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Investigating the effect of mosambi (*Citrus limetta)* peel powder on physicochemical and sensory properties of cookies

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RESEARCH ARTICLE

Abstract

This study was undertaken to investigate the effects of mosambi peel powder on physiochemical and sensory properties of cookies. Different percentages of mosambi peel powder, 4, 6, 8, 10 and 12%, were incorporated into the cookies. It was found that mosambi peel powder resulted in an increase in thickness and hardness of cookies, while width and spread ratio of cookies decreased with increasing levels of mosambi peel powder. The dietary fibre content in cookies was also enhanced by the incorporation of mosambi peel powder. This research was further extended to note the influence of mosambi peel powder on sensory properties of incorporated cookies. Mosambi peel powders pre-treated with sodium chloride and sodium bicarbonate obtained better scores, followed by untreated powders. The low score for untreated mosambi peel powders was attributed to its bitter taste.

Keywords*:* dietary fibre, hardness, sensory, spread ratio

1. Introduction

Byproducts are generated in millions of tonnes every year from various industries and mainly from the food industry. Citrus rinds and other byproducts of juice extraction are traditionally dried and commercialised for feed (Bampidis and Robinson, 2006). But also foods like cookies, pasta, whole wheat bread and food for enteral diets are examples of enriched products that have been tested. Biscuits are the most popularly consumed bakery items in India and other parts of the world. Some of the reasons for such wide popularity are their ready to eat nature, affordable cost, good nutritional quality, availability in different tastes and longer shelf life (Ayo and Olawale, 2002). Reports are available on the use of oat bran, wheat bran, rice bran, date palm as a source of dietary fibre content in bread and other bakery products (Abdul-hamid and Luan, 2000; Ellouze-Ghorbel *et al.*, 2010; El-Sharnouby *et al.*,2012; Laurikainen *et al.*, 1999; Sidhu *et al.*, 1999). On the other hand, fruit dietary fibre concentrates have better nutritional quality than those found in cereals due to a higher proportion of soluble dietary fibre (SDF) and significant content of dietary fibre associated bioactive compounds (Chau and Huang, 2003). Therefore, it becomes necessary to develop processes for the preparation of fruit fibres that minimise the losses of associated bioactive compounds, which may exert higher health-promoting effects than dietary fibre itself (Larrauri, 1999). Vergara-Valencia *et al.* (2007) reported the improvement in nutritional properties of cookies and bread with the incorporation of mango dietary fibre obtained from unripe mango fruit (whole fruit).

Dietary fibre concentrates can be used in various applications in the food industry with excellent results. Fibres with 15% of SDF are able to bind and retain several times their weight of water. Dietary fibre from several sources increases the nutritional value of food (bread, cookies, paste, muffins, and cakes) but also alter the rheological properties of the dough and, hence, the quality and sensory properties of the end product (Bjorck and Elmstahl, 2003; Grigelmo-Miguel *et al.*, 1999; Wang *et al.*, 2002). Citrus pulps were incorporated in snap cookies and up to 7.5% incorporation the cookies were tasty (Passy and Mannheim, 1983). Effect of orange peel and pulp on chemical, rheological and organoleptic characteristics of biscuits was seen by Nassar *et al. (*2008) and found that acceptable biscuits were obtained by incorporating 15% orange pulp and peel in the recipe. Recently, mosambi (*Citrus limetta*) peels were explored as new agents to enhance nutrition value to papaya jam (Younis *et al.*, 2015). In view of its beneficial effects on papaya jam, the present study was carried out to investigate physiochemical, textural and sensorial properties of cookies by the incorporation of mosambi peel powder.

2. Materials and methods

Materials

Mosambi peel was garnered from the juice vendors of Hisar market by informing them to collect peel in separate clean envelopes. Wheat flour was obtained from the Hisar Agriculture University, India. Other ingredients used in cookies were also obtained from the local market of Hisar.

Preparation of mosambi peel powder

Mosambi peel was cleaned by washing with tap water and was scalded at 95 °C to decrease microbial load (Fernández-López *et al.*, 2004). Debittering was done as described in our previous work (Younis *et al.*, 2015).

