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Use of mango seed kernels for the development of antioxidant rich health foods

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Mango seeds are nutritionally dense by-product of mangoes but commonly discarded as waste. The purpose of the study was proper utilization of mango seed kernels. Two products namely *Chapati* and *Panjiri* were prepared by incorporating 10-40 per cent level of mango seed kernel flour and evaluated for their sensory attributes. Incorporation of mango seed kernel flour at 30 per cent in *Chapati* and 40 per cent in *Panjiri* was organoleptically acceptable. The energy, crude fat and total ash content of supplemented products were significantly higher ($p<0.01$) as compare to control samples. A significant increase ($p<0.01$) in calcium and iron content was found. Antioxidant activity was found to be significantly increased ($p<0.01$) with incorporation of mango seed kernel flour and per cent increase in antioxidant activity was 22 per cent for *Chapati* and 27 per cent for *Panjiri*. Hence, the use of mango seed kernel flour can play important role in improving nutritional value of diets and could be recommended for supplementary feeding programmes in the country.

Key Words : Mango seed kernel flour, Sensory attributes, Nutritional composition, Antioxidant activity

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INTRODUCTION

Mango is one of the most economically important fruit which has been used as raw and ripened. It belongs to genus *Mangifera* of the cashew family *Anacardiaceae* and is known as "King of Fruits". It has excellent eating properties and nutritional composition. It is a seasonal fruit mostly consumed fresh and only 1-2 per cent of production is processed to make various products such as juice, jam, fruit bars, chutney, flakes, nectar, squash, puree and pickles. Mango seed is an important part of fruit and a single flat oblong seed. After consumption and industrial processing of mango, seeds are discareded as waste in considerable amount and generating a source of pollution. But nutritionally, fruit seed is the most enriched part of fruit because it acts as a storage site of nutrients. Therefore, it has drawn attention of research workers due to its ability to meet the nutritional needs of human beings at lower cost (Menon *et al.*, 2014).

By decortication of mango seed, kernel is obtained. Mango seed kernel is approximately 20 per cent of total fruit weight. It is highly loaded with nutrients. Therefore, addition of mango seed kernel flour in food products is considered a good substitute for nutritional enhancement. Starch, fat and protein are major component of mango seed kernel (Kittiphoom, 2012). It's oil is a good source of fatty acids with 44-48 per cent saturated fatty acids and 52-56 per cent unsaturated fatty acids. Stearic acid and oleic acid are main fatty acids of mango seed kernel oil. Although, mango seed kernel contains low amount of

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protein but the quality of protein is good because it contains most of the essential amino acids with highest level of leucine, valine and lysine (Abdalla *et al.,* 2007). Therefore, it has abilities to be used as nutrient rich food.

Mango seed kernel contains average protein 6, fat 11, carbohydrate 77, crude fibre 2 and ash 2 per cent on dry weight basis (Zein *et al.,* 2001). It contains high amount of iron, potassium, calcium, magnesium, sodium and phosphorus and a good source of vitamin A, B and C (Ravani and Joshi, 2013). It contains vitamin A 15.27 IU, vitamin B1 0.08, vitamin B2 0.03, vitamin B6 0.19, vitamin B12 0.12 and vitamin C 0.56 mg per 100 g of dry weight. It can be used as an alternative source of these antioxidant vitamins. Antioxidant vitamins help to reduce oxidative processes and prevent cardiovascular diseases and cancer (Fowomola, 2010).

