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RESEARCH ARTICLE

Utilization of Mango Seed Kernel Flour to Develop Value Added Rusk

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Abstract

Mango is known as "king of fruits". During its processing, major byproducts like peels and seeds kernel are generally dumped as waste. The mango kernel contributes about 15-20% of the fruit weight. The macronutrients present in it are starch, fat and protein. These seed kernels do contain ample amount of polyphenols, phytosterols as campesterol, sitosterol and tocopherols. It contain high levels of natural antioxidants and antimicrobial compounds, thus could be used as a functional food ingredient. To determine the potential use of it, the study was planned to assess the proximate composition, functional properties and shelf life of mango seed kernel flour and develop value added product by incorporating it. The study revealed that mango seed kernel flour possesses good amount of fiber and Energy. The functional properties of mango seed kernel flour reported that it can be used to develop value added food product. In the present study, mango seed kernel flour was used in different variations to develop value added Rusk. The Rusk developed by substituting 5 per cent of mango seed kernel flour for refined wheat flour was found to be highly acceptable by all the panelists. The shelf life study indicated that it can be stored safely for a period of 30 days with the microbial load within the permissible limit. The food cost of the rusk was calculated as Rs. 11.92/100g which indicates that it can be consumed by people of all socio-economic status.

Keywords: Functional properties, Mango seed kernel, Proximate composition, Rusk, Shelf life.

Globally, the mango (*Mangifera indica* L.) is one of the most important tropical fruit (Ibarra *et al.,* 2015). Mango belong to the genus Angifera, comprising of numerous species of tropical fruiting trees in the flowering plant family Anacardiaceae (Fowomola, 2010). 44.14% of the total world production of mangoes comes to the credit of India, making it the largest producer of mangoes. About 20% of the total produce of this seasonal fruit is used to produce products like pulp, squash, jam, jellies, pickles, candies, canned slice, *chutney*, juices, ice cream, etc. Processing of mango generates a total waste of 40-60%, out of which peel waste constitutes 12-15% and kernel, 15-20% (Yatnatti and Vijayalakshmi, 2017). The solid waste material from the food processing units can affect the environment by damaging vegetation, polluting water, creating unpleasant odors, asphyxiation and emitting greenhouse gas (Gupta *et al.,*2015).

Out of the total fruit weight, approximately 20 percent is of mango seed kernel. The major nutrients present in mango seed kernel are fat, protein and starch (Kaur and Brar 2017). As reported by Abdalla *et al.,* (2007), it contains appreciable amount of antioxidants like ferulic acid, cinnamic acids, gallic acid, ellagic acid, vanillin, tannins, coumarin and mangiferrin and polyphenols like tannins and flavonoids (Kaur and Brar, 2017).

The mango seed kernel possesses anticancer activity against breast and colon cancer due to its high antioxidant activity (Texas A&M AgriLife Communications, 2010). Mango seed kernel flour has an effective potential as antifungal and antibiotic, so, it can be used to treat food infections and poisoning caused by disease causing microorganisms in food industry (Khammuang and Sarnthima, 2011; Mutua *et al.,* 2017). The high tannin content is attributed to antidiarrheal effect of mango seed kernel (Rajan *et al.,* 2012). The vermifuge and astringent properties of mango kernel decoction make it suitable for treating haemorrhages, diarrhea, and bleeding haemorrhoids (Sairam *et al.,* 2003); for antibiotic effect the extracts of raw fruit, bark and leaves are used (Bbosa *et al.,* 2007; Thambi *et al.,* 2016). In Cuba, diarrhoea, fever, gastritis, and ulcers were treated with an aqueous stem bark extract from *Mangifera indica* L. (Masibo and He, 2009).

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Mangifera indica is also used widely to cure various ailments in Ayurvedic system of medicine. It is one of an active ingredient of numerous herbal and polyherbal formulations. The ripe fruit possess laxative property, whereas the seed kernel and bark are used to treat hemorrhage, diarrhea and other bodily discharge (Ganeriwala *et al.*, 2016). Keeping the therapeutic and functional properties in mind, the present study was planned to develop a value-added product by incorporating mango seed kernel flour.

