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Effect of Incorporation of Sorghum Flour to Wheat Flour on Quality of Biscuits Fortified with Defatted Soy Flour

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Abstract: Biscuits prepared from flour blends containing varying proportions of sorghum flour (0, 10, 20, 30, 40, 50 and 60%) and fortified with 5% defatted soy flour, were evaluated for different quality parameters. Spread ratio was decreased with increased proportions of sorghum flour in biscuits. Dough strength decreased but hardness, toughness, average breaking force and average breaking energy of biscuits increased ($p<0.001$) with increased proportions of sorghum flour. L* values decreased while a* value increased ($p<0.001$) with increased proportion of sorghum flour, resulting in the darkening of biscuit samples but on sensory evaluation, mean sensory scores for different level of sorghum flour incorporated biscuits fortified with 5% defatted soy flour, for all the sensory attributes, were more than the minimum acceptable score of 6 with highest overall acceptability at 10% sorghum flour level.

Key words: Sorghum biscuits, defatted soy flour, spread ratio, texture, colour, sensory evaluation

INTRODUCTION

Sorghum is a staple food for a large section of the people especially in dryland regions but nowadays coarse cereals and millets are gaining popularity amongst those who are accustomed to softer cereals like wheat and rice because of the presence of soluble and insoluble dietary fibre, beneficial in various degenerative diseases. Insoluble fraction of dietary fibre in cereal grains contains large proportion of cellulose, which has beneficial effects in the gastrointestinal tract (Riaz, 1999). The soluble fractions, which consists mainly pectin, arabinoxylan and β-glucans has the ability to lower blood serum cholesterol, through its tendency to increase viscosity in the intestine. Earp *et al.* (1983) identified the mixed linked β-glucans in sorghum pericarp, aleurone and endosperm. These β-glucans are water-soluble and form viscous, sticky solutions. Klopfenstein and Hoseney (1987) observed that rats fed bread prepared from white flour fortified with β-glucan (7% by weight) had serum cholesterol significantly lower than those fed bread from unfortified flour.

Sorghum, for human consumption, is generally utilized in the form of *roti*, snacks (puffed grain), porridges and noodles. Several studies indicated the possibility of incorporating sorghum in wheat flour at various levels for producing bread, biscuits and other snacks (Hulse *et al*., 1980; Chavan and Kadam, 1993). Elmonienm *et al.* (2002) suggested that biscuit with acceptable quality could be made from wheat dough containing 20% sorghum flour. The demand of biscuit, named Deliken, produced with 20% flour from the sorghum variety - Ntenemissa was very high (Anonymous, 2002). It has been reported that replacing wheat with 20% non-wheat flour for the manufacture of bakery products would result in an estimated savings in foreign currency of US$320 million annually (FAO, 1982). By making

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extensive use of cereals, other than wheat, like sorghum and other millets, grown widely in India, diversified food products with special features could be prepared. Incorporation of Defatted Soy Flour (DSF) in a small quantity will improve the protein quality of cereal based products without causing significant difference in the acceptability of the developed product. Mridula and Wanjari (2006) observed that the flavour and taste of full fat soy flour incorporated biscuit at 5% level was comparable with the biscuits prepared from refined wheat flour only. Therefore, the present study was carried out to examine the effect of incorporation of higher levels of pearled sorghum flour to wheat flour and fortified with 5% Defatted Soy Flour (DSF) on physical properties, texture, colour, proximate composition and sensory characteristics of biscuits.

MATERIALS AND METHODS

Preparation of Biscuits

Biscuit samples were prepared, using creamery method. The ingredients (g) used in preparation of biscuits were wheat flour or flour blends 100, fat 60, sugar 50, egg 20, baking powder 0.8, vanilla essence 0.02 and required amount of water. Flour blends for making biscuits were prepared using refined wheat flour, substituted with 10, 20, 30, 40, 50 and 60% pearled sorghum flour. All the samples of flour blends were fortified with 5% DSF. Thus, the proportion of wheat flour, sorghum flour and defatted soy flour in flour blends was 95:0:5 (control), 85:10:5, 75:20:5, 65:30:5, 55:40:5, 45:50:5, 35:60:5, respectively. Each biscuit sample was prepared from 500 g flour blend.