Due to the presence of phenolic compounds, mango seed kernel is a potential source of natural antioxidants. Major phenolic components in mango seed kernel are tannins and flavonoids (Maisuthisakul, 2009). Other constituents of antioxidants present in mango seed kernel are ellagic acid, gallic acid, coumarin, ferulic acid, vanillin and cinnamic acid (Abdalla *et al.,* 2007). It contains tannin 20.7, gallic acid 6.0, cinnamic acid 11.2, ferulic acid 10.4, mangiferin 4.2, vanillin 20.2 and caffeic acid 7.7 mg per 100 gram of dry mango seed kernel weight (Ahmed *et al.,* 2007). Antioxidant activity of mango seed kernel is higher among variety of fruit seeds such as jackfruit, tamarind and avocado due to its high polyphenolic content (Soong and Barlow, 2004). Schieber *et al.* (2003) and Nunez-Selles (2005) reported that mango seed kernel showed antioxidant effect due to polyphenols, phytosterols and microelements such as zinc, copper and selenium. Therefore, it is the reason for industrial utilization of mango seed kernel as a functional food ingredient . For supplementation of staple foods, mango seed kernels are processed into flour. Several antioxidant rich products can be developed from different combination of mango seed kernel flour with other flours.

In recent years, increased interest in health foods has made consumers demand foods with health benefits and acceptable sensory qualities. Many convenient foods enriched with antioxidants and phytonutrients are made accountable. The current study is designed for development of health foods with incorporation of mango seed kernel flour for nutritional enhancement.

Objectives :

– To develop and organoleptically evaluate mango seed kernel flour supplemented health foods.

– To study the nutritional composition of supplemented health foods.

METHODOLOGY

Procurement of mango seeds and preparation of flour:

During the summer season of 2016, ripe mango seeds as by-products were collected from local fruit processing units, near Punjab Agricultural University, Ludhiana.

Preparation of flour:

Washed mango seeds→Seperated kernels from seeds→Blanched for 2 minutes→Dried at 60° C for 6 hours→Ground into flour.

Development of health foods:

Two health foods namely *Chapati* and *Panjiri* were developed from different combinations of mango seed kernel flour with whole wheat flour in Food Laboratory of Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. Five samples of *Chapati* and *Panjiri* were prepared from whole wheat flour with incorporation of mango seed kernel flour at 10, 20, 30 and 40 per cent level. Whole wheat flour *chapati* and *panjiri* were considered as control. The following standardized recipes were used for preparation of products.

Chapati :

Whole wheat flour and mango seed kernel flour were mixed in a bowl and kneaded into a soft dough using enough water. The dough was kept for some time. Balls were made. Balls were rolled out into thin circle using a little whole wheat flour for rolling. A griddle was heated and *Chapati* was placed on it. It was cooked till small blisters appear on the surface. *Chapati* was turned over and pressed all over lightly using a cloth till it puffs up.

Panjiri :

In a heavy bottom karahi, ghee was heated. Wheat flour and mango seed kernel flour were put in it and roasted them togeather. Flour was removed from flame and cooled it. Powdered sugar was added in it. Mixed it

well and served.

Sensory evaluation :

The sensory evaluation was carried out to select the most acceptable level of mango seed kernel flour used in the development of health foods. The panel of 10 semi-trained judges including faculty of Department of Food and Nutrition were provided with score card of 9 point Hedonic Rating Scale to score the test samples for their appearence, colour, flavour, texture, taste and overall acceptability (Larmond, 1970).

Proximate composition:

After the development and organoleptic evaluation of products, the highest acceptable product along with its corresponding control (0% supplementation) were weighed, homogenized and oven dried at 60° C. Products were analyzed for moisture, crude protein, crude fat, crude fibre, total ash, carbohydrates and energy content employing standard methods of AOAC (2000). A factor of 6.25 was used to convert nitrogen into crude protein.

Mineral content:

Calcium and iron content was estimated by using the AOAC (2000) method.

Antioxidant activity:

Antioxidant activity was analysed by using DPPH method given by Liang (2008)

Statistical analysis:

The data were analysed with the help of statistical tools such as mean, standard error and to test the significant difference between the control and experimental samples, kruskal wallis and two tail t-test were applied using SPSS 16 software.

