IJFANS
International Journal of Food And Nutritional Sciences

Volume 5, Issue 2, April 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. 2, April 2016

Research Paper ***Open Access***

UTILIZATION OF SORGHUM AND MILLET WET-MILLING PROTEINS IN BREAD SYSTEM

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Received on: 21st Februar, 2016 Accepted on: 5th April, 2016

The study was conducted to examine the effect of sorghums and millet wet-milling proteins in quality of bread produced from commercial wheat and their wet-milling proteins composite flour. Proximate analysis was carried out for two local Sudanese sorghum cultivars namely (dabar and feterita) and millet cultivar. Sorghum (dabar and feterita) and millet proteins were separately extracted as wet-milling by-product and used as party substituent for wheat flour. Rheological properties were studied for wheat flour and wheat flour with 10%, 20%, and 30% sorghum or millet gluten, the result showed wheat flour with 10% sorghum or millet gluten were better than 20% and 30% sorghum or millet gluten. Commercial wheat flour was substituted by sorghum and millet proteins in different percentage 10%, 20%, and 30%, for bread making. Specific loaf volume and Sensory evaluation were carried out of bread. The specific loaf volume of 10% substitution has significant different ($P \leq 0.05$) among all and insignificantly different from the control. Generally, substitution of 20% and 30% of sorghum and millet proteins reduced specific loaf volume of the bread. Sensory assessment for bread showed that 10% substitution of sorghum and millet gluten gave the best results for color, odor, taste and texture of the bread, while the 20% and 30% substitution were less preferred for same criteria. In general, the millet gluten substitution gave lower results compared to sorghum gluten.

Keywords: Sorghum, Millet, Wet-milling, Protein, Bread

INTRODUCTION

Bread consumption has increased continuously in many developing countries due to changing eating habits, a steadily growing population and because a large proportion of the overall increased incomes can now be spent on foods (Seibel, 2011). However, the wheat flour needed for making bread had to be imported, since the climatic conditions and soil did not permit wheat to be grown locally (Seibel, 2011). Since consumers, nowadays, are more concerned about their health, they focus on consuming products which boost up their immune systems. Food with high protein and fiber content are now mostly preferred by consumers to maintain their health and keep them away from many types of diseases like cardiovascular disease, diabetes, weight gain, etc. So there is a new trend in the market to develop a product that combines the health benefits with good sensory properties. Thus, research interest in composite flours has been on the rise in the recent past, driven by the desire to find non-wheat bread-making alternatives in order to reduce non-wheat-producing countries' dependence on imported wheat (Mepba *et al.*, 2007). Much effort has been made to promote the use of composite flours, in which a portion of wheat flour is replaced by locally grown crops, in bread, thereby decreasing the cost associated with imported wheat (Olaoye