Material and Methods

Procurement of Mango Seed Kernel

Mango seeds of *Dasheri* variety were purchased during summer season from Johri Market (local market) of Jaipur City in bulk in order to avoid varietal differences.

Processing of the Mango Seed Kernel

During processing, the kernels were obtained by decortication of mango seed coat. Mango seed kernels were washed with potable water and dried in hot air oven at 60^0-70^0C for approximately 15 hours. Then, the kernels were soaked in cold water for 6-7 hours and blanched for 1-2 minutes. The kernels were redried in hot air oven at 60^0-70^0C again for 15 hours. Later, the mango seed kernels were powdered, sieved and then stored in ziplock bags.

Proximate Composition Analysis

The proximate composition (moisture, fat, crude fibre and ash) of mango seed kernel flour (MSKF) was estimated by standard AOAC methods (2018). KELPLUS (Pelican equipment) was used to determine the nitrogen content and later the nitrogen content was multiplied by 6.25 for its conversion to protein content. The carbohydrate content was calculated by composite method. The iron and phosphorus content were estimated by colorimetric method and calcium by Titrimetric method (Raghuramulu *et al.*, 2003).

Analysis of Functional Properties

The functional properties of MSKF were analyzed by standard methods. The bulk density, oil absorption capacity and water absorption capacity of mango seed kernel flour were estimated by Onwuka method (2005). The solubility index and swelling power were determined by Hirsch method (Hirsch and Kokni, 2002). The starch content was estimated by Sadasivam and Manickam method (2008).

Development of Rusk

Rusks are commonly consumed by people of all age groups, so different variations of mango seed kernel flour was used to develop value added Rusks. Standard rusks were developed from refined wheat flour and 4 variations were developed by incorporating mango seed kernel flour to refined wheat flour in the ratio of 100:0 (Control), 95:5, 90:10, 85:15 and 80:20, respectively. The control rusk was coded as 111, rusk containing 5%, 10%, 15% and 20% of MSKF were coded as 112, 113, 114 and 115 respectively. In all the variations, mango seed kernel flour was substituted for refined wheat flour to develop value added rusk. The ingredients used in the development of rusk (refined wheat flour, mango seed kernel flour, ghee sugar, salt and baking powder) were procured from Johri Market (local market) of Jaipur City.

Organoleptic Evaluation of Developed Product

The developed rusks were subjected to organoleptic evaluation by a semi trained panel of 7 judges selected through Sensitivity Threshold Test. Five Point Rating Scale was used for the evaluation of the rusks. The sensory parameters considered under the study were appearance, color, texture, taste and over all acceptability.

The Shelf Life Study of Mango Seed Kernel

The shelf life study of mango seed kernel flour was analyzed by Standard Plate Count Method (Cappuccino and Sherman (2004) on Nutrient Agar. The shelf life was assessed for a period of one month at an interval of 15 days.

Cost Analysis

The cost of the developed product was calculated according to the latest market list. Latest cost considered in the study per kg of the commodities were refined wheat flour ₹ 30, mango seed kernel ₹ 200, Sugar ₹ 44, Ghee ₹ 420, Salt ₹ 17 and Baking powder ₹ 320.

Results and Discussion

Proximate Composition of Mango Seed Kernel Flour

Proximate composition of mango seed kernel flour is represented in Table 1. The results represented that the moisture, ash, protein, fat, carbohydrate and crude fiber content of mango seed kernel flour were 10.0±0.28 g/100g, 1.56±0.89 g/100g, 6.14±0.61 g/100g , 6.17±0.59 g/100g , 55.62±1.07 g/100g and 12.59±0.50 g/100g respectively. The energy content was calculated as 302.41±3.16 KCals/100g. The micronutrients content were estimated as Iron, 1.36±0.31 mg/100g; Calcium, 76.36±0.37 mg/100g and Phosphorus, 6.74 mg/100g. In a study by Kaur and Brar (2017), the proximate composition of mango seed kernel was reported as 9.24g/100g (moisture), 2.68g/100g (ash), 6.80g/100g (protein), 10.5g/100g (fat), 2g/100g (crude fiber), 76.81g/100g (carbohydrate), and 430kcals/100g (energy). The results of a study conducted by Okpala and Gibson-Umeh (2013) revealed that mango seed flours from India cultivars had protein content, 6.0%; moisture, 5.0 %; fibre, 11.0 % and the carbohydrate, 74.41%. Mango seed kernel flour is rich in calcium (59.75 mg/100 g) and iron (11.85 mg/100 g) as reported by Kaur and Brar (2017). Elgindy (2017) analyzed the micronutrient content of mango seed kernel flour and reported that 0.76 mg of iron and 40.35 mg of calcium was present in 100g of mango of Zebda variety. The phosphorus content was found to be 20 mg/100g in a variety of mango studied by Torres-León *et al.*, (2016).

