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Functional Properties and Biscuit Making Potentials of Sorghum-wheat Flour Composite

[1]A.A. Adebowale, [1]M.T. Adegoke, [2]S.A. Sanni, [3]M.O. Adegunwa and [1]G.O. Fetuga
[1]Department of Food Science and Technology, [2]Department of Nutrition and Dietetics,
[3]Department of Foodservice and Tourism, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria

Corresponding Author: A.A. Adebowale, Department of Food Science and Technology, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria

ABSTRACT

The rapid urbanization and increase in population in recent years have resulted in an increase in the consumption of wheat-based products especially biscuits in sub-Saharan Africa. This has spurred pragmatic research on compositing flour from locally cultivated cereals to reduce wheat importation. This study was therefore, conducted to investigate the functional properties of sorghum-wheat composite flour and its biscuit making potentials. Sorghum grain was processed into flour and used to substitute wheat flour at different proportions (0, 5, 10, 15 and 20%). The functional and pasting properties of the different sorghum-wheat flour blends were determined. The composite flours were thereafter, processed into biscuit and the physical dimensions and proximate composition of the biscuits were determined. There were significant differences ($p<0.05$) in the functional properties of the composite flour except for bulk density. There were no significant differences ($p>0.05$) in the pasting profile of the wheat-sorghum flour blends except for set back viscosity and pasting temperature. Highest values of 11.84, 2.36, 1.95 and 5.31% were recorded by biscuit from 90:10% wheat-sorghum composite flours in terms of protein, ash, fibre and sugar, respectively. There were significant differences ($p<0.05$) in the proximate composition of the biscuits samples. However, no significant difference ($p>0.05$) was found in the physical dimensions of the wheat-sorghum flour biscuits. The study concluded that biscuits of acceptable quality, comparable to the quality of 100% wheat flour biscuits are obtainable from sorghum-wheat composite flour. The use of sorghum in biscuits making would greatly enhance the utilization of this crop in many sorghum cultivating developing countries where the crop has not been optimally utilized.

Key words: Composition, functional properties, pasting, biscuit, physical dimension

INTRODUCTION

Biscuits are ready-to-eat, cheap and convenient food product that is consumed among all age groups in many countries (Hussein *et al.*, 2006; Iwegbue, 2012). Biscuits have been reported to be rich in fat and carbohydrate; hence they can be referred to as energy giving food as well as good sources of protein and minerals (Kure *et al.*, 1998). The main ingredient generally used for biscuit production is wheat flour with other ingredients such as margarine (Shortening), sweeteners (sugar), leavening agents, eggs, milk, salt and flavours (Hui, 1992; Ghattas *et al.*, 2008).

In many parts of sub-Saharan Africa and most especially Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products especially biscuits and breads. However, the production of wheat in Nigeria is extremely low and far below domestic requirements. Compositing wheat flour with locally available cereals and root crops has been reported to be desirable (Oyarekua and Adeyeye, 2009). It also encourages the agricultural sector and reduces wheat imports in many developing countries. Considerable efforts have been focused on the use of composite flour for bread and baked products in many wheat importing countries within the last two and half decades (Mepba *et al.*, 2005; Mohammed *et al.*, 2011).

Sorghum is one of the crops grown in many African countries primarily as food crop with less than 5% of the annual production commercially processed by the industry (Rohrbach and Kiriwaggulu, 2001; Bohoua and Yelakan, 2007; Nidaye *et al.*, 2008; Cheng *et al.*, 2009; Okoli *et al.*, 2010). Sorghum grain ranks third among the domesticated cereals for human consumption and is a staple food in many African countries, India and China (Elkhalifa and El-Tinay, 2002; Awadalkareem *et al.*, 2008; Elemo *et al.*, 2011; Mohammed *et al.*, 2011). This study was therefore, aimed at processing sorghum into flour and to evaluate its performance in biscuit production, when used as composite with wheat flour.

MATERIALS AND METHODS

Sorghum grains, wheat flour, margarine, sugar, salt and baking powder were purchased from Kuto main market in Abeokuta, Ogun State, Nigeria.

Preparation of sorghum flour: Whole some sorghum grains free of dirt, stones and other extraneous materials were ground using a laboratory hammer mill to pass through a 0.4 mm screen (Elkhalifa and El-Tinay, 2002) to obtain fine sorghum flour.

Composite flour preparation: Five composite flours were prepared by substituting sorghum flour for wheat flour in the percentage proportion of 0:100, 5:95, 10:90, 15:85 and 20:80%, respectively.

