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Full Length Research Paper

Influence of storage temperatures on physicochemical sensory and nutritional properties of chemically preserved mango pulp

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Storage stability of mango pulp (Mp) was determined at room (r) 25 to 35°C and refrigerated (ref) 4°C with the addition of potassium sorbate (PS), sodium benzoate (SB) and potassium metabisulphite (PMS). The statistical analysis viz factorial analysis and least significant square design (LSD) verified the temperatures effect on different treatments: T0 (Mp), T1 (Mp + PS 0.1%), T2 (Mp + SB 0.1%), T3 (Mp + PMS 0.1%), T4 (Mp + PS 0.05% + SB 0.05%), T5 (Mp + PS 0.05% + PMS 0.05%), T6 (Mp + SB 0.0.5% + PMS 0.05%) and T7 (Mp + PS + SB + PMS 0.03%), respectively. Refrigerated treatment T5ref showed stability for physicochemical analysis and sensory attributes in comparison to other treatments stored at room and refrigerated temperatures during 90 days of storage. Treatments means confirmed mango pulp preserved with addition of PS in combination with PMS in T5 was found best according to physicochemical and sensory attributes. Treatments T5, T6 and T7 retained high amount of iron (0.50, 0.49 and 0.55 mg/100 g), calcium (3.24, 3.15 and 3.13 mg/100 g) and ß- carotene (59.30, 58.46 and 58.25).

Key words: Mango pulp, chemical preservatives, storage conditions.

INTRODUCTION

Mango (*Mangifera indica* L.) is an emerging tropical export crop produced in about 90 countries in the world with a production of over 25.1 million tones. The mango is indigenous to the Indian subcontinent and Southeast Asia (mango - botany-taxonomy, 2008). Asia is the main producer with 76.9% of the total world production. Pakistan is the 5th largest mango producer with production of 938000 tones per year contribution with a share of 7.6% in the world market (Sauco, 2002). Mango is a short seasoned fruit and highly perishable even in cold storage. Therefore, most of the fruit processing industry in Pakistan preserves mango pulp by adding chemical preservatives for the manufacture of mango products around the year. Chemical preservatives are used to prevent the food spoilage due to microbial attack and thus are effectively used in combinations for better preservation. No single preservative is completely effective against all microorganisms (Chipley, 1983). Salts of sulphurous acid including, potassium sulphite, bisulphite and meta sulphite are used in processed foods as an inhibitor of enzymatic and non-enzymatic browning reactions, antimicrobial agents, antioxidants and as a bleaching agent (Kim, 1995). The maximum levels for the use of these chemicals in fruit preparations, including pulp, purees and fruit as according to Codex Standards adopted in 2001 and 2006, respectively are 1000 mg/kg sodium benzoate as benzoic acid and 500 mg/kg potassium-metabisulphite as residual sulphur-dioxide (Codex Standard, 1995). Indiscriminate and non judicious use of these preservatives is a risk to the health and well being of the consumers and is considered main cause of resistant microorganisms, responsible for food borne diseases (Gibbons, 1992; Kaur and Arora, 1999; Akinpelu, 2001). The acceptable daily intake (ADI)

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Table 1. Mango Pulp storage studies at room and refrigerated conditions.

Treatment	PS%	SB%	KMS%
T0	Fresh mango pulp		
T1	0.1	-	-
T2	-	0.1	-
T3	-	-	0.1
T4	0.05	0.05	-
T5	0.05	-	0.05
T6	-	0.05	0.05
T7	0.033	0.033	0.033

values, determined by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), is 25 mg/kg of body mass for sorbic acid and for SO_2 (ADI), ranged from 0.3 to 1.2% in all age groups (Santini et al., 2009; Suh et al., 2007). There is the need for complete investigation into setting optimum dose levels of the food preservatives in Pakistan and developing countries. This study aims to accomplish this task with respect to mango pulp.

The present research work was carried out to study the inhibitory effect of potassium-metabisulphite, sodium benzoate and potassium sorbate individually and in combination at room and refrigerated conditions (4°C). This research also projected the use of preservatives in safe level of 0.1% in mango pulp. The study further explored the effect of incorporating these preservatives in the mango pulp on physicochemical characteristics and its sensory attributes.

