IJFANS
International Journal of Food And Nutritional Sciences

Volume 5, Issue 3, July 2016, www.ijfans.com e-ISSN: 2320-7876

INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

IMPACT FACTOR ~ 1.021

Official Journal of IIFANS

IJFANS International Journal of Food and Nutritional Science

e-ISSN 2320 -7876 www.ijfans.com
Vol. 5, No. 3, July 2016

Research Paper *Open Access*

NUTRITIONAL AND FUNCTIONAL PROPERTIES OF PROCESSED LITTLE MILLET FLOURS IN THE DEVELOPMENT OF COMPOSITE FLOUR BREAD

Priyadarshini Deshmukh[1] and Nirmala Yenag[2]*

*Corresponding Author: Nirmala Yenagi, ✉ niryenagi@yahoo.co.in

Received on: 28th March 2016 Accepted on: 15th June 2016

Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Composite bread is gaining importance because of it's high nutritional profile and health benefits. Little millet flour prepared by applying various processing conditions like, washing, soaking, roasting, steaming and popping and the blends of processed flour to refined wheat flour at 30% level were studied for their proximate composition, physicochemical properties and physical and sensory qualities of composite flour breads. The proximate composition, physicochemical properties of processed flour and their blends differed significantly. Soaking, roasting and popping were the treatments which showed major changes in the physicochemical properties of the flour. Similarly physical characteristics of composite flour breads were also differed significantly and the specific volume of composite flour breads was lower (1.98 to 2.55 cm^3/g) than refined wheat bread (3.46 cm^3/g). The overall acceptability of composite breads was not significantly different. Popping significantly increased the nutritional composition of the flour and improved the texture of bread.

Keywords: Traditional processing of millet, Physicochemical properties, Nutritional composition, Composite bread, Sensory quality

INTRODUCTION

Millets are indigenous small seeded cereals that, unlike wheat or rice can be cultivated in semi-arid and subtropical agronomic conditions throughout the world. These are hardy crops and quite resilient to a variety of agro-climatic adversities, such as poor soil fertility and limited rainfall. Millets have remained as the staple food of the people from lower economic strata and considered as food security crop. Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Besides, they are a rich source of dietary fibre, phytochemicals and micronutrients and hence they are rightly termed as 'nutricereals' (Chhavi and Sarita, 2012).

Although millets are nutritionally superior to cereals their utilization in the country is not wide spread. They are mostly used in preparation of traditional dishes and hence they play an important role in the local food culture. Millets are used in several traditional products like *papad, upma, rice, holgi, laddu, paddu, avalakki, idli, dosa, etc*. by applying common traditional processing technologies such as soaking, fermentation, roasting, and popping. Some previous studies have also been conducted in the department of FSN, UAS Dharwad on the use of millets for production of value added traditional products.

The ethnic millet *papads, chakali, paddu,* laddu*;* and millet based novel foods like biscuits, breads, flakes proved

[1] Ph.D. Research Scholar, Department of Food Science and Nutrition, College of RHSc, UAS, Dharwad, Karnataka, India.

[2] Professor, Department of Food Science and Nutrition, College of RHSc, UAS, Dharwad, Karnataka, India.

to have a good scope for enhancing nutrition security, marketing and income generation (Yenagi *et al.,* 2010; Ballolli *et al.,* 2014; and Mannuramath *et al.,* 2015) Little millet is one of the highly nutritious and suitable cereal crops for all age groups.

In the present scenario, ready-to-eat food products of millets are not available in the market. On the other hand bread consumption is increasing throughout the world and considered as most convenient staple foods in many of the countries. An excellent way to increase the nutritional content of wheat flour-based foods is through the use of composite flours. The use of composite flours for bread making is also recent development across the globe owing to some health, economic and social reasons as well as increased demand for nutritious bread. Millet flour incorporated breads had low glycemic indices and were acceptable and nutritious. Replacement of refined wheat flour with little millet flour will upgrade the nutritional quality of bakery products (Chhavi and Sarita, 2012; Ballolli *et al.,* 2014; and Mannuramath *et al.,* 2015). Finger millet flour can be blended with wheat flour up to 30% for preparation of bread (Beswa *et al.,* 2010) Up to 50% of foxtail millet flour and 30% little millet flour can be incorporated in bread without affecting its sensory qualities (Ballolli *et al.,* 2014; and Mannuramath *et al.,* 2015 respectively).

One possible way of extending utilization of millets could be by blending them with wheat flour after suitable processing. On addition of millet flour to wheat flour, there would be changes in physicochemical, nutritional and functional quality of wheat flour. Such information will be useful to food processors and nutritionist to formulate commercial products based on wheat-millet blends (Singh *et al.,* 2005). Household processing technologies may upgrade the functional properties of the cereal flours and thereby quality of final product. So these flours can be used in order to provide value added products to meet the urban population demand for traditional products. There is, however, limited information on the functional properties of processed little millet flours and this information is essential for determining potential uses of these products in new food product or in conventional food.

Hence, the present study was undertaken to evaluate the nutritional and physicochemical properties of processed little millet flours in the development of composite flour breads.

MATERIALS AND METHODS

Little millet grains and bread making ingredients *viz.,* sugar, salt and vegetable oil was purchased from local market. Refined wheat flour (S*upermoti*) and fresh yeast (*Prestige*) was collected from bakery unit, Directorate of Extension, UAS, Dharwad.

Processing of Little Millet and Preparation of Composite Flour

Cleaned little millet grains were subjected to different processing technologies for preparation of processed little millet flour.

