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Formulation and quality characterization of flat bread from pearl millet blended composite flour

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ABSTRACT

In the present study, pearl millet flour was blended with refined wheat flour and soy protein isolates for the development of flat bread. The developed products were stored for 18 days to ascertain the changes in physico-chemical and sensory characteristics. In case of flat bread, water absorption of composite flour showed a significant increase with the incorporation of pearl millet flour, whereas gluten content and falling number decreased with the increase in percentage of pearl millet flour. Although, T_6 (40:50:10:: pearl millet flour: refined wheat flour: soy protein isolates in flat bread) treatment recorded highest water absorption, but gluten and falling number were highest in treatment T_1 (00:100:00:: pearl millet flour: refined wheat flour: soy protein isolates). The highest moisture, crude fat, crude fibre and ash content of 26.31, 4.00, 2.81 and 2.53 per cent were recorded in T_6 (40:50:10:: pearl millet flour: refined wheat flour: soy protein isolates). However, T_2 (00:90:10:: pearl millet flour: refined wheat flour: soy protein isolates) recorded highest value of crude protein (16.58 per cent). Sensory evaluation of flat bread revealed that T_1 (00:100:00:: pearl millet flour: refined wheat flour: soy protein isolates) recorded highest mean score for overall acceptability (8.42), whereas T_6 (40:50:10:: pearl millet flour: refined wheat flour: soy protein isolates) recorded lowest mean scores for overall acceptability (6.53).

Key words: Falling number, Gluten, Pearl millet, Sensory, Soy protein isolates

Composite flour technology refers to the process of mixing various cereal and legume flours to produce high quality food products in an economical way. However, the term can also be used with regard to mixing of non-wheat flours, roots and tubers or other raw materials. Formulation of composite flour is vital for development of value added products with optimal functionality (Rehman *et al*. 2007). It has not only better nutritional quality but also the necessary attributes for consumer acceptance.

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is recognized as an important substitute for major cereal crops to cope up with world-wide food shortage and to meet the demands of increasing population of both developing and developed countries (Singh *et al.* 2006). Pearl millet is rich in energy, minerals (important source of thiamine, niacin and riboflavin), vitamin A (about 24 retinol equivalents), 8-15 times greater alpha amylase activity and is gluten free. The protein content ranges from 7.02 to 13.67% and it is low in lysine, tryptophan, threonine (Taylor 2004).

Cereal grains, including wheat are low in protein and are deficient in some amino acids such as lysine (Kumar and Kumar 2011). In contrast, legumes are higher in proteins (18 to 24%) than cereals and can be used to support certain amino acids such as lysine, tryptophan or methionine (Rababah *et al*. 2006). Therefore, soy protein is preferred because of its low cost, accessibility, widely varying functional properties and high content of good quality protein. Soy protein provides several functionalities such as water holding, binding and emulsifying properties (Arrese *et al.* 1991). However, beany flavour limits its expanded applications in food. Of all soy protein products, soy protein isolates (SPI) has the mildest flavour, higher protein content (≥ 90 per cent) and a good balance of amino acid patterns. It is highly recommended for solving protein-malnutrition in developing countries, as an expensive high protein resource. Besides its functional properties such as emulsification and foaming capacity, SPI is also naturally composed of phytochemicals such as isoflavones, which have been shown to possess natural antioxidant activity to combat oxidative degradation that could lead to disease inside the body. Therefore, the present study was undertaken with the objectives to expand the utility of pearl millet by value addition through composite flour preparation and to assess the physico-chemical and sensory characteristics of prepared flat bread.

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MATERIALS AND METHODS

Pearl millet grains of Nandi-61 cultivar were obtained in a single lot from Dryland Research Sub Station, SKUAST-J, Dhiansar (J & K). The grains were cleaned manually to remove any foreign materials and then de-hulled and milled in a running flour mill. After milling, the pearl millet flour was passed through 40 mesh sieve and packed in air tight containers for further use. Refined wheat flour used for the study was procured from local market.