Functional Properties of Mango Seed Kernel Flour

An unique quality attribute of foods and food products is functional properties. Functional properties of flour reflect the behavior of ingredients during prepreparation and cooking. The sensory characteristics like appearance, texture and tastes of a finished food product are affected due to the functional properties of flour used in preparing the product. The functional properties assessed in the present study were bulk density, swelling power, solubility, water absorption capacity and oil absorption capacity. Bulk density is a measure of heaviness of solid samples; it determines the material handling, packaging requirements and utility in the food industry (Falade and Okafor, 2015). Water absorption capacity refers to the amount of water retained by a food product after filtration and application of mild pressure of centrifugation (Falade and Okafor, 2015). Oil absorption capacity deals with protein's ability to bind fat. It is an important factor since fat acts as flavor retainers and increases the mouth feel of foods (Otegbayo *et al.*, 2013).The swelling capacity measures the ability of starch to absorb water and swell, and focuses on the extent of associative forces present in the granules of starch. Swelling capacity is considered as a quality measure of some bakery products. Singh *et al.* (2010) stated that amylose content affect the swelling power of a food product. So, higher the amylose content in a material there will be more hydrophilic groups to bind more water and increase the swelling power of the food. Besides, the amount of amylose content, the size of starch granules also affects the swelling power. High swelling power of flour indicates its wide use in food industry to develop bakery products with improved characteristics.

Table 1. Proximate Composition of Mango Seed Kernel Flour

Nutrients	Estimated Value
Moisture	10.0±0.28 g/100g
Ash	1.561±0.89 g/100g
Protein	6.14±0.61 g/100g
Fats	6.17±0.59 g/100g
Carbohydrate	55.62±1.0 g/100g
Energy	384.4±3.16 Kcal/100g
Crude Fiber	12.59±0.50 g/100g
Iron	1.36±0.31 mg/100g
Calcium	76.36±0.37 mg/100g
Phosphorus	6.74 mg/100g

The results of the study showed that mango seed kernel flour had 0.41±0.06 g/ml (bulk density), 0.75±0.07 g/g (water absorption capacity), 1.68±0.03 g/g (oil absorption capacity), 8.5±0.24 g/g (swelling power), 0.87±0.02 % (solubility) and 57.6±2.38 g/g (starch). Functional Properties of mango seed kernel flour are represented in Table 2. Okpala and Gibson-Umeh (2013) studied the functional properties of mango seed flour of an Indian cultivars and reported that the water absorption capacity was 2.0 g/g; oil absorption capacity was 2.16 g/g and foaming capacity was 3.79 g/g. The water absorption capacity and an oil absorption capacity of mango seed kernel flour were reported to be 3.2-3.4 g/ml and 0.893 – 1.033g/ml respectively by Lakshmi *et al.* (2016). Legesse and Emire (2012) reported that the functional properties of mango seed kernel flour were 0.61g/ml (bulk density) and 0.83g/g (oil absorption capacity). The solubility capacity and starch content of mango seed kernel flour were 8.2g/g and 68.5g/g respectively (Yatnatti and Vijayalakshmi, 2017). The water absorption capacity was observed to be 2g/g in a variety of mango seed flour (Okpala and Gibson-Umeh, 2013).