Determination of functional properties of sorghum-wheat composite flour: Bulk density was determined by the method of Wang and Kinsella (1976), water absorption capacity by Anderson (1982), dispersibility by Kulkarni *et al.* (1991), swelling power and solubility index by Takashi and Seib (1988). Water absorption index was carried out using the modified method of Anderson (1982) while pasting properties was determined using the Rapid Visco Analyser (Model RVA 3D+; Network Scientific, Australia).

Processing of sorghum-wheat composite flour biscuit: The baking recipe used was as described by Maohar and Rao (2002) (modified). Sugar and fat were creamed in a mixer with a flat beater for 2 min at 60 rpm. Water containing sodium chloride was added to the above cream and mixed for 5 min at 125 rpm to obtain a homogenous cream. Then, sorghum-wheat composite flour with baking powder were added and mixed for 3 min at 60 rpm. Dough was sheeted using a rolling pin to a thickness of 3.5 mm with the help of a flat rolling board. Biscuits dough were shaped by cutting with a cutter of 5 mm diameter and baked in an aluminium tray at 205°C for 10 min.

Determination of the physical properties and proximate composition of sorghum-wheat flour biscuit: Physical Dimensions (weight (g), thickness (cm) and width (cm)), of the biscuit samples were measured with a digital micrometer screw gauge while spread ratio and spread factor was calculated as follows (AACC, 1967):

$$\text{Spread ratio} = \frac{\text{Width}}{\text{Thickness}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control (100\% wheat flour)}} \times 100$$

Moisture, fat, ash, protein, crude and carbohydrates contents of the sorghum-wheat biscuit samples were determined using AOAC (1990) method.

STATISTICAL ANALYSIS

All data obtained were subjected to statistical Analysis of variance (ANOVA) using SPSS (version 15, 2007). Means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Functional properties of sorghum-wheat composite flour: Table 1 depicts the functional properties of sorghum-wheat composite flour. The functional properties are those parameters that determine the application and use of food material for various food products. The values of water absorption index ranged between 3.47 and 4.12 while that of water absorption capacity ranged from 86.8 to 92.5%. The water absorption capacity of the 100% wheat flour was lower than that of the sorghum-wheat composite. This could be indicative of the fact that addition of sorghum flour to wheat flour confers high water binding capacity to wheat flour, which in turn improves the reconstitution ability (Kulkarni *et al*., 1991; Ajanaku *et al*., 2012) and textural properties of dough obtainable from sorghum-wheat composite flour. High water absorption capacity is also attributed to lose structure of starch polymers while low value indicates the compactness of the structure (Adebowale *et al*., 2005; Oladipo and Nwokocha, 2011). The solubility index and swelling power of the flour samples ranged from 8.84-9.92 and 9.97-10.34%, respectively. Moorthy and Ramanujam (1986) reported that the swelling power of flour granules is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating (Loos *et al*., 1981). The value of dispersibility which is an index of the ease of reconstitution of flour or composite flours in water ranged between 73.5 and 76.5%. The dispersibility of the 100% wheat flour was lower than that of the sorghum-wheat composite flour samples. However, the values of dispersibility are relatively high for all the composite flour samples hence, they will easily reconstitute to give fine consistency dough during mixing (Adebowale *et al*., 2008a). The bulk density of the flour samples ranged from 0.67-0.77 g cm^{-3}. The bulk density is generally affected by the particle size and the density of flour or flour blends and it is very important in determining the packaging requirement, raw material handling and application in wet processing in the food industry (Adebowale *et al*., 2008a; Ajanaku *et al*., 2012).

Pasting properties of sorghum-wheat composite flour: Table 2 shows the pasting characteristics of the different sorghum and wheat flour combinations. Pasting property is one of the most important properties that influence quality and aesthetic considerations in the food

Table 1: Functional properties of sorghum-wheat composite flour

Sample (%)	Water absorption index	Solubility index	Swelling power (%)	Water absorption capacity (%)	Dispersibility (%)	Bulk density (g cm^{-3})^{ns}
WF (100)	3.47±0.01^{a}	9.84±0.01^{c}	10.21±0.02^{c}	86.8±0.28^{a}	73.0±0.01^{a}	0.71±0.03
SF:WF (5:95)	4.12±0.01^{c}	9.92±0.01^{d}	10.34±0.01^{d}	92.5±0.14^{b}	73.5±0.71^{a}	0.67±0.06
SF:WF (10:90)	3.93±0.07^{b}	8.84±0.02^{b}	9.97±0.01^{b}	94.3±0.14^{c}	76.5±0.70^{b}	0.77±0.08
SF:WF (15:85)	3.45±0.02^{a}	9.87±0.01^{c}	10.21±0.03^{c}	92.3±0.15^{b}	76.0±0.71^{b}	0.67±0.06
SF:WF (20:80)	3.47±0.01^{a}	8.76±0.02^{a}	9.87±0.01^{a}	93.9±0.15^{c}	75.5±0.65^{b}	0.67±0.06