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et al., 2006), which in turn decreases the demand for imported wheat while producing protein-enriched bread (Giami *et al.*, 2004). Wheat, Sorghum (Sorghum*bicolor* L. Monech) and millet (*penniseumgluacum* L.) are cereal crops that widely grown over the world for food, they provide more than nourishment to the people than any other food source and contribute substantially to the feeding of domestic animals (FAO and ICRISAT, 1996). Wheat ranks first among cultivated plants of the world .In Sudan wheat cultivation date back more than 200 years but until 1940s production was confined to the northern region whose inhabitants are traditionally wheat consumer. Sorghum is one of the most important cereal crop. It is high yielding and resistant to drought stress. World production of sorghum is about 57 million tons and rank 5^{th} after maize, rice, wheat and barley (FAOSTAT data, 2005).Pearl millet (*penniseumgluacum* L.) is indigenous African cereals that ,unlike wheat or rice, are well adapted to African semi-arid and sub-tropical agronomic conditions .Millet grow under difficult ecological conditions and tolerate poor soils Pearl millet is nutritionally better than most other cereal ;it has high level of calcium,iron,zinc,lipid and high quality proteins (Klopfenstein and Hoseney,1995).But ,as in other cereal grains, nutritional quality is considerably lowered by the presence of anti-nutritional factors leadings to poor digestibility of protein, carbohydrates and minerals.Sorghum flour has the potential to be used in composite bread (Dendy,1992). However, when sorghum flour is included in composite flour it gives a drier, grittier and a faster firming crumb. These adverse effects have been attributed to the higher starch gelatinization temperature and low water-holding capacity of sorghum flour. Biscuits prepared from our composites containing 60 : 40 and 70 : 30 (w/w) nger millet : wheat our were evaluated for dough characteristics and biscuit quality. It was indicated that a composite of nger millet and wheat our (60 : 40) was best, particularly regarding biscuit quality (Saha and others 2011).Sorghum and millet are important protein source for a large number of people living in Africa and Asia and of growing importance for people elsewhere . Although considerable research has been conducted on the proteins of these grains, especially with level for protein composition and nutritional quality. Little research has been conducted on the functionality of sorghum and millet proteins in food. Additional research is needed to discover ways to improve the functionality of sorghum and millet proteins as well as their isolated proteins in food. Sorghum has been successfully processed into starch, glucose, and other products using wet milling in Mexico, the USA and the Sudan. In 1975, wet milling discontinued in Texas because sorghum prices increased to level similar to maize. The procedure for sorghum wet milling is similar to the one used for maize (Waston, 1984). The pigments of the sorghum pericarp give sorghum starch a light pink color . Bleaching with $NaClO_3$ produces acceptable colour but the cooked starch gels has undesirable appearance. According to (Waston, 1984) the major differences between maize and sorghum wet milling is the way in which the starch and gluten separates. Sorghum pericarp more fragile than pericarp of maize, so its impedes the separation of these major component. The protein is difficult to remove from sorghum starch and recovery generally lower than maize starch.Sorghum starch is associated with more highly cross linked proteins than corn starch (Hamaker *et al.*, 1992). The objectives of the current work is to extract wet milling proteins (commercially named, gluten) from sorghum and millet cultivars and to prepare the healthy bread, enriched with sorghum and millet wet-milling proteins as well as to determinethe organoleptic acceptability of the resulting breads.

MATERIAL AND METHODS

Materials

Commercial wheat flour (72% extraction rate, 12% protein content) for bread making was purchased from local market. Two sorghum cultivar and millet grains were obtained from the Food Research Centre, shambat Khartoum north. The samples were cleaned, and well-kept for further analysis.

Methods

Chemical Composition of Sorghum and Millet Samples

The determination of moisture, crude fibre, crudefat and ash were carried out according to AOAC (1984) methods while Protein content (N × 6.25) was determined by a Dumas combustion method (Approved Method 46-30.01, AACC International, 2010).

Wet-Milling of Sorghum and Millet Samples

Wet-milling process was well conducted according to Watson *et al.* (1955).

The Rheological Properties of the Composite Flour

Farinograph tests(water absorption, %; development time or DDT, min; softening index, Brabender Units or B.U; stability, min) of wheat and composite flourdoughs were performed through a Farinograph E (Brabender, Duisburg, Germany) according to the AACC method 54-21 (1995).

Bread Test

Bread test was done according to Badi *et al.* (1978).Wheat flour wasblended with 10, 5, 20, and 30% sorghum and millet wet milling glutens. Specific volume of pan bread: The specific volume ofbread was calculated according to the AACC method 10-05.01 (AACC, 2000) by dividing volume (cc) by weight (g). Loaf volume was measured by rapeseed displacementimmediately after removal from the oven and weighing.Loaves were placed in a container of known volume intowhich rapeseeds were run until the container was full. Thevolume of seeds displaced by the loaf was considered asthe loaf volume. Loaf Specific Volume (LSV), was calculatedaccording to the following

L.S.V = Loaf volume (cc)/Loaf weight (g) = cc/g

The Sensory Assessment

Sensory evaluation of bread samples was conducted by using ranking.Ihekoronye and Ngoddy (1985)

Statistical Analysis

Each determination was carried out respectively on three separate samples and analyzed in triplicate. And figures were then averaged. Data was assessed by the Analysis of Variance (ANOVA) (Snedecor Cochran, 1987). Duncan Multiple Range Test (DMRT, 1955) was used to separate means. Significance was accepted at $P < 0.05$.