Washing: Little millet grains were washed with tap water and shade dried. **Soaking:** Little millet grains were soaked three days by changing water at every 24 hours and shade dried. **Roasting:** Little millet grains were roasted still flavour develops (8 minutes) at 80 ^{o}C. **Popping:** Popping of little millet grains was done at 220 ^{o}C. Differently processed little millet grains and raw little millet grains were milled from commercial milling machine. **Steaming:** Raw little millet flour was tied in muslin cloth and steamed for 10 minutes at 120 ^{o}C. All these processed little millet flours were blended at 30% level with refined wheat flour individually.

Breadmaking Procedure

A standard method of preparation of bread was followed (Mannuramath *et al.,* 2015). For the control bread, 250 g refined wheat flour, 3 g fresh yeast, 15 g sugar, 12.5 g oil, 4 g salt and an adequate amount of water to obtain dough of optimum consistency was used. Yeast was allowed to rise with warm water and sugar for ten minutes prior to incorporation in the flour. The flour was mixed thoroughly with all the other ingredients. A Kitchen Aid brand kneading machine was used to prepare the dough. The dough was mixed until it leaved the sides of the vessel and allowed to first proofing in an oil smeared vessel for 2 hours at room temperature. Then the dough was separated into parts weighing around 105 g and put into the baking bread moulds (12 x 4.5 x 5.5 cm), and was allowed to rest for the second proofing for an hour. The breads were baked at 220 ^{0}C for 15-20 min or till light brown colour appears and cooled. The processed little millet composite flour breads were developed by replacing refined wheat flour by 30%.

Technological Parameters

Proximate composition viz; moisture, protein, fat, crude fibre, and ash content of flour samples was analyzed by using standard methods (AOAC, 1990). Carbohydrate content of bread samples were calculated by difference method.

Bulk Density

10 g of flour was put into a 25 ml graduated measuring cylinder and tapped ten times from a height of 8 to 10 cm. the bulk density (g/ml) was calculated using the formula: Bulk density = weight of flour (g)/flour volume (ml). In case of popped little millet flour weight of sample taken was 5 g.

Water Absorption Capacity (WAC)

WAC capacity was assessed by the method of Quin and Paton (1983). To estimate WAC, 5 g of flour was weighed in a 50 mL centrifuge tube and 30 mL of water was added and stirred with a glass rod for 5 min. After allowing the contents to stand for 30 min at ambient conditions, it was then centrifuged at 11 000 g for 25 min. The volume of free liquid was measured and the retained volume was expressed as per cent of water absorbed on a dry basis.

Gluten Content

AACC method No. 10-11 (AACC, 1984) was used for gluten estimation in plain and blended flours. A weighed sample (25 g) was transferred into a clean dry mixing bowl and 13.5 mL of water was added. The contents were formed into a stiff dough ball. The dough ball was dipped into water for half an hour and then washed by hand under tap water until free from starch. The wet gluten thus obtained was weighed and its weight expressed as a percentage of the original flour sample (25 g). The wet gluten was then transferred into a dish and placed in a hot air oven at 100 ^{o}C for 2 h. After cooling in a desiccator the dry gluten was weighed and its weight expressed as a percentage of the original flour sample.

Sedimentation Value

The sedimentation value was determined according to the procedure given by Misra *et al.* (1998). A weighed sample (5 g, 14% moisture) was transferred into a 100 mL stoppered graduated cylinder. Distilled water (50 mL) was added and the cylinder shaken horizontally for 15 s. The contents of the cylinder were again shaken for 15 s at 2 and 4 min intervals. Immediately after the last shake, 50 mL of sodium dodesyl sulphate-lactic acid reagent was added and mixed by inverting the cylinder four times. Inversion was repeated four times at 6, 8 and 10 min intervals. The contents of the cylinder were then allowed to settle for 20 min before the sedimentation values were read and expressed in millilitre.

Oil Absorption Capacity

A method given by Sosulski *et al.* (1976) was used to determine oil absorption capacity. Sample (1 g) was mixed with 10 ml of vegetable oil in pre-weighed centrifuge tubes. The tubes were stirred for 1 min for complete dispersion of sample in the oil. After 30 min of holding time at room temperature, the sample was centrifuged at 3000 rpm for 25 min. The separated oil was then removed and tubes were inverted on oil absorbent paper for 25 min to drain the oil prior to reweighing. The oil absorption capacity was expressed as grams of oil absorbed per gram of the sample.

Swelling Power and Solubility

The swelling power and per cent solubility was determined according to the method used by Schoch (1964). 500 mg (W_1) of sample was added to a centrifuge tube, weight of centrifuge tube and test sample was noted (W_2). After addition of 20 ml (V_E) distilled water, the centrifuge tube was placed in the water bath at 100 °C for 20-30 min till the contents were cooked. Then it was centrifuged at 5000 rpm for 10 min. The supernatant was transferred to a test tube and the inner side of the centrifuge tube was dried well and weighed (W_3). The swelling of flour was calculated as follows.

$$Swelling\ \ power\ \left(g\ /\ g\right)=\frac{W_3-W_2}{W_1}\times 1$$

For per cent solubility, weight of dried moisture dish was noted (W_4) and after pouring 10 ml aliquot (V_A) in a dish, dried at 110 °C for 4-5 h. The moisture dish was cooled and weighed (W_5).

$$Solubility\left(\%\right)=\frac{\left(W_5-W_4\right)V_E}{V_A}\times\frac{100}{W_1}$$

pH Determination

The pH of the samples was determined according to the method of AOAC (1998). 10 g of sample was mixed in100 ml of CO_2 free distilled water. The mixture was allowed to stand for 15 min, shaken at 5 min interval and filtered with Whatman No. 14 filter paper. The pH of the filtrate was measured using a pH meter.

Total Titratable Acidity (T.T.A)

10 ml aliquots (triplicates) were pipetted and titrated against O.1 M NaOH to phenolphthalein end-point and the acidity was calculated as g lactic acid/100 (Mbata *et al.*, 2009).