±Standard deviation of two replicates, Mean values having different superscript within the same column are significantly different ($p<0.05$), ns: Not significantly different ($p>0.05$), WF: Wheat flour, SF: Sorghum flour

Table 2: Pasting properties of sorghum-wheat composite flour

Sample (%)	Peak (RVU)^{ns}	Trough (RVU)^{ns}	Break down (RVU)^{ns}	Final viscosity (RVU)	Setback (RVU)^{ns}	Peak time (min)^{ns}	Pasting temp. (°C)
WF (100)	158.63±2.30	95.96±5.60	62.67±3.0	206.71±5.00	110.75±0.59^{a}	5.83±0.14	94.48±0.04^{d}
SF:WF (5:95)	165.33±3.89	102.04±4.19	63.29±0.30	220.42±8.30	118.38±4.17^{ab}	5.87±0.09	93.85±0.00^{b}
SF:WF (10:90)	164.93±7.06	106.67±16.50	57.96±9.02	226.17±9.54	119.50±4.95^{ab}	6.00±0.28	94.23±0.06^{c}
SF:WF (15:85)	167.17±3.40	104.71±6.19	62.46±3.01	229.00±2.36	124.29±3.83^{bc}	6.03±0.24	93.63±0.04^{a}
SF:WF (20:80)	163.63±2.41	104.38±5.24	59.25±2.83	234.67±2.47	130.29±2.97^{c}	6.04±0.23	94.48±0.03^{d}

Mean±Standard deviation of 2 replicates, Mean values having different superscript within the same column are significantly different ($p<0.05$), ns: Not significantly different ($p<0.05$), WF: Wheat flour, SF: Sorghum flour

industry since they affect texture and digestibility as well as the end use of starch-based food commodities (Adebowale *et al*., 2005; Onweluzo and Nnamuchi, 2009; Ajanaku *et al*., 2012). Peak viscosity, which is an index of the ability of starch-based fruits to swell freely before their physical break down (Sanni *et al*., 2006; Adebowale *et al*., 2008b) ranged from 158.63-167.17 RVU (Relative Visco-Analyser Unit). There was no significant difference ($p>0.05$) in peak viscosity of the composite flour. High peak viscosity is an indication of high starch content (Osungbaro, 1990) and this could explain why sorghum-wheat composite flour samples had higher peak viscosity compared to 100% wheat flour. Trough, is the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand break down during cooling. The values ranged between 95.96 and 100.67 RVU with 10% sorghum composite flour having the highest and 100% wheat flour having the lowest value. Composite flour with 5% sorghum flour had the highest (63.29 RVU) break down viscosity while 10% sorghum composite had the lowest (57.96 RVU) break down viscosity. The final viscosity ranged between 206.71 and 234.67 RVU with 20% sorghum composite having the highest value and 100% wheat flour having the lowest. There was no significant difference ($p>0.05$) in the final viscosity of the flour samples. Final viscosity is commonly used to define the quality of particular starch-based flour, since it indicates the ability of the flour to form a viscous paste after cooking and cooling. It also gives a measure of the resistance of paste to shear force during stirring (Adebowale *et al*., 2005; Adebowale *et al*., 2008b). The setback viscosity ranged from 110.75-130.29 RVU. There was significant different ($p<0.05$) in setback viscosity of the composite flour samples. The higher the set back viscosity the lower the retrogradation of the flour paste during cooling and the lower the staling rate of the product made from the flour (Adeyemi and Idowu, 1990). Peak time which is a measure of the cooking time ranged between 5.83 and 6.04 min with 20% sorghum composite flour having the highest value and 100% wheat flour had the lowest. Pasting temperature ranged from 93.63-94.48°C. A higher pasting temperature indicates higher water binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of association between starch granules (Adebowale *et al*., 2008b).