MATERIALS AND METHODS

Procurement of material

This research work was carried out in the post graduate laboratories of Department of Food Science and Technology in Agricultural University, Peshawar. Sweet (Chaunsa) mango verity was purchased from local market. Mangoes were thoroughly washed to remove adherent material. PS, SB and PMS were purchased from local chemicals suppliers.

Pulp extraction, packaging, sampling and storage

Mangoes were thoroughly washed to remove adherent material. Mango pulp was extracted by pulping machine in processing hall.

Work plan

In this experiment, two groups of samples with same treatments were prepared by adding chemical preservatives in mango pulp as mentioned in Table 1. Samples were placed in clean sterilized transparent plastic jars with sealed capping. The samples were stored at room (25 to 35°C) and at refrigerated (4°C) temperatures for physicochemical and sensory analysis during 3 months of storage intervals. Total numbers of 15 × 6 samples in (90 jars) were prepared. One half of the prepared samples (45 jars) were stored at room temperature (25 to 35°C) in the dark. The other half of (45 jars) were stored at refrigerator (1 ± 4°C). All the samples were analyzed for their physiochemical and sensory attributes during 3 months of storage at an interval of 15 days.

Physicochemical and sensory analysis of mango pulp

Titratable acidity, ascorbic acid and total soluble solids were determined by titration method as mentioned in AOAC (2000). While, pH of the samples was verified using Inolab Digital pH meter according to the manual instruction of apparatus. Reducing and non reducing sugar was determined by Lane Eyon method (AOAC, 2000). All the samples were evaluated organoleptically for color, texture and flavour by using 9 points hedonic scale (Larmond, 1997).

Iron and calcium determination

Total iron and calcium was determined by wet digestion method of Khattak (1990) by using atomic absorption spectrophotometer (Perkin Elmer Model 2380, USA).

ß-Carotene determination

ß-Carotene was determined with some modifications using cold acetone for extraction of carotenoids by the method of (Ribeiro *et al*., 2007). High performance liquid chromatography (HPLC) analysis system consisted of Perkin Elmer Isochratic LC Pump 250, UV/VIS Spectrophotometric Detector LC 290, along with reverse phase C 18 column. Wave length detection was carried out at 450 nm and mobile phase containing acetonitrile, methanol and dichloromethane (70:20:10) at a flow rate of 2.0 ml/min was used. Quantification was carried out by external standardization, using β-carotene to prepare the standard curve and the peak area for calculation.

Statistical analysis

All the results were compiled by using Statistical software Statistix® 1.8. The effects of different variables (temperatures, treatments and days) were carried out by factorial design analysis of variance. The least significant square design (LSD) test was employed to check the probability of treatments.

