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Value added convenience food from composite sorghum-maize-sweet potato flour blends

MESHACK TEGEYE[1], AMARJEET KAUR[2], JASPREET KAUR[3] and HIRA SINGH[4]

Punjab Agricultural University, Ludhiana Punjab 141 004, India

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ABSTRACT

This study conducted at Punjab Agricultural University in the year 2017, was aimed at development of value added nutritious convenience food, i.e. cookies from flour blends of sorghum, maize and sweet potato. Individual flours of these underutilized crops were studied for their chemical, physical and functional properties. Blends were prepared from the flours and divided into two lots. In the first lot maize flour (MF) was fixed at 10% of the blend, sorghum flour (SF) was varied from 80-40% while sweet potato flour (SPF) was varied from 10-50%. In the second lot, SF was fixed at 10%, while maize flour was varied from 80-40% and SPF from 10-50%. Cookies prepared from each blend were evaluated for organoleptic characteristics. The most acceptable cookies were studied for their physico-chemical characteristics. Results revealed that SPF had the maximum carbohydrate and potassium contents on dry weight basis. Sweet potato flour also had the highest water solubility index (WAI), water absorption index and fat absorption index (FAI). Based upon sensory evaluation, cookies prepared from two blends, viz. SF:MF:SPF=50:10:40 and from SF:MF:SPF=10:60:30 were most acceptable to the sensory evaluation panel. The selected cookies were rich in carbohydrates, β-carotene, vitamin C, minerals calcium and potassium and were gluten-free. These could serve as nutritious convenience food for the celiac patients. This study would also help in value addition of underutilized food sources such as sorghum, maize and sweet potato.

Key words: Convenience food, Cookies, Maize, Sorghum, Sweet potato

Convenience foods such as cookies and biscuits are a category of foods processed to optimize ease of consumption. Refined wheat flour is the major ingredient of these baked products. However, over dependence on wheat flour in diet poses nutritional imbalances and causes abnormalities in individuals with celiac disease. An alternative to wheat flour should provide energy, protein and other nutrients (Lamacchia *et al.* 2014) and replicate the functional properties of wheat gluten so as to have good baking performance. Hence, it is important to develop appropriate technologies to process grains from other food sources and transform them into acceptable convenience foods especially for celiac patients.

Sweet potato [*Ipomoea batatas* (L.) Lam], world's seventh most important crop with a production of 112.84.11 million MT (FAO 2018), is a rich source of energy and carbohydrates, beta carotene, vitamins B and C, minerals (Ca, P, Fe and K) and dietary fibre (Vimala *et al.* 2011). It imparts natural sweetness, colors and flavour to processed food products. Blending of sweet potato flour with wheat flour for production of bakery goods improved functional properties and reduced retro-gradation, staling rate and production time (Adeleke and Odedeji 2010). However, due to lack of appropriate technologies, sweet potato is still an underutilized crop in most parts of the world.

Maize (*Zea mays* L.) is a versatile crop with wide adaptability over various agro-climatic conditions. Although this crop finds wide application as a feed and in starch industry, its use as a food crop is still limited. Maize is a rich source of carbohydrates, protein, vitamin B, vitamin A (yellow maize) and minerals. It is a gluten-free cereal and has high anti-oxidant activity.

Sorghum [*Sorghum bicolor* (L.) Moench], is a hardy crop which is gluten-free and has high contents of antioxidants, protein and fibre. With certain technological interventions, sorghum flour can be used as a wheat flour replacement in breads, pastas and baked goods.

Limited work has been done on utilization of flours of these crops for convenience food development. This study was proposed with the objective to develop value added cookies from underutilized food sources such as maize, sweet potato and sorghum and evaluate quality characteristics of the prepared product.