Preparation of cookies

The cookies were prepared according to the formula described by Tyagi *et al.* (2007). The control cookies formula based on flour weight was: 100 g fine wheat flour, 53 g sugar, 26.5 g shortening, 1.1 g glucose, 1.1 g sodium bicarbonate, 0.89 g sodium chloride and 12 ml water. Mosambi peel powder was incorporated in cookies as 4, 6, 8, 10, and 12% by replacing flour without changing the other ingredients. Batter was prepared in a laboratory dough mixer (model HL-120; Hobart, Offenburg, Germany) and sheeted to a thickness of 10 mm with the help of dough sheeter. The cookies were cut with a cookie die to desired diameter and transferred to a lightly greased aluminium baking tray. The cookies were baked in an electric oven (model 21w; Iyra, New Delhi, India) at 180 °C for 8-9 min.

Analytical methods

Proximate composition of wheat flour and mosambi peel powder was estimated by AOAC (1997, 1999).

Physical properties of cookies

Diameter and thickness

Diameter and thickness of cookies were measured as described by AACC (2000) with the help of a vernier caliper.

Spread ratio

The spread ratio was calculated by dividing the average value of diameter by the average value of the thickness of the cookies (Shrestha and Noomhorm, 2002):

$$\text{Spread ratio} = \frac{\text{diameter}}{\text{thickness}} \qquad (1)$$

Sensory analysis

The sensory analysis was done by using a 9-point hedonic scale to evaluate colour, texture, taste and overall acceptability (Ranganna, 2008). 10 trained panellists were used for the sensory analysis.

Texture analysis of cookies

A texture analyser (TA-XT 2i; Stable Micro Systems, Godalming, UK) with software Texture Expert Exceed (version 2.61) was used to determine the texture of the cookies. Cookies were evaluated for hardness within 24 h by measuring peak force during penetration using a 5 mm cylinder probe. The analyser was operated on compression mode and was set at a return to start cycle, a pre-test, test and post-test speed of 1.5, 2.0 and 10.00 mm/s, respectively, and penetration distance of 5 mm. A force/penetration plot was made for every test. The individual samples of cookies were placed on the platform and the probe was attached to crosshead of the instrument. For texture measurement, the probe used a Warner-Bratzler blade with a 50 kg load cell. The trigger force used was 25 g. The data acquisition rate was 400 pps. Maximum peak force (g) from force deformation curve was recorded.

Statistical analysis

One-way ANOVA was carried out to see the significant differences ($P \leq 0.05$) among treatments by using SPSS 16.0 software (SPSS Inc, Chicago, IL, USA). All the tests were performed in triplicate.

3. Results and discussion

Chemical composition of mosambi peel powder

Proximate composition (moisture, protein, fat, ash, crude fibre and dietary fibre) of mosambi peel powder and wheat flour are shown in Table 1. All the parameters of mosambi peel powder and refined wheat flour differ significantly except fat.

Table 1. Chemical composition of mosambi peel powder and refined flour.[1]

Parameters	Mosambi peel powder (%)	Refined wheat flour (%)
Moisture	10.70±0.44^{a}	13.24±0.03^{b}
Ash	3.39±0.26^{a}	0.75±0.06^{b}
Fat	1.58±0.19^{a}	1.79±0.08^{a}
Crude fibre	17.58±0.55^{a}	0.62±0.01^{b}
Protein	5.39±0.96^{a}	13.20±0.03^{b}
Total dietary fibre	70.00±1.23^{a}	2.70±0.20^{b}

[1] Means (± standard deviation) with different superscripts in a row for a particular parameter differ significantly (*P*≤0.05).