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Sensory evaluation of developed health foods :

Chapati:

Five samples of *Chapati* were prepared using whole wheat flour as control and for experimental samples, whole wheat flour was supplemented with mango seed kernel flour at 10, 20, 30 and 40 per cent levels. The mean scores of organoleptic evaluation of *Chapati* are presented in Table 1. The results revealed that higher scores for all the sensory parameters were obtained for control (C) which did not have any mango seed kernel flour incorporated. Among the experimental samples, E3 (30% mango seed kernel flour) scored highest. The scores of E3 experiment were found to be in the range 7.4-7.7 while scores of other experiments were in the range 5.5-7.6. Therefore, overall acceptability was found to be higher in E3 experiment than other experiments. Hence, E3 (30% mango seed kernel flour) was selected as final antioxidant rich health food for nutritional analysis.

Panjiri:

Five samples were prepared using whole wheat flour as control and experimental samples were supplemented with mango seed kernel flour at 10, 20, 30 and 40 per cent levels. The mean scores of acceptability trials of *Panjiri* are summarised in Table 2. The results revealed that scores obtained by E4 (40% mango seed kernel flour) experiment for all sensory parameters were higher among the experimental samples with overall acceptability 7.74 followed by E3 (30% mango seed kernel flour) 7.42, E2 (20% mango seed kernel flour) 7.52 and E1 (10% mango seed kernel flour) 7.48 overall acceptability score.

Table 1 : Mean organoleptic scores for *Chapati* supplemented with mango seed kernel flour (Mean ± SE)

Proportions	Parameters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
C (control)	7.7±0.22	7.8±0.66	7.8±0.69	7.9±0.69	8.0±0.22	7.84±0.26
E1 (10% mango seed kernel flour)	7.6±0.20	7.6±0.85	7.5±0.81	7.4±0.20	7.1±0.25	7.44±0.25
E2 (20% mango seed kernel flour)	7.5±0.16	7.5±0.63	7.6±0.51	7.4±0.16	7.6±0.16	7.51±0.16
*E3 (30% mango seed kernel flour)	7.7±0.91	7.6±0.51	7.5±0.94	7.4±0.29	7.5±0.30	7.54±0.22
E4 (40% mango seed kernel flour)	7.5±0.51	7.5±0.91	6.8±0.70	5.8±0.16	5.5±0.22	6.62±0.20
χ^2	1.273^{NS}	0.477^{NS}	2.737^{NS}	15.395**	22.211**	14.778**

**Significant at 1% level (p<0.01) NS=Non-significant

*most acceptable level of supplementation (30% mango seed kernel flour)

Appearance, colour, texture and flavour of E4 experiment were not significantly different ($p<0.05$) than control. However, the overall acceptability of E4 experimental sample was found to be lower than control sample but it was higher than E1, E2 and E3 experimental samples. Hence, E4 (40% mango seed kernel flour) was selected as the final antioxidant rich product for furthur analysis.

Proximate composition of developed health foods:

The proximate composition of antioxidant rich health foods developed using mango seed kernel flour with their control sample is summarized in Table 3.

Chapati:

The moisture content of *Chapati* ranged from 2.32 percent for control to 4.62 per cent in experimental sample (30% mango seed kernel flour). The protein content of the control was found to be 9.70 per cent while that of the experimental sample was 8.06 per cent. The fat and ash content of experimental sample were significantly increased ($p<0.01$) from 1.70 to 4.29 per cent and 2.54 to 2.66 per cent, respectively. There was no significant difference between fibre content of control and experimental sample. The carbohydrate content of the control was found to be 84.05 per cent while the experimental sample was 83.06 per cent. The energy content ranged from 526 kcal for control to 530 kcal for experimental sample, while the difference was significant ($p<0.01$). Pandey and Awasthi (2015) reported that nutritional composition of *Chapati* was improved with 20 per cent germinated fenugreek seed flour incorporation. Yadav *et al.* (2012) studied that *Chapati* of wheat flour containing 20 per cent fine defatted rice bran was significantly higher in ash and dietary fibre than control.