MATERIALS AND METHODS

Maize (PMH-1) and sorghum (PSC-4) grains were

Present address: [1]PG Scholar (tegeye06@yahoo.com), [2]Senior Milling Technologist (foodtechak@gmail.com), [3]Assistant Food Technologist (jaspau28@gmail.com), Department of Food Science and Technology, [4]Assistant Professor (hira@pau.edu), Department of Vegetable Science, Punjab Agricultural University, Ludhiana.

procured from the Department of Plant Breeding and Genetics while sweet potato (PSP-21) tubers were procured from Department of Vegetable Science, Punjab Agricultural University, Ludhiana in the year 2017. Maize and sorghum grains were cleaned manually by removing undesirable materials such as stalks, brokens and dust and packed in separate LDPE (low density polyethylene) bags which were placed in plastic containers and stored at 10±2°C. All chemicals used for the study were of analytical grade and procured from Central Drug House, New Delhi.

Preparation of maize, sorghum and sweet potato flours: Maize and sorghum grains were milled using Laboratory mill (Super Mill, Perten Industries, Sweden) and passed through a sieve of 200 µm and kept in LDPE bags in a cool place until used. Flour from sweet potato was prepared as per Olapade and Ogunade (2014) with slight modification. The tubers were peeled and washed with clean water. The clean tubers, sliced to about 5 mm thickness, were treated with 2000 ppm potassium metabisulphite for 20 min, dried at 60°C for 8 h in a cabinet drier (Mermmet, Germany) and dry milled using Laboratory mill (Super Mill, Perten Industries, Sweden). These were passed through a sieve of 0.8 mm aperture to get flour. The flour was packaged in LDPE bags and stored in a cool place (10±2°C) until used.

Chemical analysis: The raw and prepared samples were analyzed for moisture, crude protein, total fat, total ash and crude fibre according to standard methods (AACC 2000). Carbohydrate content was calculated by subtracting the sum of moisture, protein, fat, and ash from 100 (Merrill and Watt 1973). Beta-carotene (Rodriguez-Amaya and Kimura 2004), vitamin C (AOAC 2005) and tannin contents (Saxena *et al.* 2013) were also determined in flour and cookie samples. Calcium, iron, potassium, magnesium and sodium contents were determined using the Inductively Coupled Argon Plasma Atomic Emission Spectrophotometer (ICAP-AES) (Labtam 8440, GBC, Australia).

Assessment of functional properties of the flours: The samples of SF (sorghum flour), MF (maize flour) and SPF (sweet potato flour) were analyzed for bulk density (Beuchat 1997), water solubility index, water absorption index (Anderson *et al.* 1969) and fat absorption index (Lin *et al.* 1974). Colour values (L*, a* and b*) were measured at three different positions using a Minolta Spectrophotometer, CM-508d (Minolta Co., Ltd Japan) (Stojceska *et al.* 2008).

Formulation of blends for cookies making: Various blends of whole flours of sorghum, maize and sweet potato were made and separated into two different lots. In the first lot flour blends were made by fixing the amount of maize flour to 10 g/100 g blend (based on pre-trials) and the amount of sorghum and sweet potato flours were varied. SF was varied from 80g-40g/100g blend and SPF was varied from 10-50 g/100 g blend. In the second lot blends of flours were made by fixing the amount of SF to 10 g/100 g blend (based on pre-trials) and the amounts of MF and SPF were varied. MF was varied from 80-40 g/100 g blend and SPF was varied from 10- 50 g/100 g blend.

Preparation of cookies: Cookies were made using the standard procedure (method 10-50D) (AACC 2000). Ingredients used for cookie preparation are given (Table 1). Shortening (fat) and sugar were creamed in a dough mixer (National Manufacturing Company, Colorado, USA) and then dextrose solution was added and mixed for two min. Composite flour, baking powder, sodium bicarbonate and water were added and mixed until the dough was consistent. The dough was placed on wooden sheet and rolled to 5 mm thickness using rolling pin. The dough was cut with round cookie die and placed in a greased baking tray. The cookies were baked at 200°C for 10 min, cooled to room temperature and packed in aluminium laminates.

Sensory evaluation: Cookies made from the blends were subjected to sensory evaluation to obtain the best two samples, one from each lot. Ten panelists assessed the cookies as per Hedonic Rating Test for taste, texture, color and overall acceptability (Larmond 1970).