The pearl millet flour and refined wheat flour were blended with soy protein isolates in different ratios as given in Table 1.

For the preparation of flat-bread, yeast was mixed in luke warm water and sugar solution was dissolved in the yeast. The dough was made and kept for fermentation for 5-6 hours. Then again mixed and baked after proofing. The process for preparation of flat bread was standardized in the laboratory as per the method given by Dogra *et al*. (2001).

The treatment combinations of prepared flat-bread were packed in polyethylene pouches (150 gauge) and then stored for a period of 18 days at refrigerated conditions. The stored products were analyzed for physico-chemical changes and sensory characteristics at an interval of 6 days.

Twenty grams of composite flour was taken and required quantity of water added to get a dough of moderately stiff consistency. The amount of water required was noted and expressed in percent (Austin and Ram 1971).

Standard AACC (2000) procedure was followed. The sample was weighed taken in a petri plate, measured amount of water was added to it and a smooth dough ball was made. A resting time of 10 min was given. The ball was then washed under running water in a muslin cloth and all starch and other soluble materials were washed out. A sticky elastic material was left in the end which was the source of gluten.

Seven g sample of composite flour was weighed and combined with 25 ml of distilled water in a glass falling number tube with a stirrer and shaken to form slurry. As the slurry was heated in a boiling water bath at 100^{o}C and stirred constantly, the starch gelatinized and formed a thick paste. The time taken by the stirrer to drop through the paste was recorded as the falling number value.

Moisture content, crude protein, ash, crude fat, crude fibre and carbohydrates were estimated by the method described by AOAC (1995).

For sensory evaluation, samples were evaluated on the basis of overall acceptability by semi-trained panel of 7-8 judges by using 9 point hedonic scale assigning scores 9-like extremely to 1- dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al*. 1965).

Spread plate technique was used for determination of total plate count as described by Palczar and Chan (1997).

The data obtained were statistically analyzed using completely randomized design (CRD) and CRD factorial for interpretation of results through analysis of variance. Each value was mean of three replications. Data was compared at 5 per cent level of significance.

Table 1 Treatment details

Treatment	Pearl millet flour (%)	Refined wheat flour (%)	Soy protein isolates (%)
T_1	0	100	0
T_2	0	90	10
T_3	10	80	10
T_4	20	70	10
T_5	30	60	10
T_6	40	50	10

RESULTS AND DISCUSSION

Physical composition of composite flour

Water absorption is a parameter by which the appropriate amount of the water, needed to generate gluten network (i.e. to make appropriate dough) is determined. Water absorption was recorded maximum (51.06%) in treatment T_6 and minimum (45.50%) in treatment T_1. With the incorporation of pearl millet flour, the water absorption capacity increased (Table 1). This phenomenon might be associated with high fibre content of pearl millet flour than refined wheat flour. An increase in water absorption was also reported by Koca and Anil (2007).

Gluten content was observed to be maximum (24.60%) in treatment T_1 and minimum (15.96%) in treatment T_6 (Table 2) The percentage of gluten decreased significantly with increase in incorporation of pearl millet flour. Similar decrease in gluten percentage with increased percentage of millet flour blend has also been reported by Poongodi and Jemima (2009).

Falling number indicates alpha-amylase activity using starch in the samples as substrate. The maximum (390