RESULTS AND DISCUSSION

The mango pulp was analysed for physicochemical and

sensory attributes with the addition of PS, SB and PMS. During storage at room temperature T0r, T1r, T2r and T4r spoilage was observed within 15 days, while T3r and T5r showed stability for 60 days. This spoilage may be due to weak and strong interactions between chemical preservatives under the influence of pH and storage conditions (Campos et al., 1997). The antimicrobial activity of potassium sorbate also came from the undissociated acid but, unlike benzoic acid, it is less affected by pH and consequently it can be used at pH levels higher than 3.0. Sorbic acid is effective against some bacteria and yeasts and as with benzoic acid, some yeasts including *Zygosaccharomyces lentus* can become resistant (Steels et al., 1999). While in refrigeration storage, T0ref and T4ref spoiled within 15 days, T5r and T5ref spoiled with pronounced blackening due to interaction and degradation of PS, SB and carotenoids in mango pulp. Sorbates suffers oxidative degradation in aqueous solutions that depends on pH, water activity, and presence of other additives, conditions of storage, processing and type of packaging material (Campos et al., 1997). T1ref and T2ref were found stable for 30 days, while T3ref, T5ref, and T6ref were secure during 90 days of refrigeration storage. Steaming mango fruits before irradiation, 1.0 to 2.0 kGy of the pulp increased the shelf life of refrigerated pulp at 3 ± 1°C to 270 days compared with 90 days of unsteamed irradiated ones and 15 days for control (unsteamed and unirradiated) (Youssef et al., 2002). Among all the samples, T5ref and T3ref were considered best during 90 days of refrigeration storage. Addition of sulphites is an inexpensive alternative to thermal pasteurization for the production of safe apple cider for small apple cider producers (Basaran-Akagul et al., 2009). Percentage acidity increased from 0.30 (T0) to 3.46 (T3r) during 60 days, and to 2.80 (T2ref) during 90 days of storage. Overall, temperatures effect on treatments, T7ref, T5ref and T6ref with values 0.55, 0.62 and 0.66 showed less increase in percentage acidity. The values for pH decreased from 4.34 (T0) to 3.20 (T7r) during 60 and 3.00 (T2ref) in 90 days of storage. Less decrease was observed in pH for temperatures effect on treatments in refrigerated samples, T5ref, T3ref and T7ref having values 4.26 and 4.24. According to overall treatment means, T5 showed less increase in acidity with values of 0.86%, while pH was retained as 3.60. All the values for percentage acidity and pH in Tables 2 and 3 were significantly different at $p < 0.05$. Abbasi et al. (2009) showed that the percentage acidity increased and pH decreased during storage with increase in storage time of mangoes. Increase in acidity may be due to the break down of pectic substances polysaccharides into acids and oxidation of reducing sugars (Hummel and Okay, 1950; Iqbal et al., 2001; Hussain et al., 2008).

Total soluble solids (TSS) values for all samples increased from 18.00 (T0) to 26.00° Brix (T3r) during 60 days while to 21.00°Brix (T1ref) during 90 days of storage. According to temperatures effect on treatments, refrigerated samples (T5ref, T6ref and T7ref) with values 19.31and 19.28°Brix, showed retention in TSS as compared to room temperature treatments. Less increase was observed in percentage reducing sugar (%RS) from 6.02 (T0r) to 13.15 (T5r) during 60 days and 10.24 (T5ref) during 75 days of storage. While temperatures effect on treatments showed that refrigerated samples (T6ref, T7ref and T5ref) having less increase as 6.43, 6.45 and 6.70 in percentage reducing sugar (%RS) as compared to room temperature samples. The percentage non-reducing sugar (%NRS) values decreased from 8.26 (T0) to 1.95 (T5r) and T6ref 1.43%. Overall temperatures effect on treatments showed that refrigerated treatments, T3ref, T5ref and T7ref showed less increase in %NRS. Generally, the treatment means confirmed that (T3) showed increase in TSS followed by T6 and T5 with values 17.24, 16.94 and 16.89° Brix. All the values for TSS, %RS and %NRS in Tables 2 and 3 were statistically different at $p < 0.05$. About half of the soluble sugars of mango pulps are mainly composed of fructose, with about 30% sucrose and 20% glucose. The high sugar content of pulps in ripe fruits might be attributed to the transformation of starch into soluble sugars under the action of phosphorylase enzyme during ripening (Germain and Linden, 1981; Favier et al., 1993). Ascorbic acid (AA) mg/100 g content decreased in all samples with values of 8.32 (T5r) during 60 days among all the samples stored at room temperature while in refrigerated samples (T6ref) 17.04, (T5ref) 12.01 and (T7ref) 10.41 retained high amount of AA during 90 days. Temperatures effect on treatments showed that T5ref, T6ref and T7ref showed highest mean values of 25.78, 25.47 and 24.55 mg/100 g for ascorbic acid content. Among all the treatments (T5) showed higher stability for AA having value of 21.15 mg/100 g. All the values for AA mg/100 g Tables 2 and 3 were statistically different at $p < 0.05$. In mango pulp, sorbic acid did not prevent ascorbic acid loss on irradiation, but reduces storage losses (Arya and Thakur, 1993). Sensory analysis for colour of all samples showed that during 60 days of storage (T5r) 4.70 while (T5ref) 5.00, (T7ref) 4.02 and (T3ref) 4.10 were acceptable for colour during 90 days of storage. Temperatures effect on treatments showed that highest values for colour of mango pulp samples were obtained by T5ref, T3ref and T7ref; 7.21, 6.86 and 6.77. Treatment (T5r) 4.50 was suitable for flavour during 60 days of storage while (T5ref) 5.00 was acceptable for flavour with in 75 days of refrigeration storage. Temperatures effect on treatments showed T5ref, T7ref and T3ref having values 6.87, 6.39 and 6.29 were found acceptable for their flavour. During sensory analysis for odour (T5r) 5.30 and (T5ref) 5.80 were found acceptable during 60 and 90 days of storage, respectively. Overall temperatures effect on treatments showed that T5ref, T7ref and T3ref with values of 7.53, 7.21, 5.30 and 7.16 were found acceptable for odour. Treatment (T5) was observed best among all the treatments for its sensory aspects including