Particle Size Distribution of Processed Little Millet Flour

Hundred grams of processed little millet flour was taken and passed through different meshes of BSS standards from 60, 85, 100, 150, 200 and 240 with sieve opening of 0.250, 0.180, 0.150, 0.106, 0.075 and 0.063 mm respectively. The sample was passed from bigger to smaller mesh size. The sample above the sieve was weighed and recorded.

Physical Characteristics

Processed little millet flour breads were studied for loaf weight, loaf height, loaf volume and specific volume. Loaf volumes were measured by the rapeseed displacement method. Specific loaf volumes were calculated by dividing the loaf volume by the loaf weight by following this formula loaf volume (cm^3)/loaf weight (g) = Cm^3/g.

Sensory Characteristics

Sensory evaluation of breads was carried out by using nine point hedonic scale by semi-trained panel members.

Statistical Methods

The data were statistically analysed in a completely randomized design. SPSS software (version 16.0) was used to analyze the differences in the sensory quality of breads.

RESULTS AND DISCUSSION

Proximate Composition of Processed and Composite Flour Blends

Proximate composition of differently processed little millet flour (Table 1) showed that the moisture content of processed flour was significantly lower than the refined wheat flour. Among all the processed flours soaked little millet flour has got highest moisture content (11.40%) and popped little millet flour exhibited least (5.75%). Protein content of processed little millet flour ranged from 6.13 to 8.81 g/100 g and significantly less than refined wheat flour. Differently processed little millet flours had significantly higher fat, crude fibre and ash content than refined wheat flour. Results of proximate composition after blending of processed little millet flour in refined wheat flour at 30% level showed similar trend as observed in the proximate composition of individual flour (Table 1). Refined wheat flour had significantly less fat, crude fibre, ash and higher protein content than all the processed little millet composite flours. This is probably a reflection of gluten content in wheat flour as reported by (Ogunlakin *et al.,* 2014) who observed significantly less protein content in composite flour compared to wheat flour. Moisture content of the processed composite flour ranged from 10.86 to 12.90 percent. However fat, crude fibre and ash content of processed composite flour were significantly higher than refined wheat flour. Little millet composite flours showed fat content in the range of 0.46 to 0.75 g/100 g. Crude fibre and ash content of composite flours were in the range of 0.51 to 0.98 and 0.43 to 0.91 g/100 g respectively. A significant decrease in the protein, crude fibre and ash content of soaked little millet flour was observed (Table 1). These changes could be attributed due to the leaching of nutrients during soaking (Chiang and Yeh, 2002; and Srilaxmi, 2006). A similar decrease in the protein, lipid and ash content of rice grain after soaking was also noticed by (Chiang and Yeh, 2002). Roasting technology resulted in the decrease in the protein content of the flour. The change in the protein content of roasted flour could be due to loss of amino acids (Sade, 2009). Popping is a simplest, inexpensive and quickest traditional method of dry heat application, wherein whole grains will be exposed to High Temperature for Short Time (HTST) and super heated vapour will be produced inside the grains by instantaneous heating, which cooks the grain and expand the endosperm while escaping with great force through the micropores of the grain structure. The enhancement of all the nutrients was observed in popped composite flour. The presence of bran in popped grains could be the reason for higher proportion of fat, crude fibre and ash content of popped little millet composite flour. Similarly increase in the protein, fat, crude fibre and carbohydrate content of popped grains was observed by (Zeenath, 2007; Chaturvedi and Srivastava, 2008; and Shaheen, 2010).

Particle Size Distribution of Processed Little Millet Flour

The flour particle size distribution of processed little millet flours is presented in Table 2. Flour particle size of refined wheat flour was very less with maximum per cent (40.61 and 28.55) of flour distribution on the sieve size 200 to 240 mesh (0.075 to 0.063 mm). Fifty per cent weight of raw little millet flour had particle size more than 0.180mm. Washing and soaking of grains reduced the flour particle size and per cent retention was more in the sieve of 100 and 150 meshes (0.150 and 0.106 mm). Whereas roasting and steaming affected the flour particle size distribution and maximum percentage was retained on sieve of 85 mesh (0.180 mm). In case of popping the particle size retention was more on sieve 60 and 85 (0.250 and 0.180 mm).

Table 1: Proximate Composition of Processed Little Millet Flour and Composite Flour Blends (g/100 g)

Treatments	Processed Little Millet Flour						Composite Flour Blends					
	Moisture	Protein	Fat	Crude Fibre	Ash	Carbohydrate	Moisture	Protein	Fat	Crude Fibre	Ash	Carbohydrate
Control RWF	13.82±0.85	10.73±0.20	0.23±0.03	0.29±0.07	0.49±0.01	74.46±0.93	13.82±0.85	10.73±0.20	0.23±0.14	0.29±0.09	0.49±0.04	74.46±0.93
Raw LMF	10.50±0.13	7.41±0.10	1.21±0.20	1.90±0.05	1.00±0.03	77.98±0.06	12.46±0.36	9.73±0.01	0.55±0.04	0.58±0.06	0.68±0.09	76.02±0.38
Washed LMF	10.77±0.12	7.82±0.10	1.73±0.17	1.75±0.03	1.41±0.02	76.52±0.28	12.67±0.18	9.86±0.19	0.39±0.03	0.53±0.07	0.81±0.01	75.74±0.27
Soaked LMF	11.40±0.35	6.13±0.18	1.17±0.11	1.70±0.04	0.49±0.03	79.12±0.12	12.90±0.23	9.35±0.18	0.46±0.01	0.51±0.09	0.53±0.07	76.25±0.41
Roasted LMF	9.83±0.29	6.67±0.20	1.23±0.13	2.53±0.06	1.15±0.01	78.59±0.10	11.71±0.18	9.54±0.28	0.52±0.03	0.77±0.04	0.71±0.10	76.77±0.40
Steamed LMF	11.18±0.23	8.11±0.10	1.54±0.12	1.88±0.08	1.49±0.02	75.79±0.40	12.66±0.08	9.94±0.19	0.63±0.04	0.57±0.04	0.82±0.04	75.38±0.33
Popped LMF	5.75±0.10	8.81±0.20	2.08±0.10	3.30±0.05	1.75±0.10	78.31±0.25	10.86±0.10	10.15±0.20	0.75±0.03	0.98±0.06	0.91±0.02	76.35±0.25
SEM	0.22	0.09	0.07	0.04	0.03	0.28	0.22	0.12	0.06	0.04	0.05	0.27
CD (5%)	0.67	0.26	0.22	0.12	0.09	0.86	0.66	0.35	0.19	0.12	0.14	0.81