Table 2. Physical characteristics of cookies.[1]

Sample	Diameter (mm)	Thickness (mm)	Spread ratio
Control	59.03±0.68^{a}	9.85±0.31^{a}	6.00±0.24^{a}
Salt treated mosambi peel powder incorporated in cookies			
4%	56.80±0.41^{b}	10.10±0.47^{a}	5.63±0.29^{ab}
6%	56.20±0.27^{b}	10.19±0.56^{ab}	5.53±0.31^{b}
8%	55.22±0.16^{c}	10.81±0.13^{b}	5.11±0.07^{c}
10%	54.76±0.23^{c}	11.66±0.29^{c}	4.70±0.12^{d}
12%	53.66±0.23^{d}	12.13±0.31^{c}	4.43±0.10^{d}
Sodium bicarbonate treated mosambi peel powder incorporated in cookies			
4%	56.45±0.54^{b}	9.92±0.08^{ab}	5.70±0.03^{ab}
6%	55.42±1.75^{bc}	10.07±0.92^{ab}	5.54±0.65^{ab}
8%	53.38±0.28^{cd}	10.32±0.09^{ab}	5.17±0.07^{ab}
10%	53.59±0.43^{d}	11.42±0.42^{bc}	4.70±0.14^{bc}
12%	53.96±0.85^{d}	12.61±1.62^{c}	4.33±0.62^{c}
Untreated mosambi peel powder incorporated in cookies			
4%	59.10±0.64^{a}	9.82±0.10^{a}	5.62±0.15^{b}
6%	57.96±0.32^{b}	10.57±0.35^{b}	5.49±0.17^{b}
8%	57.58±0.16^{b}	11.08±0.10^{b}	5.20±0.06^{c}
10%	54.40±0.43^{c}	10.49±0.23^{c}	5.19±0.10^{c}
12%	55.12±0.50^{c}	11.36±0.26^{c}	4.86±0.15^{d}

[1] Means (± standard deviation) with different superscripts in a column for a particular parameter differ significantly (*P*≤0.05).

Physical characteristics of formulated cookies

Physical characteristics of cookies such as diameter, thickness and spread ratio are presented in Table 2. The average diameter of control cookies was found to be 59.03 mm whereas in case of cookies incorporated with untreated mosambi peel powder at levels of 4 to 12%, diameter decreased from 59.10 to 54.40 mm. In case of cookies incorporated with sodium bicarbonate treated mosambi peel powder at 4 to 12% levels, the diameter decreased from 56.45 to 53.38 mm and when incorporated with salt treated mosambi peel powder at levels of 4 to 12%, it decreased from 56.80 to 53.66 mm. A significant difference was observed in diameter between control and salt treated and sodium treated mosambi peel powder incorporated cookies. However, the diameter of untreated mosambi peel powder incorporated cookies at 4% level did not differ significantly with respect to control.

Thickness of mosambi peel powder incorporated cookies does not differ significantly with respect to control cookies. The average thickness of control cookies was found to be 9.85 mm and the cookies incorporated with untreated mosambi peel powder at levels of 4 to 12%, thickness increased from 9.82 to 11.36 mm. In case of cookies incorporated with sodium bicarbonate treated mosambi peel powder, thickness increased from 9.92 to 12.61 mm and in salt treated mosambi peel powder incorporated cookies thickness increased from 10.10 to 12.13 mm.

The changes in width and thickness are reflected in spread ratio which was 6.00 mm for control cookies. Results showed that there is no significant difference between control and 4% salt treated and 4, 6, and 8% sodium treated mosambi peel powder incorporated cookies. These values decreased from 5.62 to 4.86 mm in cookies incorporated with untreated mosambi peel powder at levels of 4 to 12%, from 5.70 to 4.33 mm in sodium bicarbonate treated mosambi peel powder incorporated cookies and from 5.63 to 4.43 mm in cookies incorporated with salt treated mosambi peel powder. This decrease in spread ratio value may be due to the viscosity effect of mosambi peel powder. Usually higher diameter and higher spread ratio of cookies are considered as the desirable quality attributes of wheat flour (Yamamoto *et al.*, 1996). However, the above results are in agreement with Uysal *et al.* (2005) in which orange peel and orange pulp was incorporated in biscuits in different proportions. It was observed that spread ratio decreased from 8.95 to 7.94 mm with incorporation of orange peel powder at different levels.