Table 2. Mean values comparison for temperatures effect on treatments for physicochemical and sensory attributes.

Storage temperature	Mango pulp during 90 days of storage												
	Treat	%acidity	pH	TSS °Brix	%RS	%NRS	AA (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)	ß-Carotene (ppm)	COL	FLA	OD
	T0r	0.04K	0.62K	2.57J	0.86I	1.18L	5.14J	0.24CD	1.576DE	22.65C	2.14K	2.14K	2.14K
	T1r	0.04K	0.62K	2.57J	0.86I	1.18L	5.49I	0.24CD	2.05CD	26.44BC	2.14K	2.14K	2.14K
	T2r	0.04K	0.62K	2.57J	0.86I	1.18L	5.43IJ	0.26BCD	2.14BCD	25.18BC	2.14K	2.14K	2.14K
Room	T3r	1.12C	2.85H	15.05F	7.02C	3.63C	15.48G	0.35ABC	2.46ABC	35.51BC	4.70H	5.00H	5.16I
25-35°C	T4r	0.04K	0.62K	2.57J	0.86I	1.18L	5.14J	-	-	-	2.14K	2.14K	2.14K
	T5r	1.10D	2.93G	14.47H	6.81D	3.68B	16.53F	0.58A	3.54A	72.58A	5.03E	5.31E	5.66E
	T6r	1.15B	2.83I	14.60G	7.38B	2.74J	17.32E	0.58A	3.54A	72.58A	4.58I	5.14F	5.22H
	T7r	1.06E	2.79J	13.67I	8.13A	2.91I	15.18H	0.58A	3.547A	72.58A	4.93F	5.06G	5.24G
	T0ref	0.04K	1.47K	2.57J	0.86I	1.18L	5.14J	0.19D	1.18E	24.19BC	2.14K	2.14K	2.14K
	T1ref	0.88F	0.62K	19.64A	6.09G	3.63D	17.44E	0.56A	2.91AB	41.75ABC	4.80G	4.91I	5.33F
	T2ref	1.37A	3.74F	19.35C	4.89H	3.24G	16.77F	0.34ABC	3.04A	39.02ABC	4.44J	4.11J	4.51J
Ref	T3ref	0.83G	4.24C	19.42B	6.71E	3.37F	22.40D	0.38ABC	2.88ABC	39.08ABC	6.86B	6.29C	7.16C
4°C	T4ref	0.04K	0.62K	2.57J	0.86I	1.35K	5.14J	-	-	-	2.14K	2.14K	2.14K
	T5ref	0.62I	4.26A	19.31D	6.70E	3.38F	25.78A	0.42A	2.94AB	46.19AB	7.21A	6.87A	7.53A
	T6ref	0.66H	4.21D	19.28E	6.43F	3.16H	24.55C	0.41AB	2.75ABC	44.34AB	6.30D	6.02D	6.61D
	T7ref	0.55J	4.24B	19.28E	6.45F	4.47A	25.47B	0.52A	2.92AB	43.94ABC	6.77C	6.39B	7.21B

Mean values in the same column followed by different alphabets are statistically different at $p \leq 0.05$.