Note: RWF-Refined wheat flour; LMF-Little Millet flour; Mean±SD, Carbohydrate content was calculated by difference method, Composite flour blend = RWF: processed LMF; 70:30.

Table 2: Flour Particle Size Distribution of Little Millet Flour

BSS Standards	Sieve Opening (mm)	Control RWF	Raw LMF	Washed LMF	Soaked LMF	Roasted LMF	Steamed LMF	Popped LMF	SEM	CD (5%)
60	0.25	$00^{f}\pm00$	$15.87^{c}\pm0.26$	$0.46^{e}\pm0.03$	$0.293^{e}\pm0.04$	$5.97^{d}\pm0.05$	$20.06^{b}\pm0.28$	$20.78^{a}\pm0.03$	0.09	0.26
85	0.18	$0.91^{f}\pm0.04$	$50.47^{b}\pm0.69$	$46.00^{c}\pm0.43$	$43.48^{e}\pm0.65$	$62.86^{a}\pm0.76$	$62.47^{a}\pm0.51$	$44.92^{d}\pm0.14$	0.3	0.92
100	0.15	$2.84^{f}\pm0.41$	$20.74^{c}\pm0.62$	$34.29^{a}\pm1.09$	$31.05^{b}\pm1.26$	$16.45^{d}\pm0.99$	$12.01^{e}\pm0.29$	$16.33^{d}\pm0.11$	0.46	1.39
150	0.106	$28.55^{a}\pm0.53$	$10.18^{d}\pm0.42$	$14.97^{c}\pm0.68$	$17.48^{b}\pm1.55$	$9.50^{d}\pm0.19$	$4.73^{e}\pm0.08$	$9.05^{d}\pm0.08$	0.4	1.21
200	0.075	$40.61^{a}\pm0.33$	$2.32^{f}\pm0.20$	$3.71^{e}\pm0.20$	$7.10^{c}\pm1.13$	$5.22^{d}\pm0.5$	$0.62^{g}\pm0.03$	$8.24^{b}\pm0.21$	0.29	0.88
240	0.063	$27.08^{a}\pm0.39$	$0.42^{c}\pm0.10$	$0.57^{bc}\pm0.04$	$0.67^{bc}\pm0.07$	$00^{d}\pm00$	$00^{d}\pm00$	$0.72^{b}\pm0.02$	0.28	0.86

Note: Means with the same superscript letters within a row are not significantly different at 5% level, RWF-Refined wheat flour, LMF-Little Millet Flour, Mean±SD, Composite flour blend = RWF: processed LMF; 70:30.

Physicochemical Properties of Processed Flour

The data on physicochemical properties of processed little millet flour is presented in Table 3. All the physicochemical properties of processed and composite flour blends were differed significantly. The most significant changes were observed with the soaking, roasting and popping technology. These changes could be due to the changes in the flour particle size (Table 2) and chemical composition (Table 1). Bulk density of little millet flour ranged from 0.28 to 0.61 g/ml. Refined wheat flour showed significantly highest bulk density than all processed little millet flours. WAC of raw and processed little millet flour was significantly higher than refined wheat flour. Among the millet flours significantly higher and lower WAC was found in popped (376%) and steamed (69.31%) flour respectively. Swelling power and solubility of refined wheat flour was 7.50 g/g and 10.20% respectively. Swelling power of soaked little millet flour was highest (9.86 g/g); whereas popped little millet flour showed lowest (5.44 g/g) swelling power among all processed little millet flours and significantly different than raw little millet flour. However, solubility of popped little millet flour was highest (16.95%) and it was least for soaked little millet flour (11.33%). Oil absorption capacity of refined wheat flour was on par with the oil absorption capacity of raw, washed, soaked and steamed little millet flour. Roasted and popped little millet flour had significantly higher (0.85 and 1.47 g/g respectively) oil absorption capacity than all

Table 3: Physicochemical Properties of Processed Little Millet Flour and Composite Flour Blends