Texture analysis of cookies

The effect of incorporation of mosambi peel powder on the texture of cookies is depicted in Table 3. The hardness of control sample was found 1.24 N which is significantly different with respect to cookies incorporated with untreated, sodium chloride treated and sodium bicarbonate treated mosambi peel powder at each level. As the level of mosambi peel powder was increased the hardness also increased for each treatment as was expected. Uysal *et al.* (2005) found that hardness was increased with the incorporation of lemon fibre in cookies. This increase in hardness is attributable to the fibre property of the peel

Table 3. Hardness of cookies.[1]

Sample	Hardness (N)
Control	1.24±0.25^{a}
Salt treated mosambi peel powder incorporated in cookies	
4%	7.45±0.33^{b}
6%	8.12±0.40^{bc}
8%	8.42±0.30^{c}
10%	9.82±0.41^{d}
12%	10.03±1.00^{d}
Sodium bicarbonate treated mosambi peel powder incorporated in cookies	
4%	7.73±0.37^{b}
6%	8.08±0.23^{bc}
8%	8.65±0.45^{cd}
10%	9.08±0.40^{d}
12%	9.90±0.40^{e}
Untreated mosambi peel powder incorporated in cookies	
4%	7.35±0.80^{b}
6%	8.47±0.40^{c}
8%	9.17±0.86^{cd}
10%	9.92±0.60^{de}
12%	10.39±0.39^{e}

[1] Means (± standard deviation) with different superscripts differ significantly (P≤0.05).

Table 4. Dietary fibre of cookies.[1,2]

Sample	TDF	IDF	SDF
Control	2.70±0.20^{a}	1.62±0.12^{a}	1.08±0.08^{a}
Salt treated mosambi peel powder incorporated in cookies			
4%	7.03±0.21^{b}	4.22±0.12^{b}	2.81±0.08^{b}
6%	8.20±0.20^{c}	4.92±0.12^{c}	3.28±0.08^{c}
8%	9.96±0.25^{d}	5.97±0.15^{d}	3.98±0.10^{d}
10%	11.90±0.23^{e}	7.14±0.14^{e}	4.76±0.09^{e}
12%	13.06±0.25^{f}	7.83±0.15^{f}	5.22±0.10^{f}
Sodium bicarbonate treated mosambi peel powder incorporated in cookies			
4%	7.00±0.25^{b}	4.20±0.15^{b}	2.80±0.10^{b}
6%	8.17±0.48^{c}	4.90±0.29^{c}	3.27±0.19^{c}
8%	9.97±0.29^{d}	5.98±0.17^{d}	3.99±0.12^{d}
10%	11.92±0.33^{e}	7.15±0.20^{e}	4.77±0.13^{e}
12%	13.08±0.28^{f}	7.85±0.17^{f}	5.23±0.11^{f}
Untreated mosambi peel powder incorporated in cookies			
4%	7.13±0.23^{b}	4.28±0.14^{b}	2.85±0.09^{b}
6%	8.32±0.26^{c}	4.99±0.15^{c}	3.33±0.10^{c}
8%	10.10±0.28^{d}	6.06±0.17^{d}	4.04±0.11^{d}
10%	12.00±0.43^{e}	7.20±0.26^{e}	4.80±0.17^{e}
12%	13.15±0.33^{f}	7.89±0.20^{f}	5.26±0.13^{f}

[1] Means (± standard deviation) with different superscripts in a column for a particular parameter differ significantly (P≤0.05).
[2] TDF = total dietary fibre content; IDF = insoluble dietary fibre content; SDF = soluble dietary fibre content.

powder. The addition of fibre is known to increase hardness in cookies (Rajiv *et al.*, 2012). Dietary fibre components for example water soluble pentoses, pectin and water insoluble hemicelluloses, cellulose, lignin significantly decrease the cookie spread and tenderness of cookies (Jeltema, 1983).

Dietary fibre of cookies incorporated with mosambi peel powder

Total dietary fibre as well as soluble and insoluble dietary fibre of cookies increased with increasing levels of mosambi peel powder as shown in Table 4. Results revealed that the total, insoluble and soluble dietary fibre contents of cookies incorporated with untreated, salt treated and sodium bicarbonate treated mosambi peel powder was significantly different as compared to control. Total dietary fibre contents of cookies incorporated with mosambi peel powder reached more than 13% at the level of 12% which was 2.70 for control. This clearly indicates that mosambi peel powder can be an alternative source of dietary fibre in cookies making.