Physico-chemical characteristics, protein solubility and protein digestibility of cookies: The most acceptable cookie samples from each lot, selected on the basis of sensory evaluation were analyzed for protein, fat, ash, crude fibre, (AACC 2000) carbohydrates, β-carotene, vitamin C and colour values L, a and b as per standard procedures. For determination of protein solubility, cookie sample was ground and sieved (60 mesh or 250 microns particle size). Approximately 35 ml of deionized water was added to 5 g ground cookie sample and kept overnight. The suspension was centrifuged at 750 rpm for 15 min. Protein content was determined using Kjeldahl method. Protein digestibility was estimated by enzymatic method of Akeson and Stahmann (1964) with slight modifications.

Statistical analysis: The data obtained were analyzed statistically by analysis of variance (ANOVA) using standard statistical software (SPSS version 16.0, SPSS Inc Chicago, USA) (Singh *et al.* 1991).

RESULTS AND DISCUSSION

Chemical analysis of sweet potato, maize and sorghum flours: Sweet potato flour (SPF) had lowest protein content as compared to maize flour (MF) and sorghum flour (SF). Although sweet potato is low in protein content (Table 2), it has been reported to be of good biological value, in both fresh and flour form (Chassy *et al.* 2008). Hence, it could serve as an important protein source for low-income consumers, especially for those whose diets contain protein

Table 1 Ingredients used in cookies preparation

Ingredient	Quantity
Flour (g)	100
Fat (g)	42.0
Sugar (g)	56.0
Dextrose (g)	1.1
Sodium bicarbonate (g)	1.0
Baking powder (g)	1.0
Water (ml)	10-15

Table 2 Nutritional analysis (db) of sweet potato, maize and sorghum flour

	SF	MF	SPF
Protein	10.91 ± 0.89	9.11 ± 1.01	1.98 ± 0.36
Fat	4.49 ± 0.07	5.43 ± 0.18	0.85 ± 0.05
Ash	1.89 ± 0.02	2.03 ± 0.06	1.71 ± 0.06
Crude fibre	2.56 ± 0.02	1.85 ± 0.08	1.05 ± 0.02
Carbohydrates	82.71 ± 0.60	83.43 ± 1.36	95.45 ± 0.50
β-Carotene μg/100g)	351.00 ± 29.00	1175.00 ± 15.00	613.22 ± 2.02
Vitamin C (mg/100g)	ND	ND	31.86 ± 1.75
Tannins (μg/100g)	5091.00 ± 2.00	104.00 ± 3.00	561.50 ± 1.50
Calcium (mg/kg)	341.50 ± 1.50	313.00 ± 3.00	655.00 ± 3.00
Iron (mg/kg)	47.85 ± 0.25	72.50 ± 1.50	44.20 ± 0.30
Potassium (mg kg)	2918.00 ± 2.00	2844.00 ± 3.00	4772.00 ± 4.00
Sodium(mg/kg)	101.00 ± 0.20	87.25 ± 0.25	166.60 ± 0.40

MF, Maize flour; SF, Sorghum flour; SPF, Sweet potato flour. *Means (±SD) of triplicate analysis

derived mostly from foods of vegetable origin. SPF had low fat content (0.85±0.05%) as compared to MF (5.43±0.18%) and SF (4.49±0.07%). Eleazu and Ironua (2013) reported fat content of 0.65±0.03% in sweet potato flour. Rai *et al.* (2014) reported 4% fat content in sorghum which was lower than that obtained in this study (4.49±0.07%). Sorghum flour had higher crude fibre content than maize and sweet potato flours. The crude fibre content in sweet potato flour (1.05±0.02%) was in the range of 0.72–4.89% as reported by Samiha (2015). Carbohydrates account for the bulk of the flour and are a good energy source (Adeyeye and Akingbala 2016). SPF had higher carbohydrates than MF and SF (Table 2).