The particle size of wheat flour, sorghum flour and defatted soy flour used for making biscuits was 0.254, 0.397 and 0.429 mm, respectively. The particle size of the flour was determined by using sieve shaker machine which carries a set of sieve No. 100, 65, 48, 35, 20, 14, 10 and 8 with pan and cover. A sample of 250 g flour was placed in the upper most sieve and the set of sieves was placed on a sieve shaker machine and was shaken for 5 min. Then material on each sieve was collected and weighed. Average particle size was determined by using following formula:

$$Dp \text{ (average particle size)} = 0.135\ (1.366)^{fm}$$

Where, fm = Fineness modulus (Total percent material retained/100)

Sorghum flour was prepared from sorghum, pearled at 12% moisture for 5 min in a grain pearler (capacity 50 kg h^{-1}), followed by grinding in a sample mill. The dough was prepared in a Hobart mixer and sheeted by using the dough sheeter to a thickness of 6 mm, cut into round shape of 50 mm diameter, transferred to a baking tray and baked at 180°C for 12 min. The cooled biscuits were packed in LDPE bags (50 μ) and evaluated for all different quality parameters after 12 h.

Physical Properties

Diameter, thickness and spread ratio of biscuit samples were calculated as per the AACC (1967) methods. Expansion in diameter and thickness was the ratio of biscuit diameter and thickness before and after baking.

Proximate Composition

Moisture, Protein, crude fat, dietary fiber and ash content were determined as per standard methods (AOAC, 1984).

Textural Properties

Dough strength, hardness of biscuits, breaking strength (peak breaking force), peak breaking energy (toughness), average breaking force and average breaking energy were measured using Texture

Analyzer (TA) TA-HDi. Stable Micro Systems. The dough strength was measured by using SMS/Chen-Hoseney Dough Stickiness Cell (A/DSC) and 25 mm perspex cylinder probe (P/25P). The TA setting was pre-test speed 2.0 mm sec^{-1}, test speed 2.0 mm sec^{-1}, post test speed 10.0 mm sec^{-1} and distance 4 mm. The dough strength was computed from the resulting curve. The distance the sample is extended on probe return on the graph was considered as dough strength.

The hardness of biscuits was measured by using cylindrical probe P/5. The TA setting for all tests, was kept as pre-test speed 3 mm sec^{-1}, test speed 2 mm sec^{-1}, post test speed 10 mm sec^{-1} and distance 5 mm. The individual samples of biscuits were placed on the platform and the probe was attached to the crosshead of the instrument. The peak force from the resulting curve was considered as hardness of biscuits.

Breaking test of biscuit was conducted using HDP/BS blade of texture analyzer. The individual samples of biscuits were placed on the platform such that they were supported at two points and the blade was attached to the crosshead of the instrument. This test simulates the evaluation of hardness by consumer holding the biscuit in hands and breaking by bending. The peak force from the resulting curve was considered as breaking strength of the biscuit and the area under the peak force on the graph is consider as peak breaking energy i.e., toughness. The average force experienced by the probe throughout the breaking test is considered as average breaking force and the total area under the breaking force on the graph is considered as average breaking energy.

Colour Determination

Colour (L*, a* and b* values) of the biscuits was determined by using Handy Colorimeter NR-3000. L* is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates a* and b* represents redness (+a) to greenness (-a) and yellowness (+b) to blueness (-b), respectively.

Sensory Characteristics

Sensory characteristics of biscuits were evaluated for different sensory attributes by a panel of nine scientist of the Institute. Sensory attributes like appearance and colour, texture, aroma, flavour and taste and overall acceptability for all samples were assessed using nine point hedonic scale (IS: 6273, 1971). Hedonic scale was in the following sequence: like extremely - 9, like very much - 8, like moderately -7, like slightly - 6, neither like nor dislike - 5, dislike slightly 4, dislike moderately, - 3, dislike very much - 2, dislike extremely - 1 (Larmond, 1977).

Statistical Analysis

Analysis of variance, F-Ratio and multiple R^2 (regression coefficient) for the data of the study were computed using Statistica 7.1.

