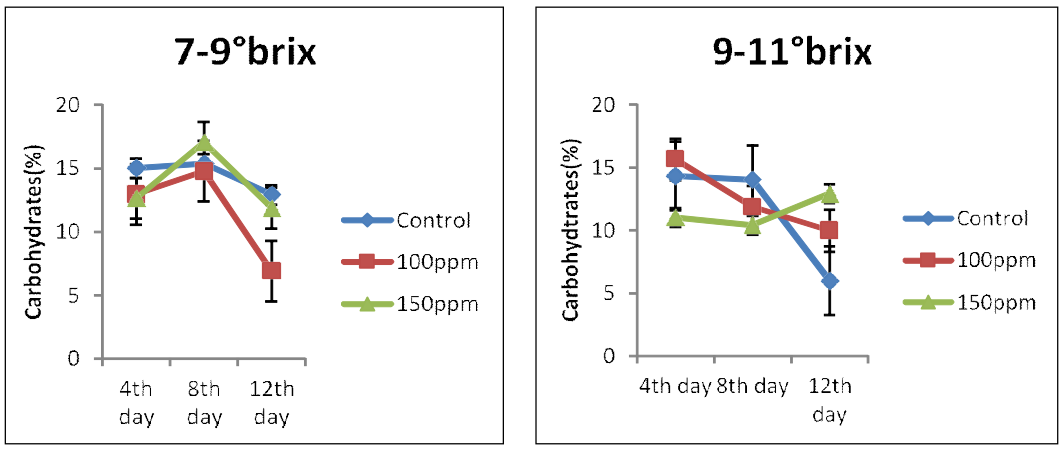

Fig. 7: Carbohydrate content (%) in all treatments of Mangoes var. *Manjeera* harvested at different maturity and ripening stages.

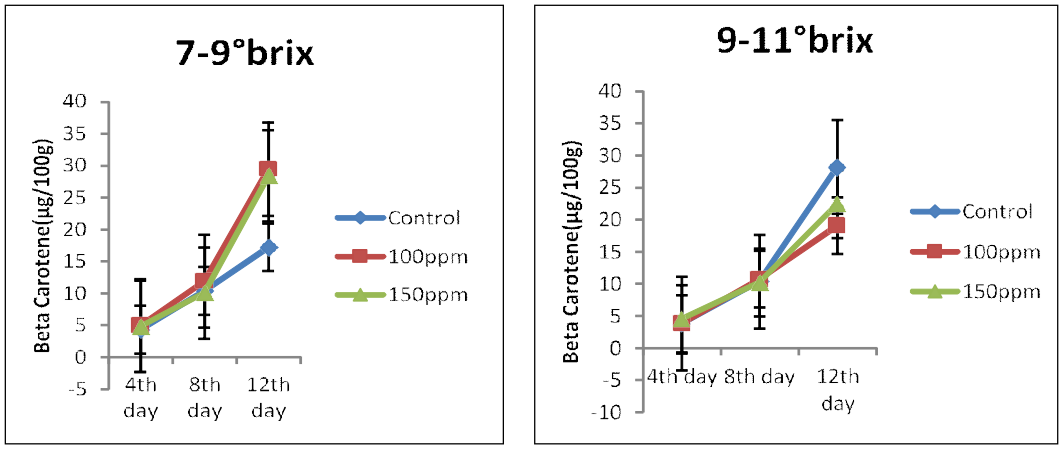

Fig 8: β-Carotene (µg/100 g) content in all treatments of mangoes var. *Manjeera* harvested at different maturity and ripening stages.

Table 2: Energy (Kcal) of Mango pulp (per100 g).

Treatment/ day of storage	Maturity stage					
	7-9°brix			9-11°brix		
	Control	100 ppm	150 ppm	Control	100 ppm	150 ppm
4th day	69.15±0.21^{h}	61.85±0.92^{e}	63.75±0.35^{f}	67.15±0.35^{g}	71.75±0.18^{i}	59.35±0.49^{d}
8th day	80.87±0.21^{k}	77.35±0.15^{j}	80.20±0.03^{k}	78.18±0.14^{j}	70.29±0.81^{h}	64.32±0.00^{f}
12th day	61.22±0.03^{e}	40.86±0.14^{b}	64.36±0.23^{f}	33.22±1.16^{a}	51.26±0.03^{c}	64.20±1.92^{f}

Note: All the values are expressed as mean±SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level.

cellulase and pectinmethylestrease activity gradually rises, reaching a peak at the edible stage.

Results for β-carotene content

According to the observations in Fig 8, the carotene content of the mangoes harvested at 7-9°brix and 9-11°brix increased significantly ($p<0.05$) from day 4 to day 12 in all treatment groups (Control, 100 ppm, 150 ppm). According to a study by Azad *et al.* (2009) on four mango varieties, mangoes' β-carotene content rises the longer they are stored. Studies by Abushita *et al.* (1997)., Nour *et al.* (2014) in mangoes and Hdider *et al.* (2013) in tomatoes reported an increase in β carotene concentration with increased ripening, which is in agreement with the current finding in mangoes.

As per the results obtained (Table 2) highest energy was found during the 8th day of ripening in all the treatments.

CONCLUSION

According to the findings of all the analyses, it can be said that the Manjeera variety of mango will have a greater nutrient composition when harvested at 7-9°brix TSS maturity stage as opposed to a harvest done at 9-11°brix TSS maturity stage. Even though ethylene-induced mango ripening sped up the ripening process, the mangoes nevertheless have significantly less nutritional value than mangoes that ripen naturally without any ethylene treatment. The finding of the study revealed that the ripening treatments have a direct correlation with the nutritional status of the fruits thus harvested, ripened for the sole purpose of the consumer distribution along with the stage of the maturity at which the fruits is harvested for the indented use.