MF had higher beta carotene content (1175.00±15.00μg/100g) than SF and SPF (Table 2). The β-carotene content in SPF was 613.22±2.02 μg/100 g. Burgos *et al.* (2001) opined that the β-carotene content varied with intensity of colouration of the sweet potatoes. Vitamin C content in SPF was 31.86±1.75 mg/100 g. This amount was higher than the amount reported by Samiha (2015) in orange sweet potato flour (26.86 mg/100 g) and white sweet potato flour (20.76 mg/100 g). SF had higher tannins content (5091.00±2.00 μg/100 g) than MF (104.00±3.00 μg/100 g) and SPF (561.50±1.50 μg/100 g) (Table 2). The amount was higher than reported by Amir *et al.* (2015) in two Sudanese sorghum varieties (1720 μg/100 g and 90μg/100 g respectively). SPF had higher calcium, potassium and sodium contents than MF and SF. However, MF had higher iron content. Sweet potato is known to be a good source of calcium and iron.

Functional and physical properties of the flours: WAI is an important functional property that indicates the ability of flour to associate with water. SPF showed higher WAI (3.13±0.01) than MF (2.41±0.02) and SF (2.12±0.05) (Fig 1). The high WAI of SPF may be attributed to the presence of higher amount of carbohydrates (starch) in this flour. High WAI is favourable in various food products like soups, dough and baked products. WSI is related to the presence of soluble molecules in the flour. WSI was higher in SPF (10.36±0.72%) than in MF (6.08±0.04%) and SF (5.32±0.08%). SPF had higher FAI than MF and SF. FAI is indicative of the ability of proteins in the flour to bind with oil, thus making it useful in food system where optimum oil absorption is desired. Moreover, it facilitates enhancement in flavor and mouth feel when used in food preparation.

Physical properties bulk density (BD) and colour of SF, MF and SPF are shown in Table 3. MF had the highest bulk density. High bulk density the bulk density, lesser is the storage and transportation space volume required as greater quantity of flour can be packed in a given volume of container or space (Kaur *et al.* 2014). L* value was recorded highest for sweet potato flour (92.47±0.47) which signifies the degree of lightness. L* values for maize and sorghum flours were (85.00±0.17) and (79.13±0.06) respectively and were lower than the value for sweet potato flour. Maize flour showed higher a* value (3.30±0.00) than sorghum (-0.60±0.01) and sweet potato (-3.57±0.21) flours, which signifies that had more reddish pigments than others. Maize flour showed higher b* value (34.91±0.02) than other sorghum (14.81±0.01) and sweet potato (13.80±0.00) flours which indicates that had more yellowish pigments, i.e. carotenoids.

Sensory evaluation of cookie prepared from different combination of sorghum, maize and sweet potato flours: Cookie samples were subjected to sensory evaluation in

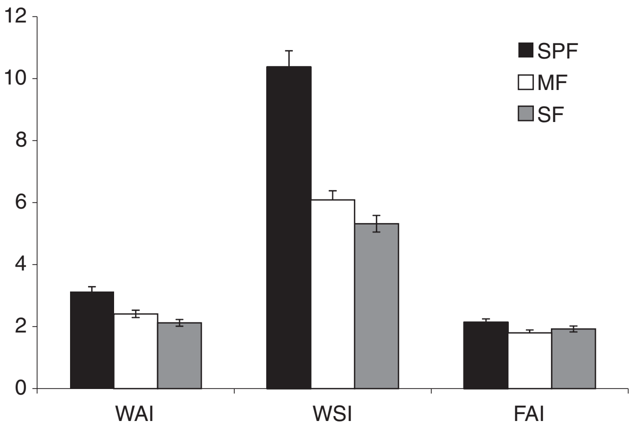

Fig 1 Functional properties of sweet potato (SPF), maize (MF) and sorghum (SF) flour. WAI, Water Absorption Index; WSI, Water Solubility Index; FAI, Fat Absorption Index.