Panjiri:

The moisture content of *Panjiri* ranged from 2.76 per cent for control to 2.66 per cent for experimental sample (40% mango seed kernel flour). The protein content of the control was found to be 6.48 per cent while the experiemntal sample was 5.36 per cent. The fat and energy content was significantly increased from 27.94 to 29.84 per cent and 526 kcal to 530 kcal, respectively.

Table 2 : Mean organoleptic scores for *Panjiri* supplemented with mango seed kernel flour (Mean ± SE)

Proportions	Parameters					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
C (control)	7.7±0.29	7.8±0.20	7.8±0.16	7.9±0.22	8.0±0.22	7.84±0.20
E1 (10% mango seed kernel flour)	7.5±0.22	7.6±0.26	7.5±0.09	7.4±0.25	7.4±0.26	7.48±0.29
E2 (20% mango seed kernel flour)	7.6±0.13	7.6±0.20	7.5±0.22	7.4±0.16	7.5±0.25	7.52±0.22
E3 (30% mango seed kernel flour)	7.4±0.29	7.7±0.16	7.6±0.25	7.4±0.30	7.1±0.16	7.42±0.30
*E4 (40% mango seed kernel flour)	7.8±0.22	7.8±0.29	7.7±0.16	7.7±0.22	7.7±0.29	7.74±0.29
χ^2	4.396^{NS}	1.654^{NS}	3.009^{NS}	6.569^{NS}	11.430*	5.938^{NS}

*Significant at 5% level ($p<0.05$) NS=Non- significant
*most acceptable level of supplementation (40% mango seed kernel flour)

Table 3 : Proximate composition of developed health foods

Health foods	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Carbohydrates (g/100g) (by difference)	Energy (Kcal)
Chapati							
Control	2.32±0.05	9.70±0.05	1.70±0.05	1.90±0.05	2.54±0.05	84.05±0.05	390±0.05
Experimental (30%supplementation)	4.62±0.05	8.06±0.05	4.29±0.05	1.93±0.05	2.66±0.05	83.06±0.05	403±0.05
t-value	281.69**	6.12**	44.63**	0.51^{NS}	14.69**	249.84**	1.51**
Panjiri							
Control	2.76±0.05	6.48±0.05	27.94±0.05	1.90±0.05	1.45±0.05	62.18±0.05	526±0.05
Experimental (40% supplementation)	2.66±0.05	5.36±0.05	29.84±0.05	1.96±0.05	2.69±0.05	60.13±0.05	530±0.05
t-value	200.85**	137.17**	232.70**	4.89**	151.86**	251.07**	541.33**

Values are expressed as Mean±SE.
**Significant at 1% level ($p<0.01$) NS=Non-significant

The fibre content of *Panjiri* ranged between 1.90 per cent for control to 1.96 per cent for experimental sample and the ash content of *Panjiri* ranged from 1.45 per cent for control to 2.69 per cent for experimental sample. Significant increment ($p<0.01$) was observed in fat, fibre, ash and energy content of products with incorporation of mango seed kernel flour. Bansal (2013) evaluated the *Panjeeri* supplemented with 50 per cent partially defatted peanut flour and found the moisture, protein, fat, fibre and ash as 1.45, 31.00, 25.50, 6.00 and 3.80 per cent which were almost higher as compared to the control *Panjeeri* except fat *i.e.* 0.37 per cent moisture, 9.27 per cent protein, 37.45 per cent fat, 1.50 per cent fibre and 3.80 per cent ash. Kaur and Kochhar (2014) analyzed nutritional composition of the control *Panjeeri* (wheat flour only) and *Panjeeri* supplemented with 40 per cent potato flour. Results showed the significant differences in the moisture, protein, fat, fibre, ash content of control and supplemented panjeeri *i.e.* 0.65, 6.60, 25.70, 1.30, 0.67% and 1.35, 7.40, 23.42, 2.40, 0.95 per cent, respectively.