Table 2 Effect of treatments on physical parameters of composite flour

Treatment	Water absorption (%)	Gluten content (%)	Falling number (Seconds)
T_1 (00:100: 00:: PMF: RWF: SPI)	45.50	24.60	390
T_2 (00:90: 10:: PMF: RWF: SPI)	46.85	20.00	364
T_3 (10:80: 10:: PMF: RWF: SPI)	47.92	19.70	350
T_4 (20:70: 10:: PMF: RWF: SPI)	48.64	18.65	326
T_5 (30:60: 10:: PMF: RWF: SPI))	49.32	17.00	309
T_6 (40:50: 10:: PMF: RWF: SPI)	51.06	15.96	286
Mean	48.22	19.28	337.5
CD (P=0.05)	2.43	2.12	2.82

seconds) falling number was recorded in treatment T_1 (Table 2) non-significantly followed by T_2 (364 seconds). There was a significant decrease in falling number with the incorporation of pearlmillet flour. Normally, bakery type wheat flour has a falling number between 200 and 300. When the falling number lies below 150, there is great danger that the bread crumb will be sticky, and when the falling number is greater than 350, bread volume is diminished and a dry crumb results, unless the defect is balanced by the addition of malt. The results are in accordance with the findings of Poongodi and Jemima (2009) in millet flour blends who reported decrease in falling number with the incorporation of millet flour.

Chemical composition of stored composite flour blended flat bread

The moisture content of flat bread differed significantly in all the treatments as well as with storage period. At 0 day of storage, the highest moisture content (26.13%) was recorded in T_6 and lowest in T_1 (25.05%) (Table 3). As the storage period advanced, there was increase in moisture content. The mean value of moisture increased from 25.63% at 0 day of storage to 25.93% after 18 days of storage. This might be due to increase in physical parameters such as diameter and thickness exposing more area of flat bread, thus increasing the moisture content. Similar increase in moisture content from 28.50 to 39.50% was reported by Ndife *et al.* (2011) in breads produced from whole wheat and soybean flour blends. At 0 day of storage, treatment T_2 recorded highest protein content (16.78%) followed by T_3 treatment (15.57%) and T_4 (15.44%). However, after 18 days of storage, treatment T_2 (highest value 16.33%) and lowest value was observed in T_1 (11.08%) (Table 3). Storage period also significantly influenced protein content of flat bread. There was a significant decrease in the protein

Table 3 Moisture (%) and crude protein content (%) of composite flour blended flat bread during storage

Treatment	Moisture					Crude protein				
	Storage period (days)					Storage period (days)				
	0	6	12	18	Mean	0	6	12	18	Mean
T_1 (00:100: 00:: PMF: RWF: SPI)	25.05	25.13	25.22	25.29	25.17	11.39	11.23	11.11	11.08	11.23
T_2 (00:90: 10:: PMF: RWF: SPI)	25.28	25.39	25.44	25.50	25.40	16.78	16.67	16.54	16.33	16.58
T_3 (10:80: 10:: PMF: RWF: SPI)	25.54	25.63	25.79	25.88	25.71	15.57	15.43	15.21	14.89	15.27
T_4 (20:70: 10:: PMF: RWF: SPI)	25.81	25.95	26.03	26.12	25.98	15.44	15.23	15.12	14.80	15.15
T_5 (30:60: 10:: PMF: RWF: SPI))	25.97	26.07	26.16	26.29	26.12	15.25	15.14	14.96	14.74	15.02
T_6 (40:50: 10:: PMF: RWF: SPI)	26.13	26.22	26.36	26.53	26.31	15.11	15.00	14.81	14.66	14.89
Mean	25.63	25.73	25.83	25.93		14.92	14.78	14.62	14.42	
	CD(P= 0.05)					*CD (P= 0.05)*				
Treatments	0.02					0.02				
Storage	0.01					0.01				
Treatments × Storage	0.03					0.03				

Table 4 Effect of different treatments and storage period on crude fat (%) and crude fibre content (%) of composite flour blended flat bread