RESULT AND DISCUSSION

Chemical Composition of Sorghum

Table 1 shows the results of the proximate composition of sorghum cultivars (Dabar and feterita) and millet cultivar. Data are expressed on dry matter basis (per 100 gm material). The moisture content of feterita and dabar sorghum cultivars was assessed as 7.55 and 7.80% respectively. These values are comparable to the range of 5.7 to 10% reported by AwadElkareem (2009), but significantly lower than the range of 8.89 to 9.88 stated by Arbab (1995) may be due to climatic or location differences. Results show that dabar and feteritasorghum cultivars contain ash 1.60 and 2.60% respectively. The value are within the range of 1.5 to 2.6%, 1.4-1.8%, 1.5-3.9% reported by Awad El Kareem (2002); Awad EL kareem (2009); Abdel Rahman (2002); Hassan (1995), respectively. The crude protein content of two sorghum cultivars dabar and feterita is given in Table 1. Results, however, showed values of 10.50 and 13.13% respectively. The protein content of feterita cultivar is significantly higher than dabar cultivars. The values are within the range of 8.61 to 18.21% reported by Sastry *et al.* (1968). The protein content of feterita cultivar is lower than the value stated by Awad El Kareem (2009) who reported the protein content of feterita was 14.0.The crude fibre analysis for the two sorghum cultivars dabar and feterita showed the values of 1.8and 1.6% respectively. Results obtained were found to be with the range of 1.2 to 1.9% and 1.4 to 2% reported by EL Tiny *et al.* (1979) and AbdlRahman (2002). The fat content of dabar andfeterita cultivars was assessed as 3.09 and 3.18% respectively. The fat content of sorghum cultivar was in range reported by Awad El Kareem (2009) who reported the fat content of Indian and Sudanese sorghum cultivar ranged between 2.84 to 312%. The carbohydrate content of sorghum cultivars was ranged between 71.60 to 74.43%. The results obtained were in range reported by Osman(2004) who reported that the carbohydrate of four local Sudanese cultivars content ranged from 71.3 to 78.7%. The values obtained of chemical composition of millet cultivar was agreed with results stated by Abdallah (1996) and Chethan and Malleshi (2007) who stated that, Finger millet also is known to have several potential health benefits and some of the health benefits are attributed to its polyphenol contents. It has a carbohydrate content of 81.5%, protein 9.8%, crude fiber 4.3%, and mineral 2.7% that is comparable to other cereals. The results obtained for millet were

Table 1: Chemical Composition of Sorghum Cultivars and Millet

Cultivar	Moisture	Ash	Oil	Fiber	Protein	Carbohydrates
Dabar	$7.50^{a} \pm 0.98$	$1.60^{b} \pm 0.50$	$3.09^{b} \pm 0.16$	$1.81^{b} \pm 0.14$	$10.50^{b} \pm 0.91$	$74.43^{a} \pm 0.06$
Feterita	$7.88^{a} \pm 1.41$	$2.60^{a} \pm 0.71$	$3.18^{b} \pm 0.27$	$1.61^{b} \pm 0.07$	$13.13^{a} \pm 0.25$	$71.60^{b} \pm 2.26$
Millet	$6.67^{a} \pm 0.50$	$2.24^{a} \pm 0.09$	$7.52^{a} \pm 0.21$	$2.65^{a} \pm 0.15$	$14.27^{a} \pm 0.47$	$66.65^{c} \pm 1.08$

Note: *Any mean values in the same column having different superscript letters differ significantly ($P < 0.05$).

comparable with those stated by (Obilana and Manyasa, 2002), who revealed that, the chemical composition of pearl millet grains is the same with those of other cereal grains, with minor exceptions. Generally, pearl millet has more oil and higher protein than most other cereal grains grown under similar conditions. Its starch, fibre, ash and sugar levels are similar to those for sorghum

Gluten Yield of Sorghum and Millet Grains

The gluten yield (gram) of protein fraction and extraction rate showed in Table 2. The gluten yield and extraction rate vary greatly among the three samples. The highest gluten yield was obtained from feterita followed by dabar and millet and this correlated to the protein content of the whole grain and the endosperm type of the grain.