colour, flavour and odour having values of 7.16, 6.09 and 6.59. All the values for colour, flavour and odour in Tables 2 and 3 were significantly different at $p < 0.05$. Akhtar et al. (2009) tested mango pulp of *chaunsa* variety for various sensory attributes and rated it as highly acceptable to the judges. Another study conducted by Hussain et al. (2003) on the sensory evaluation of chemically preserved mango pulp samples confirmed that all the samples tried for organoleptic evaluation were satisfactory up to 270 days of storage at ambient temperature. Mean values for temperatures effect on treatments during 30 days of storage showed that iron (Fe) persisted in T5r, T6r, T7r, T1ref and T5ref with values of 0.58, 0.56 and 0.42 mg/100 g. While under same effect calcium (Ca) was available in suitable amount in T5r, T6r, T7r and T5ref having values of 3.54 and 2.94 mg/100 g. Beta carotene sustained in refrigerated samples (T5ref, T6ref and T7ref) with values of 72.58 ppm each during 30 days of storage. According to treatments mean, T5 and T7 were rated best for the higher amount of availability of Fe (0.50, 0.55 mg/100 g), Ca (3.24, 3.23 mg/100 g) and ß-carotene (59.30, 58.26 ppm). All the values for Fe, Ca and ß-carotene were significantly different at $p < 0.05$. Musinguzi et al. (2007) determined the Ca 2 mg/100 g and Fe 0.7 mg/100 g in mango pulp. Fruit Ca concentration can be improved either by Ca soil or spray application (Coates et al., 1998). Charoensiri et al. (2009) determined that ß-carotene of Thai mangoes was in the range of 21.2 to 34.5 µg/100 g. In mango pulp up to 25 different carotenoids have been isolated; the densest content was ß-carotene responsible for the yellow orange pigmentation of most mango species (Chen et al., 2004).

Conclusions and recommendations

It was concluded from this research that instead of PM alone, PS and PMS should be used in combination in mango pulp. PS is antifungal and

Table 3. Treatments mean values comparison for physicochemical and sensory attributes.

Storage temperature	Mango pulp during 90 days of storage												
	Treat means	% acidity	pH	TSS °Brix	%RS	%NRS	AA (mg/100 g)	Fe (mg/100 g)	Ca (mg/100 g)	ß-carotene (ppm)	COL	FLA	OD
(25-35°C) and (4°C)	T0 (r+ref)	0.04G	0.62G	2.57G	0.86G	1.18H	5.14G	0.22D	1.37C	23.42B	2.14G	2.14G	2.14G
	T1 (r+ref)	0.46F	2.27E	11.10E	3.47E	2.40E	11.46E	0.40BC	2.48B	34.10B	3.50E	3.53E	3.73E
	T2 (r+ref)	0.70E	2.18F	10.96F	2.87F	2.21F	11.10F	0.30CD	2.59BC	32.10B	3.18F	3.13F	3.32F
	T3 (r+ref)	0.98A	3.54B	17.24A	6.86C	3.50C	18.94D	0.36BC	2.67AB	37.29B	6.20C	5.65C	6.16C
	T4 (r+ref)	0.04G	0.62G	2.57G	0.86G	1.26G	5.14G	-	-	-	2.14G	2.14G	2.14G
	T5 (r+ref)	0.86C	3.60A	16.89C	6.75D	3.53B	21.15A	0.50AB	3.24A	59.30A	7.16A	6.09A	6.59A
	T6 (r+ref)	0.90B	3.52C	16.94B	6.91B	2.95D	20.93B	0.49AB	3.15AB	58.46A	4.80D	5.58D	5.92D
	T7 (r+ref)	0.80D	3.51D	16.48D	7.29A	3.69A	20.32C	0.55A	3.23A	58.26A	6.59B	5.72B	6.22B

Mean values in the same column followed by different alphabets are statistically different at $p \leq 0.05$

PMS is antibacterial and antioxidant and has the capacity to increase the shelf life of mango pulp at ambient and refrigerated condition, when added according to recommended level of food safety. Previously, it was noted that sodium bisulphate is having the highest effective diffusivity in mango slices followed by sodium chloride and potassium sorbate but stabilization stage of mango slices during storage is achieved due to diffusivity of potassium sorbate (Ulloa et al., 2009). Refrigeration has a positive impact on the stability of mango pulp with recommended chemical preservatives. Research therefore should be done on more indigenous fruits of developing countries by adding chemical preservatives in safe level and results of such studies should be disseminated to the public. This will ensure dietary diversity and food security of marginalized and poor communities that make up the majority of the developing world.

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