Treatment	Crude fat					Crude fibre				
	Storage period (days)					Storage period (days)				
	0	6	12	18	Mean	0	6	12	18	Mean
T_1 (00:100: 00:: PMF: RWF: SPI)	3.80	3.75	3.69	3.61	3.71	1.32	1.26	1.21	1.16	1.24
T_2 (00:90: 10:: PMF: RWF: SPI)	3.85	3.79	3.71	3.65	3.75	1.38	1.32	1.27	1.21	1.29
T_3 (10:80: 10:: PMF: RWF: SPI)	3.91	3.85	3.78	3.70	3.81	2.09	1.98	1.86	1.75	1.92
T_4 (20:70: 10:: PMF: RWF: SPI)	3.97	3.90	3.86	3.79	3.88	2.35	2.27	2.19	2.14	2.24
T_5 (30:60: 10:: PMF: RWF: SPI))	4.05	3.95	3.90	3.82	3.93	2.66	2.53	2.48	2.42	2.52
T_6 (40:50: 10:: PMF: RWF: SPI)	4.11	4.03	3.96	3.88	4.00	2.91	2.84	2.78	2.71	2.81
Mean	3.95	3.88	3.82	3.74		2.12	2.04	1.96	1.90	
	CD(P= 0.05)					*CD (P= 0.05)*				
Treatments	0.02					0.02				
Storage	0.01					0.01				
Treatments × Storage	NS					0.03				

Table 5 Effect of treatments and storage period on ash (%) and carbohydrate content (%) of composite flour blended flat bread

Treatment	Ash					Carbohydrates				
	Storage period (days)					Storage period (days)				
	0	6	12	18	Mean	0	6	12	18	Mean
T_1 (00:100: 00:: PMF: RWF: SPI)	1.99	1.95	1.89	1.84	1.92	56.44	56.67	56.88	57.01	56.75
T_2 (00:90: 10:: PMF: RWF: SPI)	2.07	2.00	1.93	1.87	1.97	50.64	50.83	51.10	51.44	51.00
T_3 (10:80: 10:: PMF: RWF: SPI)	2.28	2.24	2.19	2.15	2.21	50.61	50.86	51.17	51.63	51.07
T_4 (20:70: 10:: PMF: RWF: SPI)	2.41	2.37	2.32	2.29	2.35	50.02	50.28	50.48	50.86	50.41
T_5 (30:60: 10:: PMF: RWF: SPI))	2.53	2.50	2.46	2.41	2.48	49.54	49.81	50.04	50.31	49.92
T_6 (40:50: 10:: PMF: RWF: SPI)	2.60	2.57	2.51	2.44	2.53	49.14	49.33	49.58	49.78	49.46
Mean	2.31	2.27	2.22	2.17		51.06	51.30	51.54	51.84	
	CD (P= 0.05)					*CD (P= 0.05)*				
Treatments	0.02					0.83				
Storage	0.01					0.68				
Treatments × Storage	NS					NS				

content of flat bread from 0 day to 18 days of storage. The decrease in protein content during storage might be due to hydrolysis of peptide bonds by protease enzyme which is known to cause splitting of protein molecules during storage. Similar decrease in protein content with storage period was reported by Karuppasamy *et al*. (2013) in millets blended bread.

Significant decrease in crude fat content from 3.95 to 3.74% was noticed during 18 days of storage period (Table 4). The decrease in fat content might be due to increase in moisture content of flat bread, accelerating oxidation of fatty acids. The treatment T_6 recorded the highest mean crude fat content (4.00%) and lowest fat content was observed in treatment T_1. These results were supported by the findings of Ndife *et al*. (2011) in composite breads produced from soybean flour substitution. The mean crude fibre content (Table 4) during 18 days of storage declined significantly from the initial level of 2.12 to 1.90% and the maximum crude fibre content was observed in T_6 and minimum in T_1. The increase in fibre content in the final product with increase in percentage of pearl millet flour may be due to higher percentage of fibre in pearl millet flour used for incorporation. The decrease in crude fibre content during storage might be due to the degradation of hemicelluloses and other structural polysaccharides.