Treatments	Processed Little Millet Flour								Composite Flour Blends						
	Bulk Density (g/ml)	Water Absorption Capacity (%)	Swelling Power (g/g)	Solubility (%)	Oil Absorption Capacity (g oil/g)	Total Solids (%)	pH	Titratable Acidity (as Lactic Acid)	Bulk Density (g/ml)	Water Absorption Capacity (%)	Swelling Power (g/g)	Solubility (%)	Wet Gluten (g/100 g)	Dry Gluten (g/100 g)	Sedimentation Value (ml)
Control RWF	0.64±0.01	58.00±1.00	7.50± 0.13	10.20±0.2	0.74±0.01	0.23±0.01	6.13±0.06	0.47±0.05	0.64±0.01	58.00±1.00	7.50± 0.13	10.20±0.2	34.77± 1.98	11.73±0.67	50.67±0.58
Raw LMF	0.54±0.01	70.62±1.17	8.66±0.24	16.47±0.99	0.72±0.02	0.21±0.0	5.53±0.05	0.67±0.06	0.61±0.02	42.67±1.15	8.58± 0.065	07.27±0.12	18.59± 0.14	7.58±0.21	36.67±0.58
Washed LMF	0.53±0.01	79.32±1.15	7.70±0.23	15.8±0.20	0.75±0.02	0.22±0.00	6.07±0.06	0.57±0.06	0.59±0.01	40.67±1.15	8.43±0.092	08.47±0.12	19.65±0.5	7.72±0.15	37±0.50
Soaked LMF	0.52±0.01	89.32±1.14	9.86±0.08	11.33±0.12	0.70±0.01	0.23±0.01	6.23±0.06	0.37±0.06	0.59±0.01	40.00±1.00	8.77± 0.069	07.53±0.12	20.44± 1.07	8.35±0.59	37.67±0.58
Roasted LMF	0.52±0.00	99.29±1.13	7.71±0.26	14.33±0.12	0.85±0.03	0.20±0.01	6.27±0.06	0.33±0.06	0.60±0.01	58.67±0.58	8.42± 0.0738	10.33±0.12	20.23±0.48	8.29±0.82	36.00±0
Steamed LMF	0.61±0.00	69.31±1.15	6.91±0.25	16.60±0.6	0.75±0.03	0.16±0.11	6.17±0.06	0.53±0.06	0.62±0.02	40.00±1.00	8.12± 0.14	06.37±0.06	18.27±0.17	7.67±0.2	36.67±0.58
Popped LMF	0.78±0.00	376.0±1.73	5.44±0.11	16.95±0.25	1.47±0.06	0.18±0.01	6.17±0.06	0.47±0.06	0.50±0.01	80.00±1.00	7.48± 0.017	13.70±0.1	18.78±0.13	6.95±0.04	42.73±0.46
SEM±	0.01	0.71	0.11	0.27	0.02	0.02	0.03	0.03	0.01	0.58	0.05	0.07	0.52	0.27	0.29
CD (5%)	0.02	2.15	0.35	0.81	0.05	0.07	0.1	0.1	0.02	1.75	0.16	0.22	1.57	0.83	0.89

Note: RWF-Refined wheat flour, LMF-Little Millet Flour, Mean±SD, Composite flour blend = RWF: processed LMF; 70:30.

Table 4: Physical Characteristics of Breads Developed from Differently Pretreated Composite Flour Bread

Treatments	Loaf Weight (g)	Loaf Height (cm)	Loaf Volume (cm^3)	Specific Volume (cm^3/g)
Control RWF	95.22±1.35	5.40 ±0.20	330.83 ±2.89	3.46 ±0.1
Raw LMF	92.02 ±1.98	4.20 ±0.10	224.17 ±2.02	2.44±0.04
Washed LMF	92.54 ±1.73	4.20 ±0.10	219.5 ±2.29	2.37 ±0.02
Soaked LMF	92.59 ±1.95	4.63 ±0.15	236.33 ±3.21	2.55 ±0.07
Roasted LMF	91.33 ±1.53	4.63 ±0.21	228.33 ±2.89	2.50±0.05
Steamed LMF	91.87 ±3.38	4.07 ±0.12	210.33 ±2.52	2.29±0.06
Popped LMF	104.67±1.53	4.17 ±0.21	207.67±2.52	1.98±0.02
SEM±	1.17	0.09	1.53	0.03
CD (5%)	3.54	0.28	4.63	0.1

Note: RWF-Refined wheat flour, LMF-Little Millet Flour, Mean±SD, Composite flour blend = RWF: processed LMF; 70:30.

other processed little millet flours. Per cent of total solids in all processed little millet flours were on par with refined wheat flour. pH and TTA of refined wheat flour was 6.13 and 0.47 respectively. Processed little millet flour had pH and titratable acidity in the range of 5.53 to 6.27 and 0.33 to 0.67 respectively.

Even the blends of the processed little millet flour showed the bulk density significantly lower than refined wheat flour (Table 3). Between the composite flour popping showed lowest (0.50 g/ml) bulk density followed by washed and soaked little millet flour (0.59 g/ml respectively). Whereas steamed little millet flour reveled highest bulk density. Highest bulk density for wheat flour was reported by (Ogunlakin *et al.*, 2014) compared to composite flours produced from wheat and rice/plantain/ cassava at 20% level. Increase in the bulk densities of blanched flours than untreated Cocoyam flour was noticed by James *et al.* (2013). A similar increase was found in bulk density by Ajewole and Ozo (1994) in pregelatinized tannia cocoyam flour. Bulk density in the range of 0.59 to 0.80 g/cc for whole and milled; foxtail and barnyard millet flour was noticed by Singh *et al.* (2005).

The water and oil binding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity (Chandra and Samsher, 2013) WAC of flour is closely linked to both amount of amino acids in different flours and availability of proteins functional groups in flour (Kouakou *et al.*, 2013). WAC capacity of roasted (58.67%) and popped (80.00%) composite little millet flour blend was significantly higher than all other processed composite flours. This could be due to partial gelatinization of starch due to dry heat processing (Njoki *et al.*, 2014). Same processing conditions exhibited significant increase in the oil absorption capacity of little millet flours than other processed little millet flours as well as refined wheat flour. This may be due to changes in the chemical composition of roasted and popped little millet flour (Table 1). Severity of heat treatment during popping might cause structural changes in starch and protein resulting in increased water absorption (Addis *et al.*, 2013). Increase in the oil absorption capacity and water absorption capacity of roasted millet flour was also reported by Sade (2009).