RESULTS AND DISCUSSION

Biscuits samples were prepared using the flour blends containing different levels of pearled sorghum flour (0, 10, 20, 30, 40, 50 and 60%) to wheat flour with 5% defatted soy flour in all the samples to investigate the influence of sorghum flour on quality of biscuits. During the dough preparation for biscuits, it was observed that sorghum incorporated dough samples were crumbly than the control dough and also comparatively difficult to sheet at 50 and 60% sorghum flour levels. Incorporation of sorghum flour to wheat flour affected the dough strength significantly (Table 2). As the proportion of sorghum flour in flour blends increased, dough strength was decreased ($p<0.001$). Decreased gluten and higher fiber content in the dough samples with higher level of sorghum flour and reduced proportion of wheat flour are the possible reasons for decreased dough strength. Morad *et al.*

Table 1: Analysis of variance for some physical properties of sorghum flour incorporated biscuits fortified with DSF

Physical properties	SS	df	MS	F-value
Diameter	291.2	6	48.5	149.4*
Expansion in diameter	00.1027	6	00.017	151.4*
Thickness	00.16	6	00.027	19.0*
Expansion in thickness	00.0046	6	00.0008	28.0*
Spread ratio	03.642	6	00.607	564.0*

*p<0.001

Table 2: Analysis of variance for different textural properties of sorghum flour incorporated biscuits fortified with DSF

Particular	SS	df	MS	F-value
Textural properties				
Dough strength	00.0186	6	00.0031	4.99*
Hardness	153.64	6	25.61	56.2*
Breaking strength	144.01	6	24.0	25.52*
Toughness	08.512	6	01.419	34.5*
Average breaking force	42.29	6	07.05	19.12*
Average breaking energy	01.884	6	00.314	9.87*
Colour (L*, a* and b* values)				
L* values	148.9	6	24.8	33.8*
a* values	33.15	6	05.525	43.13*
b* values	17.09	6	02.85	6.08*

*p<0.001

(1984) reported the deterioration in rheological properties with increasing levels of sorghum in blends, could be attributed to the dilution of wheat gluten upon sorghum substitution. Studies indicated a decline in quantity and quality of gluten content in blends with the increased proportion of sorghum flour (Rao and Rao, 1997). The study carried out by Brennan and Samyue (2004) showed a reduction in the viscopasting properties of the flour dietary systems with increased fibre content.

Expansion in diameter (multiple $R^2 = 0.93$), thickness (multiple $R^2 = 0.64$) and spread ratio (multiple $R^2 = 0.98$) were decreased significantly with increased proportions of sorghum flour (Table 1), may be due to decreased dough strength with increased proportion of sorghum flour. Brennan and Samyue (2004) observed that dietary fiber of the biscuit formulations also affected the thickness development during cooking.

Textural properties of biscuits are one of the most important quality parameter, which affect the demand for biscuits. The hardness of sorghum flour incorporated biscuits up to 20% was comparable with the control biscuits. Thereafter biscuit hardness increased at 30 and 40% sorghum flour levels but again a decrease was observed at 50 and 60% sorghum flour levels (Fig. 1). The similar trend was also observed in the breaking strength (peak breaking force) of different biscuit samples. As the proportion of sorghum flour increased, peak breaking energy (toughness), average breaking force and average breaking energy of biscuit samples also increased (Table 2). Higher fibre content in sorghum flour than wheat flour may be attributed to the increased toughness of the biscuits in proportion to the sorghum flour levels. Although the biscuits samples with higher proportion of sorghum flour were tougher as compared to control biscuits but found acceptable on sensory evaluation.

The colour of the food products is the first attribute that affects the decision of consumer for purchasing or consuming any food products. The results (Table 2) indicated that the proportions of sorghum flour affected the colour of biscuits significantly. The L* values (whiteness) of biscuit samples decreased while a* value (redness) increased with increased proportion of sorghum flour, but no specific trend was observed on change in b* values of different biscuit samples (Fig. 2). The decreased L* values and increased a values resulted in the darkening of the biscuits, which ultimately affected the sensory scores for appearance and colour but the appearance and colour of biscuits, even with higher proportions of sorghum flour, was well accepted during sensory evaluation. Crabtree and Dendy (1977) also stated the darkening of colour of the product, as the proportion of millet increased.

