Physico chemical characterization and the effect of processing on the quality characteristics of Sindura, Mallika and Totapuri mango cultivars

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Abstract Mango (*Magnifera indica L*) is grown in the tropical and sub tropical regions of India. The fruit has a high commercial value depending on the color, flavor and pulp characteristics of the cultivar. Sindura, Mallika and Totapuri cultivars grown in southern Karnataka were investigated for the physical chemical characteristics and the effect of processing on the quality characteristics. Sindura, Mallika and Totapuri mango cultivars had significantly different physico chemical and compositional characteristics. Sindura cultivar had a characteristic red color in the peel with high carotenoid content and slightly lower pulp content. Mallika contained higher pulp content with a pale yellow color in the peel and higher total soluble solids. Totapuri contained slightly lower pulp content than Mallika, lower total soluble solids and lower carotenoids among the cultivars. Sindura and Mallika pulps had significantly higher viscosity than Totapuri. Processing of the pulps resulted in significant decrease of carotenoids irrespective of the cultivar. Sensory quality of canned mango slices showed higher acceptability for Mallika followed by Sindura and Totapuri. Mango nectar prepared from Sindura was highly acceptable followed by Totapuri and Mallika. Processing of these underutilized mango cultivars into puree, nectar, juice beverages and slices, can result in value addition and popularization.

Keywords Mango · Mango pulp · Mango cultivars · Physical characteristics · Composition · Canning · Processing

Introduction

Mango (*Magnifera indica L*) is one of the most important tropical and subtropical fruit of the world and is popular both

in the fresh and the processed form. It is commercially grown in more than 80 countries. India occupies 52 % of the world's production of mango which is nearly 12.75 million tonnes (NHB 2009). The other leading mango producing countries of the world are China, Mexico, Pakistan, Indonesia, Thailand, Nigeria, Brazil, Philippines and Haiti. Less than 10 % of total world production of mango is exported. The demand for mango in the world market is increasing in temperate countries because of social changes, promotion of fruit trade in developing countries and accessibility to international air cargo space. The expansion of mango trade has been possible because of successful post harvest management strategies to control diseases and insects. The products prepared both from ripe and green mangoes are highly popular in India and abroad. India dominated the world trade of processed mango products, even though hardly 1 % of the total mango production in India is processed. Export of processed mango products is continuously increasing. The major mango processed product exported is canned mango pulp, which has increased over the past decade by about three times in volume and five times in value. Ripe mangoes are processed into various products like slices, pulp, jam, squash, nectar, juice, RTS beverages, mango leather etc. Mango pulp or puree is prepared by homogenising peeled ripe mangoes and processed in tin cans for long term storage and marketing. Mangoes of different cultivars from Madhya pradesh were evaluated for composition and yield characteristics. Dashehari and Langra were found to have high total soluble solids and total sugars among the different cultivars studied (Rajendra kumar et al. 2001). Mango cultivars viz., Alphonso, Banganapalli, Dashehari, Janardhan pasand, Kesar, Langra, Mulgoa, Padiri, Panakalu, Suvmarekha and Totapuri were evaluated for canned mango juice manufacture (Doreyappa Gowda and Ramanjaneya 1995). Different mango cultivars grown in Uttar pradesh, India were assessed for the physico-chemical composition and suitability for canned mango slices. Mango cultivar Nisar pasand showed highest total soluble solids (21.7°brix) and cultivar Safeda Maliabad was

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found to be most suitable for canned slices (Awasthi and Pandey 1980). Mango pulp concentrated in hot air cabinet dryer at 70 °C from 16°brix to 28°brix resulted in maximum retention of beta-carotene (Alaguselvi et al. 2009). Thermal processing of mango reportedly affected the beta-carotene stability, inactivation of peroxidase and polyphenol oxidase. Pasteurization of mango puree between 85 and 93 °C and holding for 16 min resulted in vitamin A loss of 15.4 %. Polyphenol oxidase was inactivated after 1 min, whereas residual peroxidase activities of 4.0–6.3 % were detected at all pasteurization temperatures even after 16 min (Vasquez Caicedo et al. 2007).