Swelling power of composite flours was significantly higher than refined wheat flour except for popped composite flour (7.48 g/g). High swelling of millet flour could be due to high content of starch and low protein and fat content (Kouakou *et al.*, 2013). Swelling power of soaked little millet flour was significantly high even after blending with refined wheat flour than other flours. This was in agreement with the Ocheme and Chinma (2008) and Ocheme *et al.* (2015) who observed an increase in the swelling power of millet flour and sorghum respectively as a result of germination. The increase in swelling power was probably due to an increase in soluble solids brought about by the breakdown of lipid, fiber and larger amount of amylose-lipid complex in flour that could inhibit the swelling of starch granules. Among all composite flours popping was the only processing which had significantly higher (13.70%) solubility than refined wheat flour (10.20%). Pop sorghum showed less swelling power and higher solubility than raw sorghum irrespective of cultivars (Rajalakshmi, 2015).

Wet gluten content, dry gluten content and sedimentation value of refined flour was 34.77 g/100 g, 11.73 g/100 g and 50.67 ml respectively. Composite flours exhibited significantly lower gluten content and sedimentation values irrespective of processing. Raw composite flour had wet gluten, dry gluten and sedimentation value 18.59 g/100 g, 7.85 g/100 g and 36.67 ml respectively. Soaked composite flour had significantly high wet and dry gluten (20.44 and 8.35 g/100 g respectively) content followed by roasted composite flour. However popped composite flour showed significantly higher (42.73 ml) sedimentation value than other processed little millet composite flours. Wheat is the grain of choice in bread preparation due to its high gluten level, which is combination of gliadin and glutenin. Gliadin is very sticky when wet and very extensible and imparts adhesive properties to gluten. Glutenin is a large and complex protein which gives dough strength and elasticity. The dry gluten content is a direct indicator of flour strength and bread making potentialities. The quantity and quality of gluten is responsible for better gas production and retention capacity and forms a cellular network of crumb which imparts desirable characteristics to bread (Anjuman and Walkar, 2000; and Belderok, 2000). The sedimentation test is used to assess the gluten quality and bread-making potential of the flour (Belderok, 2000). In the processed little millet composite flours there was significant reduction in the gluten content and sedimentation values which could be due to the dilution of gluten of refined wheat flour with the addition of 30% processed little millet flour. These results are in close agreement with the results found by Dhingra and Jood (2004) for composite flour. Similar decrease in the wet gluten content with the increment of wheat flour substitution in the composite flour was observed by Malomo *et al.* (2011). Decrease in gluten content and sedimentation value with increase in the addition of ragi flour in composite flour blend was noticed by Choudhary and Jood (2013).

Physical Characteristics of Processed Little Millet Composite Flour Breads

The physical quality characteristics of bread were significantly differed with the different processed little millet composite flour and refined wheat flour (Table 4 and Plate 1). Loaf height, volume and specific volume of refined wheat flour bread were 5.4 cm, 330.83 (cm^3) and 3.46 cm^3/g respectively. Specific volume of bread is one of the important parameter used to assess the bread quality. Refined wheat flour had highest (3.46 cm^3/g) specific volume than all other composite little millet flour breads. Wheat gluten could be responsible for high specific volume of refined wheat flour bread (Dhingra and Jood, 2004; and Choudhary and Jood, 2013). Similar findings were reported by (Ballolli *et al.*, 2014; and Mannuramath *et al.*, 2015) who noticed higher specific volumes of wheat breads than foxtail millet and little millet composite breads respectively. Little millet composite flour bread had weights ranging from 91.33 g (roasted) to 104.67 g (popped). Weight of popped little millet flour bread was significantly higher than all other breads. In the present study specific volume of little millet composite flour breads was improved by 2 to 4% (Table 4) with the addition of roasted and soaked composite flour. Improved flour particle size and water absorption capacity could be the reason for improvement in the specific volume of soaked and roasted composite flour breads. Whereas reduction in the specific volume of popped bread is due to the presence of bran as fibre (Table 1).

Plate 1: Composite Flour Breads Prepared from Different Processed Little Millet Flour

Control Bread	Raw LMF Bread	Washed LMF Bread	Soaked LMF Bread	Roasted LMF Bread	Steamed LMF Bread	Popped LMF Bread

Table 5: Sensory Quality Characteristics of Composite Flour Bread

Parameters	Appearance	Crust Color	Crumb Color	Taste	Crust Texture	Crumb Texture	Flavour	Mouth Feel	Overall Acceptability
Control RWF	8.46a±0.66	7.85a±1.14	8.15a±0.99	7.85ab±0.55	8.08a±1.04	8.15a±0.80	7.85a±0.38	7.92a±0.76	8.15a±0.69
Raw LMF	7.46b±0.52	7.38ab±1.19	7.23b±1.01	7.92a±0.95	6.69b±0.85	6.85c±0.88	7.38ab±0.96	7.38ab±0.87	7.46b±0.78
Washed LMF	7.38b±0.87	7.31ab±0.63	7.38b±0.65	7.46ab±0.52	7.62a±0.51	7.77ab±0.44	7.15ab±0.80	7.08bc±0.64	7.38bc±0.65
Soaked LMF	7.23b±0.93	7.08b±0.64	7.38b±0.65	7.30b±0.48	6.77b±0.73	7.54ab±0.66	6.85b±0.99	6.62c±0.77	6.92bcd±0.76
Roasted LMF	7.31b±0.48	7.23ab±0.73	6.62bc±1.33	7.62ab±0.51	6.31b±1.18	7.46b±0.78	7.23ab±0.83	7.15bc±0.69	7.38bc±0.51
Steamed LMF	7.31b±0.75	7.31ab±0.48	7.31b±0.63	7.54ab±0.78	6.85b±0.69	6.77c±0.83	7.00b±0.82	7.00bc±0.71	6.77cd±0.73
Popped LMF	6.46c±1.33	5.54c±0.88	6.00c±0.82	7.38ab±0.65	8.00a±0.82	8.15a±0.80	6.85b±1.07	6.92bc±1.26	6.62d±1.12
SEM	0.23	0.24	0.25	0.18	0.24	0.19	0.24	0.23	0.21
CD (5%)	0.65	0.66	0.7	(0.51)	0.67	0.54	(0.67)	(0.65)	0.6

Note: Means with the same superscript letters within a column are not significantly different at 5% level, RWF-Refined wheat flour, LMF-Little Millet Flour, Mean±SD.