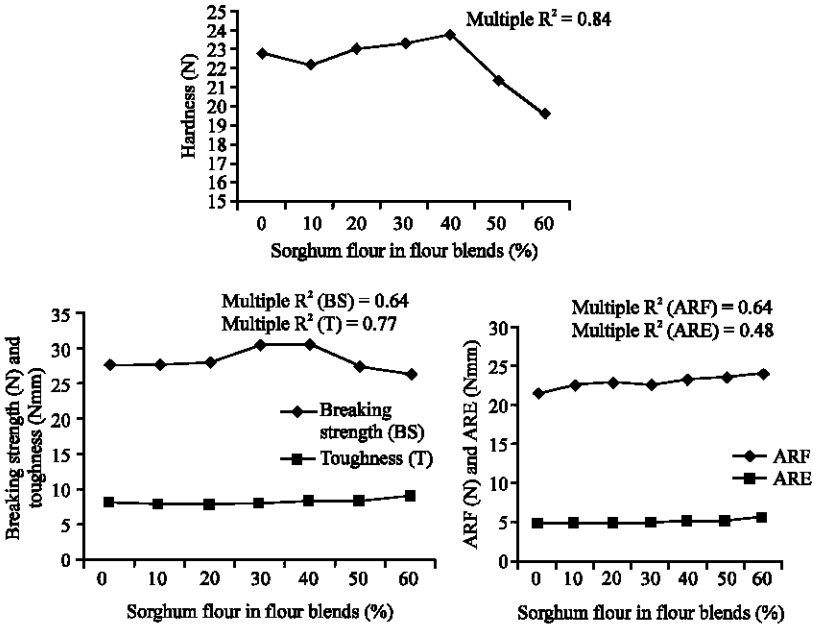

Fig. 1: Effect of different levels of sorghum flour in flour blends (0, 10, 20, 30, 40, 50 and 60%) on textural properties of biscuits fortified with 5% DSF

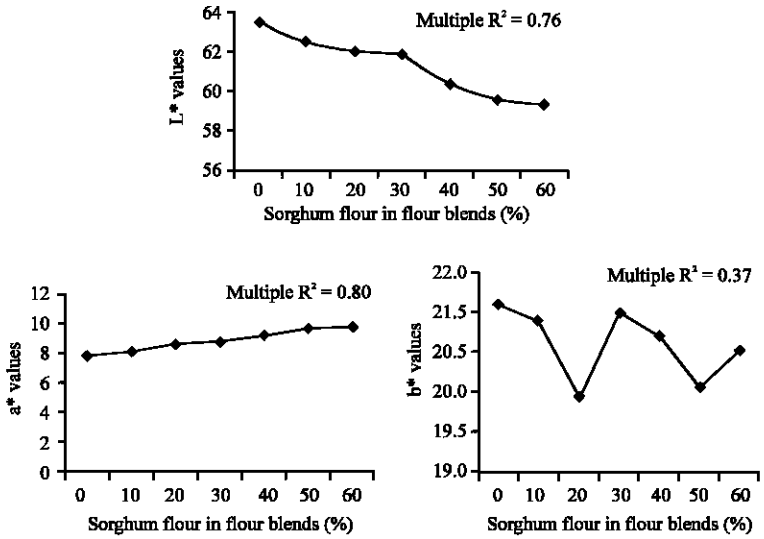

Fig. 2: Effect of different levels of sorghum flour in flour blends (0, 10, 20, 30, 40, 50 and 60%) on colour (L*, a* and b* values) of biscuits fortified with 5% DSF

The proximate composition (% dry weight basis) of wheat flour, sorghum flour and defatted soy flour used in the preparation of biscuits were protein 10.47, 9.67 and 56.31; fat 1.4, 1.11 and 1.09; ash 0.73, 1.14 and 6.42; total dietary fibre 0.42, 3.18 and 3.78 and carbohydrates 86.98, 84.73 and 32.40%, respectively. Moisture content of the different biscuit samples, baked at same temperature and time

was similar ($p>0.05$). Although the protein content in control biscuit samples was slightly higher but the higher percentage of dietary fibre and mineral content (Fig. 3) with overall acceptability scores in the range of 7.69 to 7.08 for biscuits containing sorghum flour from 10 to 50% and fortified with 5% DSF, showed the possibility of incorporation of sorghum flour with 5% DSF in biscuits on commercial scale.

