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Use of mango seed kernels for the development of antioxidant rich *idli* and *mathi*

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Abstract
Mango seeds are nutrient dense by-product of mangoes but commonly discarded as waste. The purpose of the study was proper utilization of mango seed kernels. For this purpose, mango seeds were collected, washed, mango seed kernels separated, blanched for 2 minutes, dried at 60° C for 6 hours and ground into flour. Two products namely *mathi* and *idli* were prepared by incorporating 10-40 per cent level of mango seed kernel flour and evaluated for their sensory attributes. Control and acceptable experimental samples were analysed for their nutritional composition. Incorporation of mango seed kernel flour at 10 per cent level was organoleptically acceptable. The energy, crude fat, crude fiber 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 mineral content of developed products namely calcium, magnesium and iron content was found. Antioxidant activity was found to be significantly higher ($p<0.01$) with mango seed kernel flour supplementation in *mathi* and *idli.* Hence, the use of mango seed kernel flour can play important role in improving nutritional composition of diets and could be recommended for supplementary feeding programmes in the country.

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

1. 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. After utilization of mango, considerable amount of the seeds are discareded as waste 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.

By breaking the hard coat 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 [1]. Mango seed kernel contains average 6 per cent protein, 11 per cent fat, 77 per cent carbohydrate, 2 per cent crude fiber and 2 per cent ash [2]. Difference in nutritional composition may be due to cultivation climate, ripening stage, variety of plant, harvesting time of seeds and extraction method used. It contains high amount of iron, potassium, calcium, magnesium, sodium and phosphorous. Mango seed kernel is a good source of vitamin A, B and C [3]. 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 gram 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 [4].

Due to the presence of phenolic compounds, mango seed kernel is a potential source of natural antioxidants. 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 [5]. 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. Mango seed kernel also contains phytosterols such as campesterol, stigmasterol and bsitosterol and

Tocopherol [6]. 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 [7,8]. For supplementation of staple foods, mango seed kernels are processed into flour. Several value added products can be developed from different combination of mango seed kernel flour with other flours.

In recent years, consumers show increased interest in value added food products with health benefits and acceptable sensory qualities. The current study is designed for development of food products with incorporation of mango seed kernel flour for nutritional enhancement.

2. Materials and Methods

2.1 Procurement of mango seeds and preparation of flour

During the summer season, ripe mango seeds as by-product were collected from local fruit processing units of Ludhiana. Mango seeds were washed, mango seed kernels separated, blanched for 2 minutes, dried at 60° C for 6 hours in hot air oven and ground into flour.

2.2 Product development

Two products namely *mathi* and *idli* were prepared with incorporation of mango seed kernel flour with basic ingredients (refined wheat flour and semolina) at 10, 20, 30 and 40 per cent level. Refined wheat flour *mathi* and semolina *idli* were considered as control. The standardized recipes which were used for product preparation as followings:

2.2.1 *mathi*: The standardized recipe for the *mathi* had ingredients as 100 g refined wheat flour, 20 g butter, 1g salt and 50 ml refined oil. Refined wheat flour and salt were mixed. Fat was added to the flour as shortening and mixed thoroughly with finger tips. It was kneaded into a stiff dough. The dough was divided into small balls. The balls were rolled into shape of *mathi.* The rolled *mathi* was pricked with knife so that it was remained flat even after frying. The *mathi* was deep fried till golden brown color.

2.2.2 *idli*: The standardized recipe for the *idli* had ingredients as 100 g semolina, 120 g curd, 4 g fruit salt and 10 g salt. Semolina and curd were mixed and made a smooth batter. Fruit salt was added into the batter and mixed well. The *idli* moulds were greased and poured batter in the moulds. The *idlis* were steamed in a steamer for 20 minutes and served hot.

2.3 Sensory evaluation of products

Developed products were evaluated for sensory characteristics by a panel of 10 semi-trained members using a 9 point hedonic scale. The judges were served each preparation with one control and four experimental samples. Both products were evaluated for their color, appearance, flavour, texture, taste and overall acceptability [9].