Studies on suitability for processing viz., colour, fragrance, sugar to acid ratio and storage life of mango varieties grown in China revealed that six varieties of mango were found to be suitable for processing to mango pulp and concentrate of mango juice (Yan Dong Mei et al. 2006). ‘Sindura’ and ‘Mallika’ are mango cultivars grown in significant quantities in southern regions of Karnataka, India. Most of these fruits are used for table purpose and are not commercially processed. It would be interesting for the technologists, processors and researchers to assess the quality characteristics and changes during processing of Sindura and Mallika mangoes in comparison to Totapuri mango which is the main processing variety. Therefore, it is necessary to establish the physico-chemical characteristics and the suitability of these cultivars for processing into canned products. The compositional characteristics and the effect of processing of these mango cultivars on the physico chemical and sensory properties of the canned mango products were reported in the present study.

Materials and methods

Mango fruits of Sindura, Mallika and Totapuri cultivars were procured from an orchard near Bangalore, India. The fruits were sorted, washed and ripened by dipping in 1,000 ppm ethrel solution for 5 min and stored at room temperature for 5 days. The ripened fruits were washed, sliced and passed through pulp extractor fitted with a stainless sieve having a pore diameter of 0.4 mm diameter, to extract pulp.

Canning of mango pulp

Mango pulp was analysed for total soluble solids, pH and acidity. The pulp was blended with 10 % water for improving the flow characteristics and facilitating heat transfer during canning process. pH of the mango pulp was adjusted to 4 by the addition of 10 % citric acid solution (w/v). Pulp was heated to 85 °C in a stainless steel steam jacketed kettle and filled hot into sterilised A 2 1/2 open top sanitary (OTS) tin containers with a net weight of 850 g. The cans were sealed and processed in boiling water bath for 20 min and cooled in

running tap water. Cooled cans were wiped, labelled and stored at room temperature.

Canning of mango slices

Mango fruits were peeled and sliced vertically using stainless steel knives. Slices were filled into the sterilised plain tin cans of 850 g net weight capacity. Sugar syrup of 40°brix was boiled, filtered and added to the cans. The cans were exhausted in an exhaust box to a temperature of 80 °C, sealed and processed as described earlier.

Canning of mango nectar

Mango nectar was formulated to contain mango pulp 20 %, 15°Brix and 0.3 % acidity by adding required quantity of sugar, citric acid and water to the pulp. The blended nectar was homogenized, heated to 90 °C, hot filled into sterilised cans, sealed and processed as described earlier.

Physical characteristics

Fruit weight, length, diameter, pulp, peel, seed content and visual colour of randomly selected 10 fruits were recorded. Hunter color values were measured using Shimadzu Color Measuring system (Model No. UV—2100, Japan). Total soluble solids (TSS) of the pulp were determined using ATAGO digital refractometer (Model No. RX 5000, ATAGO, Japan). pH was measured using digital pH meter (Model No. APX 175, Control Dynamics Ltd. Bangalore, India). Titrable acidity was determined by titrating 5 g of sample against 0.1 N NaOH with 2–3 drops of phenolphthalein indicator to pink color and expressed as citric acid. Reducing and total sugars were determined by Inversion method. Ascorbic acid was determined by 2, 6-Dichlorophenol indophenol titration method, based on the reduction of ascorbic acid by the dye in the pH range of 1–3.5. (AOAC 2000). All the chemical analysis was carried in triplicate.

Texture of the sample was analysed using Universal Texture Measuring instrument (M/s. Lloyd's texture measuring systems Inc, USA). The texture was measured for both shear and penetration. The load cell of 1 KN at a cross head speed of 50 mm/min was used. Viscosity of the samples were determined by using a viscometer, Model No. RIM.3 (M/s Rheology International Shannon Ltd, Ireland). Viscosity was measured by using spindle No.4 and speed 30 rpm. Canned mango slices were pulped in a blender and the viscosity of the pulp was measured. Viscosity was expressed as ‘m.Pa.S’.