Conflict of Interest

The authors declare that they have no conflict of interest.

REFERENCES

Abushita, A.A. Hebshi, E.A. Daood, H.G. Biacs, P.A. (1997). Determination of vitamin and antioxidant in tomatoes. Food and Chemistry. 48: 2075-2081.

Adeyemi, O.S. and Oladiji, A.T. (2009). Compositional changes in banana (*Musa* sp) fruits during ripening. African Journal of Biotechnology. 8(5): 858-859.

AOAC. (2005). Official method 992.23 Crude Protein in Cereal Grains and Oilseeds. Association of Official Analytical Chemists International. Ch. 32. pp. 28.

AOAC. (2006). Official Method 922.06 18th ed. Crude fat. In: Association of Official Analytical Chemists International Gaithersburg, [Horwitz, W. (ed.)]. MD.

AOAC. (2007). Official method 962.09 Fibre (Crude) in Animal Feed and Pet Food. In: Association of Official Analytical Chemists 18th ed. [Horwitz, W. (ed.)]. International Gaithersburg, MD, Ch. 4. pp. 44.

Atwater, W.O. and Woods, C.D. (1896). The chemical composition of American food materials. US Official Experiment Stations, Washington, DC. Bulletin No. 28.

Azad, M. Ittafaqul. Mortuza, M. Golam. Al-Amin, M. Naher, M.N.A. Alam, S.M. Khorshed. (2009). Qualitative analysis of Mango (*Mangifera indica* L.) fruits at different maturity stages. The Agriculturists. 7(1): 1-5.

Bally, I.S.E. (2006). *Mangifera indica* (mango) (Ver. 3.1). In: Species Profiles for Pacific Islands Agroforestry. [Elevitch, C.R. (ed.)], Permanent Agriculture Resources (PAR), Holualoa, Hawaii, USA.

Brito, E.S.D. and Narain, N. (2002). Physical and chemical characteristics of sapota fruit at different stages of maturation. *Pesquisa Agropecuária* Brasileira. 37(4): 567-572.

Hdider, C. Ilahy, R. Tlili, I. Lenucci, M.S. Dalessandro, G. (2013). Effect of the stage of maturity on the antioxidant content and antioxidant activity of high pigment tomato cultivars grown in Italy. Food. 7(1): 1-7.

Hopping, B.N., Erber, E., Grandinetti, A., Verheus, M., Kolonel, L.N. and Maskarinec, G. (2010). Dietary fiber, magnesium and glycemic load alter risk of type 2 diabetes in a multiethnic cohort in Hawaii. The Journal of Nutrition. 140(1): 68-74.

Joseph, J.A. Shukit-Hale, B. Denisova, N.A. Bielinski, D. Martin, A. McEwen, J.J. Bickford, C. (1999). Reversal of age-related declines in neuronal signal transduction, cognitive and motor behavioral deficits with blueberry, spinach, or strawberry dietary supplementation. Journal of Neuroscience. 19: 8114-8812.

Mahmood, T. Anwar, F., Bhatti, I.A. Iqbal. T. (2013). Effect of maturity on proximate composition, phenolics and antioxidant attributes of cherry fruit. Pakistan Journal of Botany. 45(3): 909-914.

Opara, U.L. Al-Ani, M.R. Al-Rahbi, N.M. (2012). Effect of fruit ripening stage on physico-chemical properties, nutritional composition and antioxidant components of tomato (*Lycopersicum esculentum*) cultivars. Food and Bioprocess Technology. 5(8): 3236-3243.

Ravani, A. and Joshi, D.C. (2013). Mango and it's by product utilization-A review. Trends in Post-Harvest Technology. 1(1): 55-67.

Sharma, H.P. Patel, H. Sharma, S. Vaishali. (2014). Study of physico -chemical changes during wood apple (*Feronia Limonia*) maturation. Journal of Food Research and Technology. 2(4): 148-152.

Slavin, J. (2013). Fiber and Prebiotics: Mechanisms and health benefits. Nutrients. 5: 1417-1435.

Slavin, J.L. (2008). Position of the american dietetic association: health implications of dietary fiber. Journal of the American Dietetic Association. 108: 1716-1731.

Tharanathan, R.N., Yashoda, H.M Prabha, T.N. (2006). Mango (*Mangifera indica* L.) the king of fruits-A review. Food Reviews International. 22: 95-123.

Tosun, I., Ustun, N.S., and Tekguler, B. (2008). Physical and chemical changes during ripening of blackberry fruits. Scientia Agricola. 65: 87-90.

Nour, V., Ion, T. Mira, E. Ionica. (2014). Evolution of antioxidant activity and bioactive compounds in tomato (*Lycopersicon esculentum* Mill.) fruits during growth and ripening, Journal of Applied Botany and Food Quality. 87: 97-103

World Health Organization. (2003). Diet, nutrition and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation (Vol. 916). World Health Organization.

Wurochekke, A.U. Eze, H.T. Declan, B. (2013). Comparative study on the nutritional content of carica papaya at different ripening stages. International Journal of Pure and Applied Sciences and Technology. 14(2): 80-83.

Ye, Z. and Song, H. (2008). Antioxidant vitamins intake and the risk of coronary heart disease: meta-analysis of cohort studies. European Journal of Cardiovascular Prevention and Rehabilitation. 15(1): 26-34.

Yong, L.C., Brown, C.C., Schatzkin, A., Dresser, C.M., Slesinski, M.J., Cox, C.S., and Taylor, P. R. (1997). Intake of vitamins E, C and A and risk of lung cancer the NHANES I epidemiologic followup study. American Journal of Epidemiology. 146(3): 231-243.