Quality characteristics and nutritional value of pearl millet composite bread supplemented with soy flour

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Abstract

The aim of this study was to characterize the effect of soy addition on the quality of pearl millet flour composite bread. Bread with 30% pearl millet flour was developed. Further 5% soy flour and 10% gluten were incorporated in pearl millet composite flour by replacing wheat flour and to flour developed breads were analyzed for physical, textural, sensory and nutritional quality. Wheat bread was superior in specific volume, texture and sensory quality. The texture of pearl millet bread improved on addition of soy and gluten, on significant decrease in the hardness. Sensory quality of soy and gluten incorporated bread was on par with pearl millet composite bread. On addition of pearl millet; fat, dietary fibre of wheat bread was enhanced. Soy and gluten supplementation showed further enhancement in the protein, dietary fibre, and ash. Supplementation of non-gluten flours enriched the nutritional quality of wheat bread and would meet the demand of population for nutrient dense bread with good acceptability.

Keywords: Pearl millet, Nutritional quality, Soy, Gluten, characteristics quality.

1. Introduction

Recently with the modernization and changing food habits the consumption of convenient ready to eat (RTE) cereal foods is increasing throughout the world and bread has become a staple food of the modern diet. Traditional Yemeni bread depends on the quality of agricultural cereals produced and food habits because it varies from region to other, preparing bread from pearl millet flour, corn flour, wheat flour and lentils flour composite bread, in the recent period traditional bread is made from wheat flour. Apart from being a good source of calories and other nutrients, the cereal proteins are deficient in essential amino acids such as lysine and threonine, but have good Sulphur amino acid content (Eggum and Beame,1983). The consumption of bread and other baked goods produced from wheat flour is very popular, but the low protein content of wheat flour, which is the most vital ingredient used for the production of different kinds of baked goods has been major concern in its utilization (Young, 2001). Supplementation of wheat flour with inexpensive staples, such as cereals and pulses help in improving the nutritional quality of wheat products. The use of composite flours for product development and / or for value addition is also recent development across the globe owing to some health, economic and social reasons as well as increased demand for nutritious products. Utilization of locally grown cereals in baking industry is an additional advantage for the farmers to have more economic value to crop, better remuneration, value addition and diversified health products.

Millets are indigenous small-seeded cereals that, unlike wheat or rice can be cultivated in semi-arid and subtropical agronomic conditions throughout the world. Millets are rich in vitamins, minerals, Sulphur containing amino acids and phytochemicals, and hence are termed as “nutri-cereals". Moreover, they have higher proportions of non-starchy polysaccharides and dietary fibres thus have a low glycemic index (Chhavi and Sarita, 2012). As an

important component crop, soy is the legume richest in nutrients, is known to be a good source of the trace elements copper, zinc and manganese, and can be said to contain all the nutrients needed in food (Ampofo, 2009). Soybean is an excellent source of protein (35-40%), hence the seed is the richest in food value of all plant foods consumed in the world (Olaoye et al., 2006). Supplementation of wheat flour with not more than 30% soy bean flour would greatly improve the quantity of nutritional protein in bread. The increase in the protein content of the bread could be due to the significant quantity of nutritional protein in the soy bean seeds (Basman, and Koksel, 2003). It is also rich in calcium, iron, phosphorus and vitamins. It is the only source that contains all the essential amino acids (Olaoye et al., 2006). Several researchers have investigated the effect of supplementation of wheat flour with soy and other legume flours for making products such as bread (Dhingra and Jood, 2001; Olaoye et al., 2006; Abioye et al,. 2011; Ndife et al., 2011). Replacement of wheat flour with millet flour upgrades the nutritional quality of bread and up to 30 to 50% millet flours can be incorporated in bread without affecting its sensory qualities (Chhavi and Sarita, 2012; Mannuramath, et al., 2015 and Ballolli et al., 2014 respectively). The benefits of these composite flours are largely centered on nutritional considerations.