Sensory analysis

The products were evaluated by a trained panel consisting of the staff and students of the department. The samples were

assessed for color, flavor, texture and overall quality by a 10 member trained panel, on a 10 point scale, where 1–2=poor, 3–4=fair, 5–6=good, 7–8=very good, and 9–10=excellent. Samples receiving an overall quality score of 7 or above were considered acceptable.

Statistical analysis

Chemical composition and sensory data were subjected to analysis of variance and the means separation by Least significant difference (LSD) at p 0.05 (Askar and Treptow 1993).

Results and discussion

Physical characteristics

Physical characteristics of mangoes from Sindura, Mallika and Totapuri are presented in Table 1. A random sample of 10 fruits of mango were examined for fruit shape, colour, average diameter, average weight. Mean weight of Sindura, Mallika and Totapuri fruits were 237.15 g, 429.84 g and 396.1 g respectively. Mallika and Totapuri mangoes had significantly higher weight as compared to Sindura. Physical parameters viz., diameter, length and shape index were also significantly higher for Mallika and Totapuri cultivars. However peel content and seed content were higher in Sindura. Maximum pulp content was observed in Mallika (75.3 %) followed by Totapuri (70.8 %) and Sindura (62.5 %). Doreyappa and Huddar (2004) reported that the fruit weight of Totapuri mango was 324.7 ± 2.38 g and pulp recovery was 73.3 ± 1.17 %. Texture of the ripened fruit plays an important role in handling and other unit operations during processing. Totapuri mango cultivar showed

higher firmness as compared to the Mallika and Sindura. Higher firmness facilitated cutting of slices during processing.

Totapuri was yellowish red in color with higher lightness, yellowness and lower redness values. Sindura exhibited higher redness, lower yellowness and lightness. Redness was more predominant in Sindura, which appears to be the characteristic of the cultivar. Mallika had more yellowness as compared to the red color component indicating the pale yellow color.

Compositional characteristics

Mallika and Sindura contained higher total soluble solids as compared to Totapuri which is responsible for more sweetness in those cultivars. Mallika cultivar had higher total soluble solids, reducing sugar and total sugar content (Table 2). Total soluble solids was positive correlated with reducing sugars and total sugars. Rajendra kumar et al (2001) reported that Dashehari, a mango cultivar grown in northern India possessed high total soluble solids of 25.75 % with a total sugar content of 21.2 %. Carotenoid content was highest in Sindura followed by Mallika and Totapuri. Higher carotenoid content appeared to be the characteristic of Sindura mango cultivar.

Yield and physico chemical properties of pulp of ten mango cultivars of European for use in manufacture of fruit nectars and purees were reported by Pinera et al. (1995). Yield of pulp ranged from 42.6 to 72.3, soluble solids from 12.3 to 15.3, pH from 3.8 to 4.0, and acidity from 0.28 to 0.70. Pulp from La Paz, San Felipe, Santa Cruz and Senora cultivars were found suitable for use in mango nectar and puree manufacture. These cultivars had significantly lower soluble solids as compared to the Indian cultivars, which could be due to the cultivar and agroclimatic differences.

Sindura mango pulp had the highest redness value followed by Mallika and Totapuri. The higher redness value of Sindura mango pulp corroborates with high carotenoid content. Mallika and Sindura contained more yellowness as compared to Totapuri. Sindura mango pulp had the highest viscosity followed by Mallika and Totapuri (Table 2). Doreyappa and Huddar (2004) also reported that among the mango cultivars used for processing, Totapuri mango had the lowest carotenoid content.