Physical properties of sorghum-wheat composite biscuit: Table 3 shows the physical properties of sorghum-wheat composite flour biscuit. The weight, thickness, width, spread ratio and spread factor ranged from 5.30-5.70 g, 3.90-4.00 mm, 4.40-4.60 mm, 1.16-1.19 and from 97.50-99.20, respectively. There were no significant differences (p>0.05) between the weight, thickness, width and spread ratio of 100% wheat flour biscuit (control) compared to that of sorghum-wheat composite flour biscuits. This result is contrary to the findings of Mridula *et al*. (2007), who reported significant reduction in the thickness and spread ratio of wheat-soybean and sorghum composite biscuit with increased proportion of sorghum flour. Hence, it may be implied that the decrease in the thickness and spread ratio reported by Mridula *et al*. (2007) was due to the addition of soya bean flour rather than the addition of sorghum flour.

Chemical composition of sorghum-wheat composite flour biscuit: Table 4 shows the chemical composition of sorghum-wheat composite flour biscuit. The moisture content ranged from 10.24-11.24% with 5% sorghum biscuit having the highest value while 100% wheat flour biscuit had the lowest. These values were within the range reported to have no adverse effect on the quality attributes of the product (Kure *et al*., 1998). Sanni *et al*. (2006) reported that the lower the moisture content of a product to be stored the better the shelf stability of such product. Hence, low moisture ensures higher shelf stability in dried products. The moisture content of a food is indicative of the dry matter in that food. However, low residual moisture content in confectionaries is advantageous in that microbial proliferation is reduced and storage life may be prolonged if stored inside appropriate packaging materials under good environmental condition. Biscuit sample from composite flour containing 10% sorghum flour had the highest protein content of 11.84 while 15% sorghum composite flour biscuit had the lowest value of 8.61%. The fat content ranged from 3.29-4.57% while ash content ranged from 2.20-2.36%. The ash content of a food material could be used as an index of mineral constituents of the food because ash is the inorganic residue

Table 3: Physical properties of sorghum-wheat composite flour biscuit

Sample (%)	Weight (g)[ns]	Thickness (mm)[ns]	Width (mm)[ns]	Breaking force (N)[ns]	Spread ratio[ns]	Spread factor[ns]
WF (100)	5.30±0.13	4.00±0.03	4.50±0.06	9.50±0.71	1.16±0.04	-
SF:WF (5:95)	5.60±0.3	3.90±0.23	4.50±0.08	8.00±2.83	1.14±0.04	98.70±0.65
SF:WF (10:90)	5.60±0.37	3.90±0.18	4.60±0.07	6.00±2.81	1.14±0.07	98.70±3.10
SF:WF (15:85)	5.70±0.31	3.90±0.02	4.40±0.05	5.50±0.71	1.19±0.01	97.50±4.82
SF:WF (20:80)	5.70±0.50	3.90±0.01	4.40±0.01	3.00±0.05	1.12±0.01	99.20±4.87

±Standard deviation of 2 replicates, ns: Not significant (p>0.05), WF: Wheat flour, SF: Sorghum flour

Table 4: Proximate composition (%) of sorghum-wheat composite flour biscuit

Sample (%)	Moisture content	Protein	Fat	Ash	Crude fibre	Sugar	Starch
WF (100)	10.24±0.02[a]	9.76±0.03[c]	3.75±0.07[d]	2.27±0.01[bc]	1.87±0.01[c]	4.55±0.02[c]	67.58±0.08[c]
SF:WF (5:95)	11.24±0.01[e]	9.12±0.01[c]	3.59±0.01[c]	2.32±0.03[cd]	1.77±0.02[b]	5.13±0.03[d]	66.84±0.05[b]
SF:WF (10:90)	10.67±0.07[b]	11.84±0.01[e]	4.57±0.02[e]	2.36±0.04[d]	1.95±0.01[d]	5.31±0.03[e]	63.32±0.04[a]
SF:WF (15:85)	10.87±0.02[c]	7.06±0.04[a]	3.29±0.01[a]	2.24±0.02[ab]	1.66±0.0.3[a]	4.24±0.01[b]	70.65±0.01[e]
SF:WF (20:80)	11.11±0.01[d]	8.61±0.02[b]	3.47±0.01[b]	2.20±0.07[a]	1.73±0.01[b]	3.97±0.02[a]	68.92±0.03[d]

±Standard deviation of 2 replicates, Mean values having different superscript within the same column are significantly different (p<0.05), WF: Wheat flour, SF: Wheat flour remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent (Sanni *et al.*, 2008). The crude fibre, sugar and starch contents ranged from 1.66-1.95, 3.97-5.31 and from 63.32-70.65%, respectively.

CONCLUSION

Biscuits of desirable physical properties and chemical composition comparable to 100% wheat flour biscuits have been produced from sorghum-wheat composite flour. The use of sorghum in biscuits making, would greatly enhance the utilization of this crop in sub-Saharan African countries like Nigeria where the crop has not been optimally utilized.

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