Recently, consumers' awareness of the need to eat high quality and healthy foods – known as functional foods, that is, foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements, is increasing (Ndife and Abbo, 2009). Therefore, the trend is to produce specialty breads made from whole grain flour and other functional ingredients known as health breads or functional foods (Dewettinck et al., 2008). Hence, the purpose of this investigation was to characterize the effect of soy addition on the quality of pearl millet flour composite bread. Composite flours affect baking and sensory quality of breads. Therefore, to counteract the deleterious effects of legume flour in composite breads, additions of gluten have also been evaluated.

2. Materials and methods

Pearl millet (*Pennisetum glaucum*) grains and, wheat flour (Sanibel), soybean grains, sugar, salt, sunflower oil, dry yeast (Saf-instant) and gluten were purchased from the local market-Yemen. Pearl millet grains were cleaned, washed and dried. Soybean grains were cleaned, washed, soaked, germinated in plastic trays after being placed on top of a piece of wet cloth, put in incubator to 48 hr., at 25^0c, and dried. Pearl millet grains and soybean grains milled in two stages, the first stage: the grain was crushed by a laboratory grinder**.** Second stage: Milled by laboratory mill - Brabender OHG Duris burg - Germany, and Keep the flour without sieve in closed polyethylene bags and stored until use.

2.1. Preparation of composite flours

Pearl millet flour was blended at 30% level with wheat flour to develop pearl millet composite flour. Further, 5% soy flour and 10% gluten were added in the developed pearl millet composite flour by replacing wheat flour.

2.2. Method of preparation of bread

A standard method of preparation of bread given by (Mannuramath et al., 2015) was followed for the wheat flour bread. Ingredients used for bread making were 150 g flour, 2.25 g dry yeast, 9 g sugar, 7.5 g oil and 2.4 g salt. An adequate amount of water by using Farinograph, was determined according to (AACC.38-12.02, 2000). Optimized method of Pearl millet composite bread for processing conditions was used to prepare composite breads (Priyadarshani, and Nirmala, 2016).

2.3. Physical quality characteristics of bread

Bread loaves were weighed 2 hr. after baking, using a laboratory scale balance and the readings recorded in grams. Height, length and width of the bread loaves were measured by measuring scale. The loaf volume was determined using seed (salgam seeds) displacement method. Specific volume was calculated as volume to mass ratio (cm3**/**g).

2.4. Texture analysis

Instrumental Texture Profile Analysis (TPA) of bread was performed with a TA. XT2i **.**Texture Analyzer (Stable Micro Systems **,**Surrey, UK). The selected settings were Mode - Measure force in compression, option return to start, Pre -Test speed-1.00 mm.s^{-1}. Test speed- 1.7 mm/ s^{-1}. Post-Test speed - 10 mm/ s^{-1}, Distance – 5mm, time-30 sec, trigger force - Auto -5 g, tare mode - Auto, data acquisition rate - 250pps, probe - 35 mm end aluminum compression disc (Probe P/ 35**.)**, TPA was carried out using Texture Export Exceed software. Triplicate measurements were made for all breads.

2.5. Colour measurement

Colour of the bread samples was measured using a Hunter Lab Colorimeter. Hunter lab colorimeter value L* (0-black, 100- white), a ***(+value – red, - value- green) and b*** (+ value- yellow, -value-blue) were recorded.

2.6. Sensory evaluation of bread

Sensory evaluation of bread was carried out by ten member trained panel of Food Science department using 9 - point hedonic scale. The rating was ranged from 9- like extremely to 1-dislike extremely

2.7. Chemical analysis of bread

Bread samples were analyzed for moisture **,**protein, fat, Dietary fibre and ash content by using standard methods (AOAC 2000). Carbohydrate content of bread samples was calculated by difference.