Rheological Properties of Wheat Flour

With the special instruments, such as Farinograph, Extensograph and mixo-graph, the comparison of different dough rheological parameters can be performed (Liu *et al.*, 2005). The resistance of dough is evaluated by the Farinograph test, which means the evaluation of behaviour of dough against mixing at a specific constant speed with specific water addition. Rheological properties of wheat flour and wheat flour plus sorghum cultivars and millet wet-milling protein blends were shown in Table 3. The final product quality depends upon the dough rheology taking place during the processing of the constituents. The nature of ingredients, their proportions, mixing time and beating conditions are responsible for the quality of batter which finally determines the bakedproduct quality. The farinograph or mixograph are two most common methods used for measuring the rheological properties of dough during mixing. The mixing of flours results in the hydration which leads to the formation of gluten matrix (Mani *et al.*, 1992). Among the farinograph parameters of the composite flours are significantly affected as the level of replacement of sorghums and millet wet-milling proteins in the wheat flour was enhanced. The farinographic studies of composite flour dough's prepared from wheat flour replaced with sorghum cultivars and millet proteins 10%, 20%, 30% showed that water absorption, dough development time and mixing tolerance index increased as the amount of protein increased, while dough stability decreased at 20%, 30% of wet-milling protein supplementation.

Table 2: Wet-Milling Protein Fraction of Sorghums and Millet

Grain	Gluten Fraction	
	Yield (gm)	Extraction (%)
Feterita	51.31	25.65
Dabar	39.21	19.61
Millet	32.35	16.17

Bread Characteristics

The baking characteristics of commercial wheat flour and wheat flour substituted with sorghum proteins (dabar and feterita) and millet protein is shown in Table 4. Bread specific volume values of commercial wheat flour was 3.236 (cm/g). The bread specific volume values of wheat flour with dabar, feterita, and millet proteins was 3.693, 2.450, 2.446 for dabar, and 3.673, 2.77, and 2.250 for feterita, and 3.573, 2.360, and 2.210 for millet with 10%, 20%, and 30% sorghum (dabar and sorghum) and millet proteins, respectively. The results were confirmed by data by Ahmed (1995) who showed that the bread specific volume of Sudanese wheat cultivar ranged between 3.25 and 3.95. Also the results were in agreement with Mohamed (2000) who stated that the bread volume of four Sudanese wheat cultivars (debira, condor,elnielin, and sasaaib) ranged between 3.76 and 4.05. The statistical analysis showed significant differences ($P \leq 0.05$) among the commercial wheat and wheat flour substituted with different ratios of dabar, feterita, and millet protein. The substitution of 10% sorghum or millet proteins gave the best results compared with control and the rest of treatments. From these results, it's clear that the specific of bread was negatively affected by the increasing ratio of sorghum and millet protein substituted in wheat flour. The result obtained were comparable to Abdel-Aal *et al.* (1993) who reported that loaf and specific volumes of pan breads prepared from composite flours were 25-60% lower than those obtained from pure wheat flour but that flat breads tolerated protein supplements extremely well. On the other hand, Badi *et al.* (1976) reported that adding 10% millet-sorghum flour to the standard baking formula slightly increased loaf volume and improved crumb grain. However, adding sorghum flour (5-20%) to the standard formula decreased loaf volume although acceptable breads were produced.This finding is in agreement with that reported by Aluko and Olugbemi's (1989), who found lower volumes associated with composite asopposed to 100% wheat. This can be attributed to lower levels of gluten network in the dough and consequently

Table 3: The Farinografic Readings of Bread Wheat Flour and its Composite Flours

Flour Blends	Farinogram Readings			
	Water Absorption (%)	Dough Stability (min)	Dough Development Time (min)	Mixing Tolerance (min)
Control (W.F.)	67.1	14.5	2.55	6.25
90% W.F. 10% fet. pro	67.5	8.75	2	5
80% W.F. 20% fet. pro.	64.7	5.5	8	10.75
70% W.F. 30% fet. pro.	64.9	5.25	6	8.5
90% W.F. 10% deb. pro	65.4	7	3	6.25
80% W.F. 20% deb. pro.	64.1	6.25	4	7
70% W.F. 30% deb. pro.	64.6	3.75	7	9.75
90% W.F. 10% mill. pro	68.6	9	1.75	4.75
80% W.F. 20% mill. pro.	67.1	8.25	3.25	6
70% W.F. 30% mill. pro.	64.2	7	5.5	9.5