Table 3 Physical properties of sweet potato, maize and sorghum flour

Sample	Bulk density (BD) (g/ml)	L	a	b
SF	0.69±0.02	79.13±0.06	0.60±0.01	14.81±0.01
MF	0.73±0.02	85.00±0.17	3.30±0.00	34.91±0.02
SPF	0.68±0.00	92.47±0.47	3.57±0.21	13.80±0.00

MF, Maize flour; SF, Sorghum flour; SPF, Sweet potato flour. *Means (±SD) of triplicate analysis

order to obtain most acceptable cookie from each of the two lots. The means of sensory attributes such as appearance, colour, texture, odour, mouth feel and overall acceptability were not significantly different at P≤0.05 between samples in both lots (Fig 2a, b). In lot A, there was an increase in colour scores with increase in proportion of SPF and decrease in SF in the blend. The darker colour of cookies prepared from blends with higher proportion of SF may have resulted in slightly lower colour scores. Sorghum with a pigmented pericarp may impart natural dark colour to food products (Dykes and Rooney 2006). In lot A, sample A4 (SF: MF: SPF (50:10:40) had highest overall acceptability (7.57±0.82). This may be attributed to higher scores for colour, texture and odour. In lot B, B3 (SF: MF: SPF (10:60:30) was most acceptable (7.61±0.67). It also had the maximum score for appearance (top grain) and colour.

Physico-chemical analysis of cookies: Results for physico-chemical analysis of the most acceptable samples are shown in Table 4. Higher protein content in A4 than B3 may be a result of higher proportion of sorghum flour in A4 blend. Similarly, higher content of carbohydrates in A4 was a result of higher proportion of sweet potato flour. Adeyeye and Akingbala (2016) reported a decrease of moisture, crude fibre, fat and protein content of the cookies from different flour blends as the percentage of sweet potato flour in the blends increased. The ash and carbohydrates contents increased as the percentage of sweet potato flour in the blends increased.

A4 cookie sample, with more sweet potato flour had higher vitamin C content than B3 but it had higher content of tannins due to higher amount of sorghum flour. Tannins, the major phenolic compounds in sorghum, are related to higher antioxidant activity, especially when present as condensed form (Dykes and Rooney 2006). However, tannins are known to bind to nutrients such as proteins, carbohydrates, and minerals and reduce digestibility of these nutrients.

Cookies prepared from blend with more maize flour contained higher beta carotene than sample with lower maize flour (B3). Colour analysis showed that cookie with more maize flour (B3) had higher L* and b* values than A4. The darker colour of SF may have resulted in lower L* value in the cookies prepared with blends containing higher content of SF. Higher protein digestibility was observed for A4 (82.07±0.24) as compared to B3 (80.39±0.32).

Based on sensory evaluation results, two best cookie formulations, i.e. SF:MF: (SPF=50:10:40 and SF:MF:SPF=10:60:30) were found most acceptable. These