Sensory Quality of Composite Flour Breads

Data on sensory quality attributes of processed little millet flour breads is presented in Table 5. Though the physicochemical properties of composite flours and physical characteristics of breads differed significantly, the results of sensory evaluation for overall acceptability was not significant except for the popped bread. This is due to the non significant differences for the sensory scores for appearance, crust colour, crumb colour, flavor and mouth feel (Table 5). Appearance scores of composite flour breads ranged from 6.46 to 7.46 and were significantly lower than the refined wheat flour bread. Crust colour of some composite flour breads were on par with the refined wheat flour bread. Taste evaluation data of composite flour breads reveled that all the composite flour breads had taste scores on par with refined wheat flour bread except for the soaked composite little millet flour bread. The sensory scores of texture for composite bread of popped flour were significantly higher (8.15) than other composite breads and equal to refined wheat bread. Improvement in the texture of popped composite flour bread may be due to the increase in the soluble dietary fibre content during popping of millet (Table 1). Increase in total dietary fibre, insoluble dietary fibre and soluble dietary fibre content of popped finger millet compared to raw finger millet grains was reported by Krishnan *et al.* (2012). Overall acceptability of all the processed composite flour breads was on par with each other and significantly less than refined wheat flour bread.

CONCLUSION

Processing of little millet has been found to bring significant changes in the nutritional composition of differently processed little millet composite flours. Incorporation of little millet flour enhanced the nutritional quality of composite flour irrespective of processing. However protein content of soaked and roasted flour was significantly decreased. Physicochemical properties of the composite little millet flours were significantly different than refined wheat flour. Soaking roasting and popping were the treatments which showed major changes in the physicochemical properties of the flour. Specific volume of composite flour bread was improved with soaked and roasted little millet composite flour and popping showed significant positive effect on the texture of bread. However sensory quality of all processed little millet composite flour was not really far from each other. Popped flour represents feasible ingredient in bread making with improved texture and can be used for value addition as functional ingredient with better nutritional quality. Hence popping found to be an interesting area for research and further studies are under investigation on popped little millet composite bread with respect to its nutritional benefits.

ACKNOWLEDGEMENT

The first author wish to acknowledge the Dept. of Science and Technology for providing financial support in the form of INSPIRE FELLOWSHIP to carry out this research work.

REFERENCES

- AACC (1984), "Methods 10-11, 54-40 and 0-10B", Approved Method of the American Association of Cereal Chemists, St. Paul, MN, USA.
- AOAC (1990), *Official Methods of Analysis*, 20th Edition, Association of Official Analytical Chemists, Washington DC.
- AOAC (1998), *Official Methods of Analysis*, 16th Edition, Association of Official Analytical Chemists, Vols. 1 and 2, Arlington, VA.
- Addis G, Singh V, Pratape V, Srivastava A, Gowda L, Asha M and Bhattacharya S (2013), "Development and Functional Properties of Low-Cost Complementary Food", *African Journal of Food Science*, Vol. 7, No. 9, pp. 274-284.
- Anjuman F M and Walker C E (2000), "Grain, Flour and Bread-Making Properties of Eight Pakistani Hard White Spring Wheat Cultivars Grown at Three Different Locations for 2 Years", *International J. of Food Sci and Technol.*, Vol. 35, pp. 407-416.
- Ajewole I A and Ozo O N (1994), "Food Gels from Pregelatinized Cocoyam *(Xanthosoma species)* Flour: A Comparative Study", *Journal of Agriculture and Technology*, Vol. 2, No. 1, pp. 63-66.
- Ballolli U, Malagi U, Yenagi N, Orsat V and Gariepy Y (2014), "Development and Quality Evaluation of Foxtail Millet [*Setaria italic* (L.)] Incorporated Breads", *Karnataka J Agric Sci.*, Vol. 27, No. 1, pp. 52-55.
- Belderok B (2000), "Developments in Bread Making Process", *Plant Foods for Human Nutrition*, Vol. 55, pp. 3-86.
- Beswa D, Kock S and Siwela M (2010), "Wheat- Finger Millet-Assessment of the Feasibility of Using a Wheat Finger Millet Composite Flour for Bread Making", Lap Lambert Academic Publishing.
- Chandra S (2013), "Samsher, Assessment of Functional Properties of Different Flours", *Afr J Agric Res.*, Vol. 8, No. 38, pp. 4849-4852.
- Chaturvedi R and Srivastava S (2008), "Genotype Variations in Physical, Nutritional and Sensory Quality of Popped Grains of Amber and Dark Genotypes of Finger Millet", *J Food Sci Technol.*, Vol. 45, No. 5, pp. 443-446.
- Chiang P Y and Yeh A (2002), "Effect of Soaking on Wet-Milling of Rice", *J of Cereal Sci.*, Vol. 35, No. 1, pp. 85-94.
- Chhavi A and Sarita S (2012), "Evaluation of Composite Millet Breads for Sensory and Nutritional Qualities and Glycemic Response", *Mal J Nutr.*, Vol. 18, No. 1, pp. 89-101.
- Choudhary H and Jood S (2013), "Functional and Nutritional Characteristics of Ragi-Wheat Composite Flour and its Use in Bread Making", *Asian Journal of Dairy and Food Research*, Vol. 32, No. 2, pp. 120-125.
- Dhingra S and Jood S (2004), "Effect of Flour Blending on Functional, Baking and Organoleptic

Characteristics of Bread", *Int J Food Sci and Technol*., Vol. 39, pp. 213-222.