Canned mango pulp from different cultivars

Physico chemical characteristics of canned mango pulp is shown in Table 2. TSS of Mallika was found to be significantly higher than the other two cultivars. No significant differences were observed in pH and acidity of different cultivars. Reducing sugars and total sugars were slightly higher in Mallika canned mango pulp followed by Totapuri and Sindura. Carotenoids decreased in canned pulp which may be attributed to the thermal processing during canning. Carotenoid content was highest for Sindura and lowest for

Table 1 Physical characteristics of Sindura, Mallika and Totapuri mango cultivars

Parameter	Sindura	Mallika	Totapuri
Weight (g)	237.2 $\pm$ 64.20	429.8 $\pm$ 84.94	396.1 $\pm$ 78.88
Diameter (cm)	7.5 $\pm$ 0.95	8.0 $\pm$ 0.55	8.5 $\pm$ 0.58
Length (cm)	8.8 $\pm$ 1.14	14.1 $\pm$ 1.01	14.3 $\pm$ 0.71
Shape Index	1.2 $\pm$ 0.07	1.7 $\pm$ 0.10	1.7 $\pm$ 0.10
Specific gravity	1.02 $\pm$ 0.00	1.03 $\pm$ 0.01	1.05 $\pm$ 0.04
Peel content (%)	19.6 $\pm$ 1.22	14.8 $\pm$ 1.33	15.5 $\pm$ 0.75
Seed content (%)	17.9 $\pm$ 1.22	10.7 $\pm$ 0.77	13.7 $\pm$ 2.35
Pulp content (%)	62.5 $\pm$ 1.74	75.3 $\pm$ 2.03	70.8 $\pm$ 2.93
Texture (N)	11.2 $\pm$ 3.34	11.6 $\pm$ 1.40	20.6 $\pm$ 1.88
L	35.51 $\pm$ 5.00	55.16 $\pm$ 2.87	62.60 $\pm$ 2.23
a	29.11 $\pm$ 1.10	7.73 $\pm$ 4.60	14.26 $\pm$ 1.07
b	16.18 $\pm$ 0.64	29.47 $\pm$ 2.28	35.98 $\pm$ 0.57

Mean $\pm$ SD (n =10)

Table 2 Physical and chemical characteristics of mango pulp from different cultivars before and after canning

Parameter	Mango pulp before canning			Mango pulp after canning		
	Sindura	Mallika	Totapuri	Sindura	Mallika	Totapuri
TSS (°Brix)	19.5 ^d	21.8 ^e	15.3 ^b	17.2 ^c	19.6 ^d	14.4 ^a
pH	4.2 ^f	4.0 ^e	3.9 ^b	3.8 ^d	3.7 ^a	3.8 ^c
Titration acidity (%)	0.27 ^a	0.48 ^e	0.38 ^b	0.42 ^c	0.47 ^e	0.41 ^c
Reducing sugars (%)	2.7 ^b	3.5 ^e	2.9 ^c	2.3 ^a	3.5 ^e	3.0 ^d
Total sugars (%)	14.5 ^d	16.8 ^f	10.5 ^b	13.1 ^c	15.1 ^e	9.7 ^a
Total carotenoids (µg/100 g)	7154.1 ^c	4801.7 ^d	1894.8 ^a	3279.9 ^c	2413 ^b	1794.3 ^a
Viscosity (mPa.S)	6714 ^f	6384 ^e	5704 ^d	5301 ^b	5341 ^c	2930 ^a
L	43.65 ^b	48.35 ^d	42.67 ^a	47.83 ^c	49.62 ^f	48.73 ^e
a	9.53 ^f	9.34 ^e	5.23 ^c	2.42 ^b	6.13 ^d	2.01 ^a
b	28.08 ^b	30.34 ^e	25.65 ^a	29.24 ^c	30.44 ^f	29.88 ^d

Mean ± SD ($n=3$); L Lightness, a(+) redness, b(+) yellowness

Means in the rows with the same superscript are not significantly different by LSD at p (0.05)

Totapuri. Canned pulp had lower viscosity as compared to fresh pulp. Lower viscosity could be due to the addition of water to improve the flow characteristics of pulp for canning. Redness of canned pulp decreased irrespective of the cultivar. Loss of carotenoids to some extent and browning reactions during thermal processing could be responsible for the decrease in red color component. Barrett (2008) reported that the effects of processing on maximum nutritional values of fruits with regard to studies on nutrient concentration in fresh and canned fruits.