Mineral content of developed health foods :

The mineral content of developed products is presented in Table 4. Significant increment was found in calcium and iron content of mango seed kernel flour supplemented *Chapati* and *Panjiri.*

The calcium content of experimental *Chapati* with 30 per cent mango seed kernel flour was observed as 36.44 mg/100 g while control sample contained calcium 33.02 mg/100 g. In case of *Panjiri,* calcium content of experimental sample (31.12 mg/100g) with 40 per cent mango seed kernel flour was significantly different ($p<0.01$) from control sample (28.02 mg/100g). The iron content of *Chapati* and *Panjiri* was significantly increased from 3.60 to 6.77 mg/100 g and 3.32 to 5.30 mg/100 g, respectively. Fowomola (2010) reported that mango seed kernel contained 111.3 mg calcium and 11.9 mg iron per 100 g of dry weight. Thus, mango seed kernel flour supplemented health foods cointained higher amount of calcium and iron than control which was made only from wheat flour. Kadam *et al.* (2012) reported that supplementation of 5 per cent methi powder increased the nutritional quality of *Chapati* particularly in calcium and iron. Salve *et al.* (2011) reported that calcium, phosphorus and iron content of panjiri were found to increase on supplementation with 10 per cent skimmed milk powder.

Table 4 : Mineral content of developed health foods

Health foods	Calcium (mg/100g)	Iron (mg/100g)
Chapati		
Control	33.02±0.05	3.60 ±0.05
Experimental(30% mango seed kernel flour)	36.44 ±0.05	6.77 ±0.005
t-value	222.2**	914.5**
Panjiri		
Control	28.02±0.05	3.32 ±0.05
Experimental(40% mango seed kernel flour)	31.12 ±0.05	5.30±0.05
t-value	66.13**	447.03**

Values are expressed as Mean±S.E. **Significant at 1% level ($p<0.01$)

Table 5 : Antioxidant activity of developed health foods

Health food	Antioxidant activity (%)
Chapati	
Control	36.0±0.57
Experimental (30% MSK flour)	44.0±0.57
t-value	40.14**
Panjiri	
Control	36.8±0.006
Experimental (40% MSK flour)	46.0±0.57
t-value	38.43**

Values are expressed as Mean±S.E.
**Significant at 1% level ($p<0.01$)

Antioxidant activity of developed health foods :

Antioxidant activity of control and mango seed kernel flour supplemented products has been given in Table 5. A significant increase ($p<0.01$) in antioxidant activity was observed in all experimental samples using mango seed kernel flour.

In *Chapati*, antioxidant activity of mango seed kernel flour supplemented *Chapati* (30 % mango seed kernel flour) was 44.0 per cent which was significantly higher ($p<0.01$) than the control *Chapati* made of whole wheat flour *i.e.* 36.00 per cent. In *Panjiri*, antioxidant activity of experimental sample (40% mango seed kernel flour) and control (whole wheat flour) was 46.0 and 36.8 per cent, respectively. Antioxidant activity was found higher in the experimental samples supplemented with mango seed kernel flour as compared to control sample possibly due to the presence of phenolic compounds. Aslam *et al.* (2014) reported that composite flour of mango peel and mango seed kernel powder increased the phenolic content of biscuits from 0.43 to 10.28 mg/g. The antioxidant activity of biscuits incorporated with mango seed kernel and peel powder was higher than control.

Conclusion :

Incorporation of mango seed kernel, a by-product of fruit industry, in product formulation showed considerable effects on physico-chemical and sensory properties of products. The results of the study concludes that health foods namely *Chapati* and *Panjiri* with acceptable sensory properties, high antioxidant activity, enhanced fat, ash, calcium and iron content can be developed by incorporating mango seed kernel flour upto a level of 30 per cent in *Chapati* and 40 per cent in *Panjiri* with wheat flour. Thus, mango seed kernel flour could also be used as a potential source for various products as a functional food ingredients.

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