Table 2. Functional properties of mango seed kernel flour

Parameters	Amounts
Bulk Density	0.41±0.06 g/ml
Water Absorption Capacity	0.75±0.07 g/g
Oil Absorption Capacity	1.68±0.05 g/g
Swelling Power	8.5±0.24 g/g
Solubility Capacity	0.87±0.02 %
Starch	57.6±2.38 g/g

Development of Value Added Rusk by Incorporating Mango Seed Kernel Flour

For product development, a plain surface was greased with ghee and to it other ingredients (sugar, water, salt) were added and later the mixture was kneaded to form smooth dough. Then, the dough was kept for 2 hours at room temperature for proofing. Later, it was rolled and then cut into pieces, then placed on a perforated tray and baked for 20 minutes at a temperature of 150° C. The baked pieces were further rebaked at 150°C for 20 min. The rebaking was done to impart perfect colour development and crispiness.

Organoleptic Evaluation of Developed Product

The organoleptic evaluation was carried out to identify the best acceptable variation of rusk. The results revealed that the mean score of overall acceptability of standard rusk containing 100% of refined wheat flour was 4.5 (Table 3; Fig. 1). The rusk containing 5% of mango seed kernel flour (112) was found to be acceptable with the mean overall acceptability score of 4.3. Code no. 112 was followed by 113 (rusk containing 10% of mango seed kernel flour) on the overall acceptability criteria with the mean score of 4.2. The rusk developed by adding 15 % (114) to 20% (115) of mango seed kernel powder were found to be less acceptable with the mean overall acceptability values of 3.4 and 3.0 respectively. Code No. 114 and 115 were found to be less acceptable due to darkness of colour and softness of the texture (Fig.2).

Kaur and Brar (2017) in a study reported that biscuits developed from whole wheat flour containing up to 30 percent mango seed kernel flour were found to be acceptable on sensory parameters. This could be because in the biscuits a good amount of sugar and butter were added. Sugar has the ability of suppressing bitterness imparted due to MSKF and butter imparts good flavor, thus improving the overall acceptability of the biscuits/products. Menon *et al.* (2014) reported that mango kernel flour lends a slightly bitter taste due to its high polyphenol and tannin content. The presence of tannin in mango seed kernel flour could be the reason for enhanced coloration of the final baked product. When the proportion of mango seed kernels is increased in a recipe, the interaction of nutrients during processing and baking time along with temperature combination can cause change in colour of the product (Legesse and Emire, 2012).

Table 3. Organoleptic characteristics of standard rusk and it's variations

Code No.	Appearance	Color	Texture	Taste	Over all acceptability
111 (Standard)	4.7±0.48	4.4±0.79	4.5±0.72	4.5±0.72	4.5±0.63
112 (5g MSKF)	4.2±0.46	4.0±0.61	4.4±0.45	4.5±0.73	4.3±0.73
113 (10g MSKF)	3.9±0.4	3.4±0.36	3.9±0.4	3.5±0.37	4.2±0.43
114 (15g MSKF)	3.2±0.34	3.2±0.34	3.5±0.37	3.2±0.35	3.4±0.34
115 (20g MSKF)	3.0±0.32	3.0±0.32	3.1±0.33	2.7±0.29	3.0±0.32