Changes in canned mango pulp during storage

No significant changes in TSS, pH, titration acidity were observed during storage of 2 months at room temperature. Carotenoid content decreased slightly during storage. Lightness increased in the pulp from all the cultivars, redness and yellowness decreased slightly. Viscosity of the pulp increased slightly during storage.

Canned mango slices from different cultivars

Physico chemical analysis of the canned mango slices is shown in Table 3. TSS and total carotenoids were higher for Sindura canned mango slices. Titration acidity of the totapuri slices were slightly higher than Mallika and Sindura, however no significant differences were observed in pH. Viscosity and colour values were higher in Sindura followed by Mallika and Totapuri. Mallika slices were highly acceptable with respect to sensory quality followed by Sindura and Totapuri (Fig. 1a). Totapuri mango slice had mashy texture after canning. Khurdiya and Roy (1986) also reported that flavour rating of the cultivar Mallika was also found to be the best compared to other cultivars.

Changes in canned mango slices during storage

Canned mango slices were analysed every month for the physico chemical parameters (Fig. 2). There was not much variation in TSS of slices of three cultivars during storage. Slight increase in pH and acidity of the mango slices was observed during storage. Reducing sugars and total sugars increased irrespective of the cultivar during storage. Doreyappa and Huddar (2004) also reported increase in the reducing and total sugars of canned mango slices during storage. Similar increase in reducing sugars and total sugars of processed mango products during storage has been reported by Palaniswamy et al (1974) and Doreyappa Gowda et al (1994). Kalra and Tandon (1985) found that reducing sugars increased four times during storage. Among the different cultivars, highest reducing sugar was observed in Totapuri. Total sugars were found to be higher in Sindura followed by Totapuri and Mallika. Sensory analysis showed that canned slices from Mallika were highly acceptable followed by Totapuri and Sindura.

Sindura and Mallika had significantly higher carotenoids while lowest was found in Totapuri which was attributed to genetic nature of these cultivars. Loss in carotenoids was observed in all cultivars during storage. Loss in carotenoids in mango pulp during storage was also observed by Doreyappa and Huddar (2004). Viscosity of pulp made from canned slices was higher for Mallika cultivar followed by Sindura and Totapuri. Viscosity of canned slices increased slightly during storage, which could be due to the absorption of soluble solids from syrup. According to Doreyappa and Huddar (2004) canned slices of Totapuri had greater viscosity than Mallika.

Hunter colour values redness, yellowness and lightness were highest for Sindura cultivar and the lowest for Totapuri. The redness and yellowness decreased during storage of canned slices.

Table 3 Physical and chemical characteristics of canned mango slices and canned mango nectar from different cultivars

Parameter	Canned mango slices			Canned mango nectar		
	Sindura	Mallika	Totapuri	Sindura	Mallika	Totapuri
TSS (°B)	32.6 ^d	31 ^c	27.4 ^b	15.6 ^a	15.6 ^a	16 ^a
pH	3.7 ^c	3.7 ^c	3.7 ^c	3.4 ^a	3.5 ^b	3.5 ^b
Titration acidity (%)	0.31 ^b	0.31 ^b	0.42 ^c	0.28 ^{ab}	0.30 ^{ab}	0.27 ^a
Reducing sugars (%)	11.1 ^c	12.3 ^f	8.5 ^d	4.3 ^b	4.5 ^c	3.5 ^a
Total sugars (%)	22.0 ^f	21.2 ^d	21.4 ^e	13.3 ^b	13.5 ^c	12.0 ^a
Total carotenoids (µg/100 g)	4873.0 ^e	3591.9 ^d	1855.3 ^c	1079.7 ^b	854.5 ^b	319.4 ^a
Viscosity (mPa.S)	8600 ^f	7357 ^e	5406 ^d	530 ^c	390 ^b	163 ^a
L	47.61 ^e	46.69 ^d	55.27 ^f	36.75 ^b	40.55 ^c	34.21 ^a
a	9.34 ^f	7.47 ^e	2.12 ^c	−1.85 ^b	−1.00 ^a	−4.08 ^d
b	31.7 ^f	30.27 ^e	29.86 ^d	21.79 ^b	22.79 ^c	17.52 ^a