- James E O, Peter I A, Charles N I and Joel N (2013), "Chemical Composition and Effect of Processing and Flour Particle Size on Physicochemical and Organoleptic Properties of Cocoyam *(Colocasia esculenta var. esculenta)* Flour", *Official Journal of Nigerian Institute of Food Science and Techonology*, Vol. 31, No. 2, pp. 113-122.
- Kouakou B, Marie N A, Halbin K J, Tagro G, Florent N K and Dago G (2013), "Biochemical Characterization and Functional Properties of Weaning Food Made from Cereals (Millet, Maize) and Legumes (Beans, Soybeans)", *J Food Chem Nutr*., Vol. 01, No. 01, pp. 22-32.
- Krishnan R, Dharmaraj U and Malleshi N G (2012), "Influence of Decortication, Popping and Malting on Bioaccessibility of Calcium, Iron and Zinc in Finger Millet", *J Food Sci Technol*., Vol. 48, pp. 169-174.
- Mbata T I, Ikenebomeh M J and Alaneme J C (2009), "Studies on the Microbiological, Nutrient Composition and Antinutritional Contents of Fermented Maize Flour Fortified with Bambara Groundnut (*Vigna subterranean L)", Afr J Food Sci*., Vol. 3, No. 6, pp. 165-171.
- Malomo S A, Eleyinmi A F and Fashakin J B (2011), "Chemical Composition, Rheological Properties and Bread Making Potentials of Composite Flours from Breadfruit, Breadnut and Wheat", *Afr J of Food Sci*., Vol. 5, No. 7, pp. 400-410.
- Mannuramath M, Yenagi N and Valerie O (2015), "Quality Evaluation of Little Millet (*Panicum miliare)* Incorporated Functional Bread", *J Food Sci and Technol*., Published Online 19 July.
- Misra B K, Gupta R K and Ram S (1998), "Protocol for Evaluation of Wheat Quality India: Directorate of Wheat Research Karnal India", pp. 11-32.
- Njoki J W, Sila D N and Onyango A N (2014), "Impact of Processing Techniques on Nutrient and Anti-Nutrient Content of Grain Amaranth (*A. albus)", Food Science and Quality Management*, Vol. 25, pp. 10-17.
- Ogunlakin Abioye V F and Olewepo M O (2014), "Evaluation of the Quality Attributes of Wheat Composite (Wheat-Cassava, Wheat-Plantain & Wheat-Rice) Flours in Bread Making", *Afr J Biotechnol*., Vol. 13, No. 38, pp. 3907-3911.
- Ocheme O B, Adedeji O E, Lawal G and Zakari U M (2015), "Effect of Germination on Functional Properties and Degree of Starch Gelatinization of Sorghum Flour", *Journal of Food Research*, Vol. 4, No. 2, pp. 159-165.
- Ocheme O B and Chinma C E (2008), "Effects of Soaking and Germination on Some Physicochemical Properties of Millet Flour for Porridge Production", *Journal of Food Technology*, Vol. 6, No. 5, pp. 185-188.
- Rajalakshmi H G (2015), "Evaluation of Pop Sorghum Cultivars and Traditional Foods for Nutritional Benefits", Thesis, Univ Agric Sci Dharwad (India) M. H.Sc.
- Sade F O (2009), "Proximate Antinutritional and Functional Properties of Processed Pearl Millet (*Pennisetum glaucum*)", *J Food Technol*., Vol. 7, No. 3, pp. 92-97.
- Schoch T J (1964), "Swelling Power and Solubility of Granular Starches", in *Carbohydrate Chemistry*, Whistler R L, Smith R J, Miller N J and Wolform M I (Eds.), pp. 106-108, Academic Press, New York.
- Singh P, Singh G, Srivastava S and Agarwal P (2005), "Physico-Chemical Characteristics of Wheat Flour and Millet Flour Blends", *J Food Sci Technol*., Vol. 42, No. 4, pp. 340-343.
- Shaheen J (2010), "Development and Evaluation of Popped Sorghum Breakfast Cereal for Nutrient Adequacy", *Thesis, Univ Agric Sci Dharwad* (India), M.H.Sc.
- Shittu T A, Raji A O and Sanni L O (2007), "Bread from Composite Cassava-Wheat Flour: I, Effect of Baking Time and Temperature on Some Physical Properties of Bread Loaf", *Food Res Int*., pp. 280-290.
- Sosulski F W, Humbert E S, Bui K and Jones J O (1976), "Functional Properties of Rapeseed Flour Concentrates and Isolates", *J Food Sci.*, Vol. 41, pp. 1348-1354.
- Srilaxmi B (2006), *Food Science*, 3rd Edition, New Age International (P) Ltd. Publishers.
- Quin J R and Paton D A (1983), "Practical Measurement of Water Hydration Capacity of Protein Materials", *Cereal Chem*, Vol. 56, pp. 38-44.
- Yenagi N B, Handigol J A, Ravi S B, Mal B and Padulosi S (2010), "Nutritional and Technological Advancements in the Promotion of Ethnic and Novel Foods Using the

Genetic Diversity of Minor Millets in India", *Indian J Plant Genet Resour*., Vol. 23, No. 1, pp. 82-86.

- Zeenath A G, Yenagi N and Chittapur B M (2007), "Nutritional Quality of Pop Sorghum Cultivars After Popping", *The Indian J Nutr Dietet*, Vol. 44, pp. 532-537.

IJFANS
International Journal of Food
And Nutritional Sciences