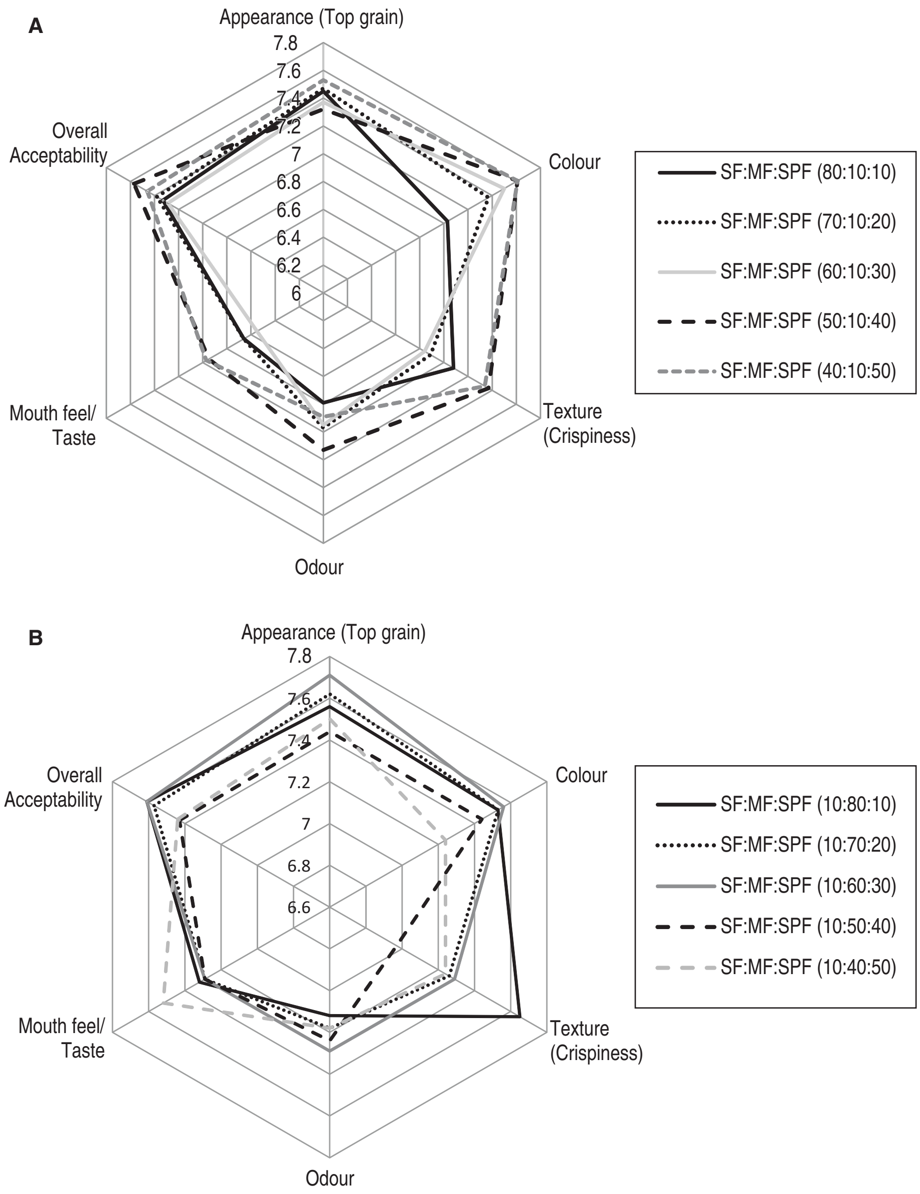

Fig 2 Sensory evaluation of the gluten-free cookies for lot A (a) and B (b).

Table 4 Physico-chemical analysis of cookies

Parameter	A4	B3
Protein	3.97±0.09	3.58±0.38
Fat	23.99±0.68	27.28±1.24
Ash	1.69±0.06	1.08±0.36
Crude fibre	1.03±0.01	1.11±0.01
Carbohydrates	70.35±0.50	68.09±1.82
β-Carotene (μg/100g)	152.17±3.33	164.17±1.44
Vitamin C (mg/100g)	18.20±0.70	15.72±3.15
Tannins (μg/100g)	1426.50±133.50	660.00±100.00
Calcium (mg/kg)	1.64±0.01	8.95±0.03
Iron (mg/kg)	0.06±0.00	3.39±0.01
Potassium (mg/kg)	366.15±0.15	414.27±0.25
Sodium(mg/kg)	180.48±0.45	239.15±0.15
L	61.17±0.21	67.10±0.30
A	4.83±0.12	4.62±0.02
B	21.10±0.10	29.70±0.02
Protein solubility (%)	0.09±0.01	0.10±0.01
Protein digestibility (%)	82.07±0.24	80.39±0.32

*Means (±SD) of triplicate analysis, ** A4 (SF:MF:SPF =50:10:40), B3 (SF:MF: SPF =10:60:30)

cookies were rich in carbohydrates, β-carotene, vitamin C, and the minerals potassium and calcium. These cookies may serve as nutritious diets for people suffering from gluten intolerance. Such products would also help in value addition of these neglected food sources.

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