L Lightness, a(+) redness, b(+) yellowness, Mean ± SD (n=3)

Means in the rows with the same superscript are not significantly different by LSD at *p* (0.05)

Canned mango nectar from different cultivars

Canned mango nectar analysis from different cultivars showed no significant differences in TSS, pH and titration acidity (Table 3). Reducing sugar and total sugar contents were slightly

lower in the nectar prepared from Totapuri cultivar. Carotenoids profile was similar as that of the mango pulp, with Sindura having the highest carotenoid composition and Totapuri the least. Viscosity was highest for mango nectar from Sindura cultivar followed by Mallika and Totapuri. Totapuri nectar had

Fig. 1 Sensory characteristics of (a) canned mango slices and canned mango nectar (b) from different varieties (n=3)

Fig. 2 Changes in physico-chemical parameters in canned mango slices from different varieties ($n=3$)

more greenness followed by Sindura and Mallika. Yellowness and lightness were higher for Mallika followed by Sindura and Totapuri nectars. Overall acceptability of canned nectars showed that, Sindura was suitable for the preparation of canned nectars, followed by Totapuri and Mallika (Fig. 1b). Doreyappa Gowda and Ramanjaneya (1995) reported that Alphonso to be the best cultivar for canned juice preparation due to its very good colour, consistency and flavour to that from Totapuri.

Changes in canned mango nectar during storage

Canned mango nectars showed slight increase in TSS for all the three cultivars during storage. There was not much variation in acidity and pH during storage of mango nectars from different cultivars. Reducing sugar and the total sugar

contents increased in all the cultivars during storage (Fig. 3). Carotenoid profile showed similar pattern as that of canned slices. Carotenoid content decreased during storage and Sindura cultivar had the highest carotenoid content. Viscosity of nectar from all the cultivars increased slightly during storage, which could be due to the polymerization of pectic substances. Reduction in greenness and yellowness was observed in nectar from all the three cultivars. Flavour of the nectars was not affected significantly during the storage of nectars. Gofur et al (1994) reported no significant changes in colour, acidity, pH, total soluble solids, ash, fibre and sugar in the mango nectar during storage for 360 days; thereafter deterioration in colour and taste was observed. Nutrient changes due to processing and storage of fresh and canned fruits focuses on effects of canning and storage on contents of vitamin A, carotenoids, vitamin E, minerals (Na, Ca and K) and fibre were also reported by Rickmann et al. (2007). In the present study the variation in composition of mango pulp from different cultivars significantly affected the quality characteristics of the canned products.

Fig. 3 Changes in viscosity of canned nectar from different varieties during storage ($n=3$)

Conclusion

Sindura, Mallika and Totapuri mango cultivars had significantly different physico chemical and compositional characteristics. Sindura cultivar had a characteristic red color in the peel with high carotenoid content and slightly lower pulp content. Mallika contained higher pulp content with a pale yellow color in the peel and higher total soluble solids. Totapuri contained slightly lower pulp content than Mallika, lower total soluble solids and lower carotenoids among the cultivars. Sindura and Mallika pulps had significantly higher viscosity than Totapuri. Processing of the pulps resulted in significant decrease of carotenoids irrespective of the cultivar. Sensory quality of canned mango slices showed higher acceptability for Mallika followed by Sindura and Totapuri. Mango nectar prepared from Sindura was highly acceptable followed by Totapuri and Mallika. Sindura and Mallika can be used for processing into nectar, juice beverages and slices, which will result in value addition to these underutilized mango cultivars.

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