Statistical analysis

A minimum of three replications were performed for each analysis. Statistical analysis was conducted to compare treatment means by using one-way ANOVA procedure of SPSS software, version 16.0 **.**

3. Results

3.1. Physical characteristics

There were significant (P< 0.05) differences in the loaf weight, volume and specific volume, whereas, changes found in the loaf height, width and length were statistically non-significant (Table 1)**.**

Table.1 Physical characteristics of soy flour and gluten incorporated bread

Breads	Loaf weight (g)	Loaf Height (cm)	Loaf Width (cm)	Loaf Length (cm)	Loaf volume (cm^3)	Specific volume (cm^3/g)
WC	118.84^{b}±1.43	6.2^{a}±0.37	5.8^{a}±0.27	12.87^{a}±0.43	421.33^{a}±4.76	3.52^{a}±0.04
PMC	120.07^{b}±1.75	5.63^{a}±0.53	6.0^{a}±0.22	12.98^{a}±0.58	377.42^{b}±4.20	3.12^{b}±0.11
PMSG	124.12^{a}±1.15	5.6^{a}±0.58	5.9^{a}±0.45	12.97^{a}±0.39	373.33^{b}±4.08	2.98^{c}±0.03
F.value	20.259	2.708	1.126	0.109	209.406	92.278
S. Em±	0.60	0.20	0.14	0.19	1.78	0.03
CD (5%)	1.80	NS	NS	NS	5.36	0.09

[a] WC- wheat flour control, PMC- pearl millet composite, PMSG- pearl millet soy gluten, mean ±SD **,**means with the same superscript letters within a column are not significantly different at 5% level**.**

3.2. Textural quality

Incorporation of germinated soy flour and gluten showed significant improvement in the textural quality of pearl millet composite flour bread (Table 2).

Table.2 Textural quality of soy flour and gluten incorporated bread

Breads	**Hardness (N)**	**Springiness**	**Cohesiveness**	**Gumminess (N)**	**Chewiness (N)**	**Resilience**
WC	7.93 [c] ±0.10	0.93 [b] ±0.00	0.71 [a] ±0.03	5.94 [b] ±0.13	5.33 [b] ±0.24	0.39 [a] ±0.03
PMC	15.51[a] ±0.60	0.91 [c] ±0.01	0.51 [b] ±0.01	7.60 [a] ±0.13	6.76 [a] ±0.21	0.26 [b] ±0.04
PMSG	10.94 [b] ±0.74	0.96 [a] ±0.00	0.67 [a] ±0.01	7.50 [a] ±0.50	7.21 [a] ±0.30	0.29 [b] ±0.04
F.value	95.271	42.931	78.040	27.366	45.579	13.489
S.Em±	0.374	0.005	0.005	0.177	0.144	0.025
CD (5%)	1.29	0.02	0.02	0.62	0.50	0.09

[a] WC- wheat flour control, PMC- pearl millet composite, PMSG- pearl millet soy gluten, mean ±SD **,**Means with the same superscript letters within a column are not significantly different at 5% level**.**

3.3. Colour of bread crust and crumb

Significant differences were noticed in the colour of breads (Table 3). Incorporation of soy flour and gluten significantly increased the L*, a* and b* values of crust and a* and b* values of crumb with significant decrease in the L* value of crumb.

Table.3 Mean crust and crumb colour values of soy flour and gluten incorporated bread

Breads	**Crust**			**Crumb**		
	L*	**a***	**b***	**L***	**a***	**b***
WC	38.89 [b] ±0.16	18.27 [b] ±0.04	24.12 [b] ±0.12	72.28 [a] ± 1.00	1.12 [c] ±0.03	18.17 [b] ±0.15
PMC	31.99 [c] ±0.03	16.85 [c] ±0.05	19.75 [c] ±0.10	71.24 [a] ±0.39	138 [b] ±0.03	18.26 [b] ±0.05
PMSG	39.41 [a] ± 0.42	18.89 [a] ±0.06	27.25 [a] ±0.42	67.19 [b] ±0.85	2.60 [a] ±0.09	18.70 [a] ±0.05
F.value	562.641	1331	635.827	31.566	553.99	14.588
S.Em±	0.14	0.02	0.14	0.45	0.03	0.06
CD (5%)	0.52	0.08	0.51	1.58	0.10	0.23