Table 4: Specific Volumes of Bread Loaves

Flour Blends	Bread Specific Volume
Control (wheat flour)	3.2367^{c}
90% W.F. 10% D.G	3.6933^{d}
80% W.F. 20% D.G	2.4500^{a}
70% W.F. 30% D.G	2.4467^{a}
90% W.F. 10% F.G	3.6733^{d}
80% W.F. 20% F.G	2.7700^{a}
70% W.F. 30% F.G	2.2500^{b}
90% W.F. 10% M.G	3.5730^{d}
80% W.F. 20% M.G	2.3600^{c}
70% W.F. 30% M.G	2.2100^{b}

Note: *Any mean values in the same column having different superscript letters differ significantly (P<0.05). (W.F = Wheat flour, D.G = Dabargluten, F.G = feterita gluten, and MG = Millet gluten).

less ability of the dough to rise; due to the weaker cell wall structure.

Sensory Assessment of Breads

The sensory properties of pan breads made from blends of wheat and sorghum and millet wet milling gluten as well as the 100% wheat bread are presented in Table 5. All sensory scores of colour, odour, taste, and texture were significantly different among blendsamples.Overall, the results have shown that the level of preference declined with decreasing the level of wheat flour in the bread. 10% sorghum and millet proteins substituted in wheat bread were better in all attributes tested compared with 20% and 30%. The colour change occurred from light-brown (control) to darkerbrown this may be because loaves containing additional glucose had a darker crust. Colour appeared to be a very important criterion for the initial acceptability of the baked product by the consumer. Moreover, as the development of colour occurs classically during the later stages of baking, it can be used to judge completion of the baking process. Surface

Table 5: Sensory Assessment of Breads

Flour Blends	Sum of Ranks			
	Colour	Odour	Taste	Texture
Control (wheat flour.)	7.80^{d}	7.20^{e}	5.90^{b}	7.70^{b}
90% W.F. 10% fet. protein	5.50^{c}	5.10^{d}	4.90^{b}	2.00^{ab}
80% W.F. 20% fet. protein	3.90^{ab}	2.90^{bc}	3.20^{a}	1.80^{a}
70% W.F. 30% fet. protein	3.90^{ab}	1.60^{a}	3.00^{a}	1.60^{a}
90% W.F. 10% deb. protein	7.30^{d}	5.00^{d}	5.40^{b}	4.60^{c}
80% W.F. 20% deb. Protein	3.30^{ab}	1.60^{a}	3.20^{a}	1.60^{a}
70% W.F. 30% deb. protein	2.70^{a}	1.60^{a}	2.90^{a}	1.70^{a}
90% W.F. 10% mill. protein	4.40^{bc}	3.80^{c}	3.60^{a}	3.00^{b}
80% W.F. 20% mill. protein	3.30^{ab}	2.00^{ab}	2.70^{a}	6
70% W.F. 30% mill. protein	3.20^{ab}	2.00^{ab}	3.30^{a}	1.40^{a}

Note: *Any mean values in the same column having different superscript letters differ significantly ($P < 0.05$).

colour depends both on the physico-chemical characteristics of the raw dough (i.e., water content, pH, reducing sugars and amino acid content) and on the operating.The results obtained were comparable with (Abdelghafor *et al.*, 2011), who stated that, Whole and decorticated sorghum flours were used to replace 0, 5, 10, 15, and 20% by weight of bread wheat flour. Sensory evaluation results showed that up to 20% wheat replacement with whole or decorticated sorghum flour produced acceptable pan and balady breads. Decreases, however, were noted in all sensory properties except odor.In contrast to the above results, Carson *et al.* (2000) and Hugo *et al.* (2000) reported that addition of 20 to 50% sorghum flour towheat flour produced excellent bread.

CONCLUSION

The study has shown that 10% sorghum cultivars and millet wet-milling proteins could be used as wheat substitute to produce bread that would be well accepted by the consumers, while the high level of substitution (20% and 30%) accompanied by dramatic deterioration in both bread volume and sensory attributes. Generally, sorghum wet-milling proteins have advantages over millet protein.

ACKNOWLEDGMENT

The authors would like to thank Food Research Centre, shambat, Khartoum North and department of grain science and technology, faculty of science and technology, university of Gezira, Wadmedani for providing laboratories facilitation.

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