Sensory evaluation of cookies

Sensory evaluation of cookies containing different levels of mosambi peel powder as compared to control cookies is shown in Table 5. Sensory scores of incorporated cookies were decreased as the level of mosambi peel powder was increased as compared to control cookies. Stastical analysis revealed no significant differences in overall acceptability among treatments contained 4 and 6% salt or sodium bicarbonate treated mosambi peel powder as compared to the control cookies. Cookies prepared by incorporation of untreated mosambi peel powder exhibited lower scores and were rejected at every level of incorporation mainly due to taste and showed significant difference for all treatments with respect to control cookies. The reason for lower scores could be attributed to the bitterness of the peel which increased as the level of mosambi peel powder increased. In this study, desirable results for overall sensory acceptability of cookies were obtained at 8% level of both sodium chloride and sodium bicarbonate treated mosambi peel powder incorporation.

4. Conclusions

Mosambi peel is generated in huge amounts everyday at every juice corner. The utilisation of mosambi peel not only prevents environment pollution but can also provide a good and sustainable source of functional food. The results from this study suggest that the mosambi peel powder has a potential to be used in cookie industry as a functional

Table 5. Sensory evolution of cookies.[1]

Sample	Colour	Texture	Taste	Overall acceptability
Control	8.5±0.47[a]	7.4±0.39[a]	7.9±0.21[a]	8.0±0.33[a]
Salt treated mosambi peel powder incorporated in cookies				
4%	8.5±0.47[a]	7.5±0.47[a]	7.5±0.47[b]	7.8±0.26[ab]
6%	8.5±0.47[a]	7.5±0.47[a]	7.5±0.47[b]	7.8±0.26[ab]
8%	7.9±0.21[b]	7.4±0.39[a]	7.3±0.42[b]	7.5±0.47[bc]
10%	7.5±0.47[b]	7.0±0.33[b]	7.2±0.42[b]	7.2±0.42[c]
12%	7.5±0.47[b]	6.2±0.26[c]	6.0±0.33[c]	6.6±0.52[d]
Sodium bicarbonate treated mosambi peel powder incorporated in cookies				
4%	8.5±0.47[a]	7.4±0.52[a]	8.0±0.47[ab]	8.1±0.52[ab]
6%	8.5±0.47[a]	7.4±0.52[a]	7.6±0.52[ab]	7.7±0.42[abc]
8%	8.5±0.47[a]	7.2±0.26[a]	7.5±0.47[b]	7.6±0.52[bc]
10%	8.1±0.21[ab]	7.0±0.58[a]	7.5±0.47[b]	7.3±0.42[cd]
12%	7.8±0.42[b]	6.4±0.52[b]	6.5±0.47[c]	7.0±0.67[d]
Untreated mosambi peel powder incorporated in cookies				
4%	8.1±0.52[a]	6.7±0.42[bc]	5.1±0.52[b]	6.7±0.42[b]
6%	7.5±0.47[b]	7.0±0.58[cd]	3.7±0.42[c]	6.5±0.67[b]
8%	7.4±0.52[bc]	6.5±0.47[cd]	2.5±0.47[d]	5.2±0.42[c]
10%	7.0±0.33[c]	6.6±0.52[d]	1.4±0.52[e]	4.6±0.52[d]
12%	7.0±0.33[c]	6.5±0.47[d]	1.2±0.42[e]	4.2±0.42[d]

[1] Means (± standard deviation) with different superscripts in a column for a particular parameter differ significantly (*P*≤0.05).

ingredient. Furthermore, mosambi peel can be obtained easily from the market with less or no cost, which would not affect the final cost of the product. Further its high dietary fibre content can be exploited as a remedy for many diseases like constipation, diabetes which suggests that mosambi peel waste has a promising future and could be used as a raw material for many products.

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