[a] WC- wheat flour control, PMC- pearl millet composite, PMSG- pearl millet soy gluten, mean±SD, means with the same superscript letters within a column are not significantly different at 5% level**.**

3.5. Sensory quality of bread

The mean sensory scores of refined wheat flour bread for appearance were significantly high (8.9) when compared with pearl millet bread (7.4) and soy and gluten added bread 7.5 (Table 4). Sensory scores of crust and crumb colour of wheat flour were 8.6 and 8.8 respectively. Addition of soy flour and gluten showed positive effect on the crust colour of bread with the mean sensory score of (7.7). No significant difference was observed in the taste scores of wheat bread and pearl millet bread. Taste score of soy flour and gluten incorporated breads were found to be declined significantly when compared with the pearl millet composite bread (7.1) and (8.1) respectively. Texture of pearl millet composite bread was improved with the addition of soy flour and gluten. No significant difference was by observed in the overall acceptability of wheat flour and pearl millet flour and later with that of soy and gluten added bread.

Table.4 Sensory quality of soy flour and gluten incorporated bread.

Breads	**Appearance**	**Crust Colour**	**Crumb Colour**	**Taste**	**Crust texture**	**Crumb texture**	**Flavour**	**Mouth feel**	**Overall acceptability**
WC	8.9^{a}±0.3	8.6^{a}±0.5	8.8^{a}±0.4	8.4^{a}±0.5	8.6^{a}±0.5	8.9^{a}±0.3	8.5^{a}±0.7	8.1^{a}±0.4	8.4^{a}±0.3
PMC	7.4^{b}±0.7	7.6^{b}±0.7	7.7^{b}±0.4	8.1^{a}±0.6	7.3^{b}±0.7	7.4^{b}±0.8	7.6^{b}±0.8	7.4^{b}±0.9	7.8^{b}±0.6
PMSG	7.5^{b}±0.7	7.7^{b}±0.4	7.5^{b}±0.8	7.1^{b}±0.7	7.6^{b}±0.5	7.6^{b}±0.5	7.4^{b}±0.7	7.4^{b}±0.5	7.4^{b}±0.7
F value	19.37	13.45	12.97	10.03	20.32	18.46	14.23	14.23	18.03
S.Em±	0.24	0.24	0.25	0.26	0.18	0.24	0.20	0.24	0.23
CD (5%)	0.71	0.72	0.73	0.77	0.56	0.71	0.70	0.71	0.68

[a] WC- wheat flour control, PMC- pearl millet composite, PMSG- pearl millet soy gluten, Mean±SD **,**Means with the same superscript letters within a column are not significantly different at 5% level

3.6. Nutrient composition of breads

Significant difference ($p<0.05$) was observed in the moisture content of wheat flour**,** pearl millet flour and pearl millet soy flour and gluten incorporated breads with a mean per cent moisture content of 32.8, 31.85 and 33.9% respectively (Table 5). The protein content of wheat flour bread was 12.70% which was declined to 11.7 % in case of pearl millet flour bread. However, incorporation of soy flour and gluten showed significantly higher protein content 13.58%. These results were in agreement with those reported by Dhingra and Jodo, (2001) Whom found that protein content of composite bread decreased upon supplementation of barley flour, which was increased with incorporation of soy flour in the flour blend. The fat content for wheat flour bread was 2.73%, which increased significantly to 3.29% on blending with pearl millet flour. A significant decrease was observed in fat content for soy flour and gluten incorporated bread 1.52%. This could be attributed to the fat content of these flours. The dietary fibre increased significantly ($P<0.05$) on blending with pearl millet flour, Ash content of breads varied significantly with the highest 2.34% being for soy and gluten added breads and lowest was found in wheat flour bread 2.03% while the pearl millet composite bread had ash content of 2.23%. The highest carbohydrate content was seen in wheat flour bread with a mean per cent value of 46.96%. Incorporation of soy flour and gluten showed significant decrease 40.23% in the carbohydrate content of bread.