As level of sorghum flour increased (Table 3) the sensory scores for sensory texture, flavour and taste and overall acceptability decreased. The effect of sorghum flour was also found significant on other attributes like appearance and colour and odour of biscuits. The mean sensory scores, for different sorghum flour incorporated biscuits, for all the sensory attributes were more than the minimum acceptable score of 6. The results thus indicated that the biscuits prepared from different level of sorghum flour with 5% defatted soy flour were accepted by the panelist with highest acceptability at 10% sorghum flour level.

Table 3: Effect of different levels of sorghum flour in flour blends on sensory quality of biscuits fortified with 5% DSF

Sorghum flour in flour blends (%)	Appearance and colour	Texture	Aroma	Flavour and taste	Overall acceptability
0	7.72	7.61	7.44	7.56	7.64
10	7.75	7.74	7.47	7.56	7.69
20	7.28	7.56	7.28	7.52	7.50
30	7.22	7.61	7.17	7.28	7.33
40	7.50	7.43	7.14	7.22	7.28
50	7.06	7.28	7.22	7.25	7.08
60	6.83	6.61	6.75	6.89	6.75
Analysis of variance for different sensory attributes					
df	6	6	6	6	6
SS	6.256	7.914	3.12	3.204	5.913
MS	1.043	1.319	0.521	0.534	0.985
F-ratio ($p<0.001$)	29.30	30.67	7.36	9.93	16.46

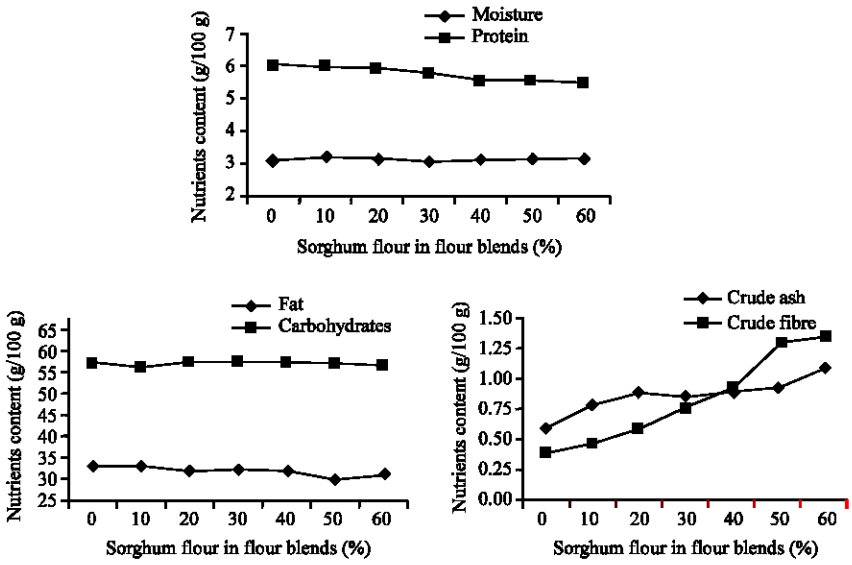

Fig. 3: Effect of different levels of sorghum flour in flour blends (0, 10, 20, 30, 40, 50 and 60%) on proximate composition of biscuits fortified with 5% DSF

CONCLUSION

Substitution of wheat flour with pearled sorghum flour and fortified with 5% DSF affected the physical, textural, nutritive and sensory characteristics of biscuits in general. However, the study showed that pearled sorghum flour can be utilized for making acceptable quality biscuits up to 50% levels with 5% DSF but the best sensory acceptability of biscuits with highest mean sensory scores for appearance and colour (7.75), texture (7.74), flavour and taste (7.56) and overall acceptability (7.69) of the biscuits was observed for the biscuits containing 10% sorghum flour.

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