2.4 Proximate analysis

Protein, fat, moisture, ash and crude fiber were determined by using the method of association of official analytical chemist [10]. The carbohydrate content was calculated by difference method.

2.5 Mineral content determination

For the estimation of calcium, iron and magnesium content of developed products, samples were prepared by wet digestion method in which 0.5 gm of sample which was moisture free was taken in the conical flask and 25 ml of diacid was added to each sample. Samples were digested on hot plate till 1ml volume is left and colourless. Then volume was made to 100 ml and after it was filtered through whatman no. 41 filter paper. Representative sample in a suitable liquid form is sprayed into the flame of an atomic absorption spectrophotometer and the absorption or emission of the mineral to be analysed was measured at a specific wavelength for calcium 422.7 nm, iron 248.3 nm and magnesium 285.2 nm.

2.6 Antioxidant activity determination

Antioxidant activity was determined by DPPH method [11]. Two gram of dried sample was extracted with 20 ml methanol (99.5%). the extraction process was done twice (20 ml + 20 ml) each for 2 hours in a shaking machine. supernatant was filtered using whatman no. 1 filter paper after centrifuging the suspension at 10,000 rpm for 15 minutes. an aliquot of 0.1 ml of the samples was taken in a test tube and then 2.9 ml of 0.01mm dpph reagent was added, vortexed and let to stand at room temperature in the dark for 30 minutes. the decrease in absorbance at 517 nm was measured. antioxidant activity was expressed as percentage inhibition of the dpph radical and was determined by the following equation:

Antioxidant activity % = (1-a/b x 100) where, a = absorbance of the sample, b = absorbance of the blank.

2.7 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.

3. Results and Discussion

3.1 Sensory evaluation of developed products

3.1.1 *mathi*

Five samples were prepared using refined wheat flour for control and for experimental samples, mango seed kernel flour was incorporated at 10, 20, 30 and 40 per cent levels. The mean scores of acceptability trials of *mathi* are presented in Table 1. After control, highest scores for all the sensory attributes were obtained by *mathi* supplemented with mango seed kernel flour at 10 per cent level (E1 experiment) with sensory scores in the range of 8.0-8.2 which was liked very much among experimental samples. The scores of E1 experiment were found comparable with control with an overall acceptability score of 8.1 and 8.2, respectively. It was noticed that incorporation of more than 10 per cent mango seed kernel flour cause decline in all sensory attributes. Therefore, E1 (10% mango seed kernel flour) was selected as final antioxidant rich *mathi* for analysis.

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

Proportions	Parameters					
	Appearance	Colour	Texture	Flavour	Taste	Overall Acceptability
C (Control)	8.2±0.20	8.2±0.23	8.1±0.29	8.4±0.24	8.4±0.20	8.2±0.24
E1(10% mango seed kernel flour)	8.0±0.21	8.0±0.20	8.2±0.25	8.1±0.23	8.1±0.22	8.1±0.20
E2(20% mango seed kernel flour)	7.8±0.23	7.8±0.29	7.8±0.20	7.8±0.26	7.8±0.22	7.8±0.26

E3(30% mango seed kernel flour)	8.0±0.24	8.0±0.19	8.0±0.20	7.9±0.20	7.9±0.23	7.9±0.22
E4(40% mango seed kernel flour)	6.9±0.19	6.9±0.29	6.9±0.21	6.8±0.25	6.9±0.29	6.9±0.21
χ^2	14.369*	14.369*	16.635*	20.060*	17.739*	17.531*

* Significant at 5% level (p<0.05)

3.1.2 *idli*

Five samples of the *idli* were prepared using semolina for control and for experimental samples, semolina was supplemented with mango seed kernel flour at different levels (10, 20, 30 and 40%). The mean scores of organoleptic evaluation of *idli* are presented in Table 2. The addition of mango seed kernel flour decreased the mean score of appearance (8.2-6.9), colour (8.1-6.9), texture (8.1-6.9), flavour (8.4-6.8) and taste (8.4-6.9). It was observed that the control was significantly scored higher than experiments but E1 experiment (10 % mango seed kernel flour) was scored higher among the experiments. Therefore, it was highly acceptable and selected for analysis.