Table.5 Nutrient compositions of soy and gluten incorporated bread

Breads	Moisture (g/100g)	Protein (g/100g)	Fat (g/100g	D. F. (g/100g)	Ash (g/100g)	Carbohydrate (g/100g)
WC	32.8^{ab}±0.9	12.70^{b}±0.21	2.73^{a}±0.07	2.80^{b}±0.10	2.01^{b}±0.03	46.96^{a}±0.85
PMC	31.85^{b}±0.53	11.70^{c}±0.10	3.29^{a}±0.12	8.39^{a}±0.11	2.34^{b}±0.04	42.43^{b}±0.90
PMSG	33. 9^{a}±0.85	13.58^{a}±0.24	1.52^{b}±0.58	8.54^{a}±0.05	2.23^{a}±0.07	40.23^{c}±0.37
F value	5.036	71.442	20.541	3830	49.104	240.553
S.Em±	0.45	0.11	0.20	0.05	0.05	0.04
CD (5%)	1.57	0.38	0.69	0.18	0.09	1.47

[a] WC- wheat flour control, PMC- pearl millet composite, PMSG- pearl millet soy gluten, mean ±SD **,**means with the same superscript letters within a column are not significantly different at 5% level

4. Discussion

The results of Physical characteristics (Table 1) showed that the wheat flour bread was significantly higher specific volume than the pearl millet composite and soy flour and gluten incorporated pearl millet composite bread. This may be due to replacement of gluten with the incorporation of non-gluten flours. The obtained results confirmed the data presented by Sadowska et al., (2003). found that the addition of germinated pea flour resulted in decreased volume of bread. Frank et al., (2006) previously reported that volume of bread decreased with increased addition of grains (flax seed flour at 15% level and soy flour at 5 and 10% level). Moreover, Dhingra and Jood (2001) reported that, the decline in the specific volume of soy flour incorporated wheat breads; and concluded that 15% soy flour addition was organoleptically acceptable.

Hardness, springiness and cohesiveness values were significantly improved with the incorporation of germinated soy flour and gluten in the pearl millet composite flour bread. Though the differences were not significant gumminess and resilience was also improved. This may be due to increase in the soluble dietary fibre content of this bread,

The result of Colour of bread crust and crumb was reflected in the sensory scores of these breads which shown that higher scores for crust with decreased scores for crumb colour. Doxastakis et al., (2002) reported darkened crust colour and increased yellowness of bread crumb with addition of soy flour at 5 to 10% level. This may be because loaves containing additional glucose have a darker crust. This condition is attributed to Maillard browning caused by the reaction between wheat proteins and the added sugar (Fayle and Gerrard, 2002) and caramelization, which are influenced by the distribution of water and the reaction of added sugars and amino acids (Kent and Evers, 1994) due to a higher lysine content (Mohammed et al., 2012).

The sensory analysis results were similar to those reported by Dooshima et al., (2014) declined of taste score and no difference in the overall acceptability for wheat, soy and banana composite flour bread. Nutritional quality viz., protein, dietary fibre and ash content of the soy flour and gluten added bread was found to be superior in comparison with wheat flour as well as pearl millet composite bread .Similarly, Dhingra and Jood (2001) reported increase in the protein, fat and ash content of bread with addition of soy flour at different levels. Significant change was also reported in soluble dietary fibre contents of wheat bread supplemented with barley pulse full fat soy and barley pulse defatted soy flours (Dhingra and Jood, 2001). Wheat flour bread had significantly higher specific volume with better acceptability than the composite breads. Nevertheless, nutritional quality of pearl millet composite bread was superior to that of wheat flour bread which was further enriched with supplementation of soy flour at 5% level and 10% gluten. Textural quality of pearl millet composite flour bread improved significantly as an effect of soy flour and gluten addition. Supplementation of non-gluten flours like millet and soy enriched the nutritional quality of wheat bread. Such functional breads would meet the demand of general population for nutrient dense bread and may help those suffering from metabolic disorders being a healthy choice with good acceptability.

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