Ash content of different treatments increased significantly from 1.92 in T_1 to 2.53% in T_6 (40:50:10:: pearl millet flour: refined wheat flour: soy protein

Table 6 Effect of different treatments and storage period on overall acceptability and total plate count (cfu/g) of composite flour blended flat bread

Treatment	Overall acceptability					Total plate count				
	0	6	12	18	Mean	0	6	12	18	Mean
T_1 (00:100: 00:: PMF: RWF: SPI)	8.56	8.51	8.49	8.46	8.50	0	$1.33×10^2$	$2.38×10^2$	$2.44×10^2$	$2.05×10^2$
T_2 (00:90: 10:: PMF: RWF: SPI)	8.45	8.41	8.38	8.36	8.40	0	$1.19×10^2$	$2.16×10^2$	$2.21×10^2$	$1.85×10^2$
T_3 (10:80: 10:: PMF: RWF: SPI)	8.36	8.30	8.26	8.20	8.28	0	$1.04×10^2$	$2.04×10^2$	$2.09×10^2$	$1.72×10^2$
T_4 (20:70: 10:: PMF: RWF: SPI)	8.09	7.99	7.95	7.88	7.98	0	$0.96×10^2$	$1.91×10^2$	$1.95×10^2$	$1.60×10^2$
T_5 (30:60: 10:: PMF: RWF: SPI))	6.95	6.84	6.73	6.64	6.79	0	$0.88×10^2$	$1.78×10^2$	$1.82×10^2$	$1.49×10^2$
T_6 (40:50: 10:: PMF: RWF: SPI)	6.62	6.56	6.51	6.46	6.54	0	$0.70×10^2$	$1.62×10^2$	$1.78×10^2$	$1.37×10^2$
Mean	7.84	7.77	7.72	7.67		0	$1.01×10^2$	$1.98×10^2$	$2.04×10^2$	
	CD(P= 0.05)					*CD (P= 0.05)*				
Treatments	0.02					0.03				
Storage	0.01					0.02				
Treatments × Storage	0.03					0.06				

isolates) (Table 4). However, with the storage periods, the ash content decreased in all treatments from 2.31 to 2.17%. A decreasing trend in ash content due to moisture absorption was reported by Ahmed *et al.* (2006). With the progression in storage period, the carbohydrate content increased significantly (Table 5). After 18 days of storage, the highest mean carbohydrate content (56.75%) was recorded in T_1 and the lowest of 49.46% in T_6. The difference may be due to the fact that refined wheat flour is rich in starch/gluten whereas, pearl millet flour is poor in starch/gluten. Similar results have been reported by Akesowan (2010) in konjac flour and soy protein isolates incorporated chiffon cake.

Sensory evaluation of composite flour blended flat bread

A decrease in overall acceptability score was observed in all the treatments with the advancement of storage period from 7.84 to 7.67 (Table 6). Among the treatments T_1 obtained maximum score of 8.40 followed by T_2. The reduced acceptability of flat bread at 30 and 40% level of incorporation of pearl millet flour may be attributed to the poor flavour contributed by pearl millet flour at higher levels.

Microbiological analysis of composite flour blended flat bread

A general increase in total plate count (TPC) was observed during 18 days of storage of blended flat bread (Table 6). The freshly prepared flat bread did not have any microbial count but it increased progressively with the increase in the storage period. The results obtained were below the maximum limit in the specification of commercial breads ($< 3.1\times10^3$ cfu/g). Similar results have been reported by Ndife *et al*. (2011) in whole wheat breads.

From the present studies, it is therefore concluded that pearl millet flour incorporated with soy protein could be used as a nutritional ingredient to partially substitute flat bread. The level of 20% pearl millet flour and 10 per cent soy protein isolates against wheat flour (70%) was the optimum proportion to produce the acceptable ready to eat products with 34.91% more protein in flat bread, when compared to control. Hence, the millet flour blend with soy protein isolates incorporation has potential as an ingredient in novel products targeting health conscious consumers who associate darker coloured cereal based foods with superior nutritional composition.

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