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

Proportions	Parameters					
	Appearance	**Colour**	**Texture**	**Flavour**	**Taste**	**Overall Acceptability**
C	8.2±0.22	8.2±0.26	8.1±0.22	8.4±0.30	8.4±0.26	8.2±0.21
E1	8.0±0.20	8.0±0.20	8.0±0.25	8.1±0.26	8.1±0.20	8.1±0.22
E2	7.8±0.16	7.8±0.20	7.8±0.16	7.8±0.29	7.8±0.21	7.8±0.26
E3	8.0±0.29	8.0±0.29	8.0±0.30	7.9±0.24	7.9±0.28	7.9±0.21
E4	6.9±0.16	6.9±0.10	6.9±0.19	6.8±0.20	6.9±0.24	6.9±0.22
χ^2	14.369*	14.369*	16.635*	20.060*	17.739*	17.531*

* Significant at 5% level (p<0.05)

3.2 Proximate analysis of developed products

The results of proximate analysis of developed products are summarised in Table 3.

3.2.1 *mathi*

The moisture content of control sample (refined wheat flour) was 2.20 per cent which was significantly lower (p<0.01) than experimental sample (10% mango seed kernel flour) that was 3.40 per cent. Crude protein content was significantly higher (p<0.01) in control sample (6.41%) than the experimental sample (6.17%). There was a significant increase in the crude fat content of experimental sample that was 42.20 per cent from the control sample whose crude fat content was 40.31 per cent. Crude fiber content of experimental sample was 0.67 per cent which was more than the control sample that was 0.30 per cent. Total ash content of control sample and experimental sample was showed significant difference (p<0.01) with 0.36 and 0.49 per cent, respectively. Carbohydrate content was observed more in control sample as 52.50 g than experimental sample with 50.36 g carbohydrates. Energy content of experimental sample was higher with 606 Kcal followed by control sample with 598 Kcal. Thus, it was observed that the supplementation of mango seed kernel flour at 10 per cent level in *mathi* significantly increased (p<0.01) energy, fat, fiber and ash content as compared to the control *mathi* made from refined wheat flour only. Inline to our study, previous research also reported that nutritional value of *mathi* supplemented with 25 per cent potato had moisture 3.93, protein 6.44, fat 35.93, fiber 1.28 and ash 1.35 per cent which were higher than the control *mathi* except protein with moisture 3.43, protein 6.52, fat 35.20, fiber 0.46 and ash 1.27 per cent. [12]

Table 3 Proximate composition of developed products (on dry weight basis)

Products	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Total Ash (%)	Carbohydrates (g/100g) (by difference)	Energy (Kcal)
Mathi							
Control	2.20±0.05	6.41±0.05	40.31±0.05	0.30±0.05	0.36±0.05	52.50±0.05	598±0.05
Experimental (10% mango seed kernel flour	3.40±0.05888	6.17±0.05	42.20±0.05	0.67±0.05	0.49±0.05	50.36±0.05	606±0.05
t-value	14.69**	29.39**	32.57**	6.37**	15.92**	262.09**	996.94**
Idli							
Control	2.76±0.05	6.41±0.05	2.54±0.05	0.20±0.05	0.43±0.05	90.28±0.05	409±0.05
Experimental (10% mango seed kernel flour	4.40±0.05	6.25±0.05	3.10±0.05	0.38±0.05	0.53±0.05	89.68±0.05	411±0.05
t-value	200.85**	19.59**	68.58**	3.10*	13.47**	73.48**	75.13**

Values are expressed as Mean±SE.
*Significant at 5% level (p<0.05)
**Significant at 1% level (p<0.01)

3.2.2 *idli*

It was observed that the moisture content (4.40%) of experimental sample (10 % mango seed kernel flour) of *idli* was higher as compared to the control sample (2.76%). Significantly higher (p<0.01) crude protein content was observed in control sample (6.41%) as compared to experimental sample (6.25%). The crude fat content increased significantly (p<0.01) in experimental sample than the control from 2.54 to 3.10 per cent due to high fat content of mango seed kernel flour. The crude fiber content in control was found to be 0.20 per cent which was significantly lower (p<0.05) than experimental sample that was 0.38 per cent. There was also significant difference (p<0.01) in the ash content of control and experimental samples with 0.43 and