Values as rated on a 5 point rating scale

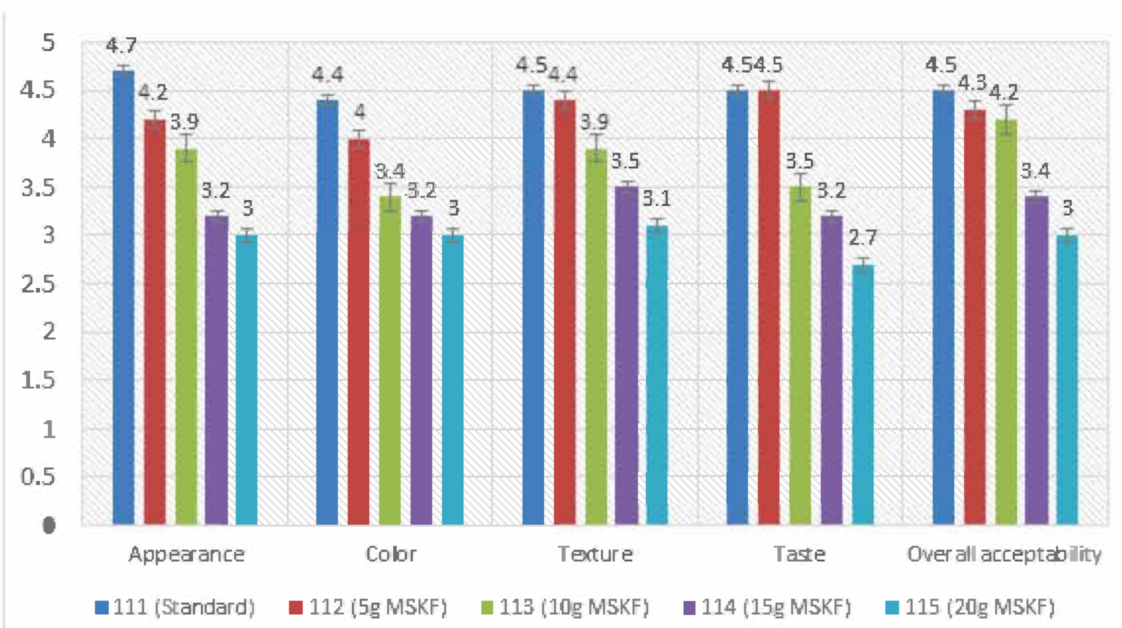

Fig.1. Organoleptic characteristics of different variations of value added rusk

Fig.2. Different variations of Rusk developed by adding mango seed kernel flour

Shelf Life Study of Mango Seed Kernel

The shelf life study of mango seed kernel flour at 0^{th} day, 15^{th} day and 30^{th} day was $8x10^2$ cfu/g, $2.4x10^3$ cfu/g and $5.6x10^3$ cfu/g, respectively. The results revealed that the shelf life of mango seed kernel flour was good up to 30^{th} day (Table 4).

Table 4. Standard Plate Count of Mango Seed Kernel Flour

Product Name	Microbial Activity (cfu/g)		
	At 0^{th} Day	At 15^{th} Day	At 30^{th} Day
Mango Seed Kernel Flour (MSKF)	$8x10^2$	$2.4x10^3$	$5.6x10^3$

Cost Analysis of Developed Rusk

The cost of the developed rusk was calculated according to the latest market list. The food cost per 100g of rusk was calculated to be Rs. 11.92. Though the overhead, labour and profit have not been included to the cost of the rusk, only food cost has been calculated. Rusk is a commodity which is consumed by people of all socio-economic status, so during commercialization the profit margin should be kept minimal to suit the purchasing capacity of people of all strata.

Conclusions

Mango seed kernel is a waste developed from household and processing units. Instead of dumping it as garbage, it can be utilized for value addition to various food products. Also, mango seed kernels can be procured in bulk during summer season and can be stored safely after drying, for use throughout the year. Thus, it can be concluded from present study that rusks with high fat, protein, dietary fiber and calcium content can be prepared by adding 5-10 percent of mango seed kernel flour in refined wheat flour. Mango seed kernels are a rich source of polyphenols and possess high antioxidant properties, so the developed product can also be consumed by elderly as well as people suffering from non communicable diseases. The functional properties of mango seed kernel flour revealed that it could be added to products like biscuits, cookies, *mathris, golgappa, khakhra, chappati, parantha, idli* etc. The use of composite flours is trending now-a-days in the bakery industry, so it could be used in various bakery products as a functional food ingredient. The sensory evaluation of the value added rusk developed in the present study reported that only 5-10% of the mango seed kernel flour can be used for value addition, as adding more quantity will darken the colour and imparts bitterness to the product. The shelf life of mango seed kernel flour indicates permissible microbial count till 1 month of storage. The shelf life of flour can be improved by using commercial drying techniques.Thus, the present study concludes that the mango seed kernel is a rich source of many macro and micronutrients like starch, carbohydrate, fats, fibre and calcium and is available at low cost to the community, so it can be used to develop value added products both at household and commercial level.

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