0.53 per cent, respectively. The carbohydrate content of experimental sample was found to be 89.68 g per 100 g of dry weight basis. The energy content of experimental sample was higher with 411 Kcal as compared to control sample with 409 Kcal. From the results, it was concluded that the supplementation of mango seed kernel flour in *idli* at 10 per cent level leads to significant increase in energy, crude fat, crude fiber and ash content as compared to the control *idli*. The results of a similar studies also revealed that *idli* supplemented with oats at 15 per cent level had higher total ash, crude protein, fibre and fat content than the control sample [13] and moisture, protein, fat, fiber and ash content of control and supplemented *idli* with potato flour at 30 per cent level was ranged from 3.32-4.5, 7.93-8.5, 2.8-3.5, 1.32 2.04 and 0.56-0.98 per cent, respectively [14].

3.3 Mineral content of developed products

The developed products were analysed for minerals like calcium, iron, magnesium and comparison between their control and acceptable experiments are presented in Table 4. Mango seed kernel flour supplemented *mathi* and *idli* were found to have significant increase in calcium, iron and magnesium content. Calcium, iron and magnesium conten of *mathi* was significantly increased (p<0.01) from 25.42 to 26.0 mg, 2.08 to 3.34 mg and 24.72 to 35.33 mg/100 g, respectively. *Idli* supplemented with 10 per cent mango seed kernel flour contained significantly higher (p<0.01) amount of calcium (60.4mg), iron (2.93mg) and magnesium (43.11 mg) than control. Thus, calcium, iron and magnesium content of food products increse with incorporation of mango seed kernel flour at 10 per cent level.

Table 4 Mineral content of developed products (on dry weight basis)

Health foods	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)
Mathi			
Control	25.42±0.05	2.08±0.05	24.72±0.05
Experimental (10% mango seed kernel flour)	26.0±0.05	3.34±0.05	35.33±0.05
t-value	72.26**	304.96**	47.76**
Idli			
Control	58.3 ±0.05	1.26±0.05	37.25±0.05
Experimental (10% mango seed kernel flour)	60.4 ±0.05	2.94±0.05	43.11±0.05
t-value	60.32**	194.79**	17.14**

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

3.4 Antioxidant activity of developed products

Antioxidant activity of control and mango seed kernel flour supplemented *mathi* and *idli* has been given in Table 5. A significant increase (p<0.01) in antioxidant activity was observed in experimental samples of *mathi* and *idli* using 10 per cent mango seed kernel flour. Antioxidant activity of experimental *mathi* (10% mango seed kernel flour) was significantly higher (p<0.01) with 37.0 per cent than the control sample (refined wheat flour) with 31.8 per cent. The antioxidant activity of experimental *idli* (10% mango seed kernel flour) was higher (35.2%) than control *idli* (31.0%) made of semolina only.

Table 5 Antioxidant activity of developed health foods

Experiment	Antioxidant Activity (%)
Mathi	
Control	31.8±0.006
Experimental (10% mango seed kernel flour)	37.0±0.57
t-value	38.43**
Idli	
Control	31.0±0.57
Experimental (10% mango seed kernel flour)	35.2±0.57
t-value	24.49**

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

Thus, 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. 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 [15]. Antioxidant activities exhibited by mango seed kernel (98.10%) were significantly higher when compared to mango seed (74.70%) [16].

4. Conclusion

Incorporation of mango seed kernel, a by-product of fruit industry, in *mathi* and *idli* formulation showed considerable effects on physico-chemical and sensory properties of products. The results of the study concludes that products with acceptable sensory properties, high antioxidant activity, enhanced fat, ash, fiber, calcium, iron and magnesium content can be developed by incorporating mango seed kernel flour up to10 per cent level. Thus, mango seed kernel flour could also be used as a potential source for various food products and functional food ingredients.

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