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ORIGINAL RESEARCH PAPER

STUDIES ON PASTING AND FUNCTIONAL PROPERTIES OF FLOUR FROM CANNELLINI COWPEA AND ITS POTENTIAL IN BAKING

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The pasting and functional properties of flour blends produced from wheat and cannellini cowpea in respective ratios of 100:0, 95:5, 90:10, 85:15 and 80:20 were determined; the potential of the blends in the baking of bread was also evaluated. Higher values (%) of ash (1.82), crude fat (3.26) and crude protein (13.83) were recorded in 80:20 flour blend than others. The highest values of 1.13 g/ml, 29.02 ml/g, 3.01%, 3.51 g/g and 6.98% were obtained respectively for 100:0 blend in bulk density, foaming capacity, water absorption capacity, oil absorption capacity and swelling index respectively. Pasting properties were higher for the 100:0 flour. The 80:20 bread sample contained higher contents (%) of ash, crude fibre, crude fat and crude protein than others. No significant difference ($P > 0.05$) was noted between 100:0, 100:5 and 100:10 bread samples in most of the sensory attributes tested. It was concluded that acceptable and nutritionally comparable bread could be produced from flour blends of wheat and cannellini cowpea.

Keywords: pasting and functional properties, flour blends, bread, sensory attributes, nutritionally comparable

Introduction

Functional and pasting properties of flour are important quality indices of priority consideration in the baking food products as they affect their texture, crispiness, softness and rheological characteristics. Due to recent advances in the research of composite flour technology in the production of baked food items, efforts are being required in the determination of composite flours of wheat and vegetables in order to evaluate their suitability for use in such food products (Olaoye and Ade-Omowaye, 2011). One of the vegetables than may be adopted in composite flour technology is cannellini cowpea (*Phaseolus vulgaris*), which is regarded as "poor man's meat". Cannellini cowpeas supply protein, complex carbohydrates, fiber and essential vitamins and minerals to the diet, they are low in fat and sodium and contain no cholesterol (Seleem and Omran, 2014). The inclusion of legume, especially cowpea, into the category of cereal based products could be a good option for increasing nutritional intake of people (Olaoye *et al.*, 2007). According to Livingstone *et al.* (1993), the combination of wheat with legume proteins may help provide good essential amino acid balance, which may be of significance in developing countries where protein intake is inadequate for economic reason.

Edema *et al.* (2005) have stressed that bread forms an important stable food in the developing countries especially in the tropics. The authors further noted that bread may however be relatively expensive as a result of its production from imported wheat that is not cultivated in many countries due to unsuitable climatic conditions.

According to Olaoye *et al.* (2006), bread production is common in many countries of the tropics, and this has been attributed to the increase in population density in such countries. Even with the substantial progress in the composite bread technology, in order to obtain high quality final products about 70% of the composite should consist of wheat flour. The partial substitution of vegetable flour with cowpea flour along with wheat flour in baking has been reported by research investigators, including Olaoye *et al.* (2006, 2007), Mepba *et al.* (2007), Ade-Omowaye *et al.* (2008) and Olaoye and Onilude (2008). In a recent study, Olaoye *et ai.* (2015) reported the use of malted maize flour for substituting the wheat flour in the production of cake.

As a result of underutilization of cannellini cowpea (*Phaseolus vulgaris*), research efforts are required in the possible production of composite flour along with wheat for use in baking of food products such as bread. Therefore, this study was aimed at determining the functional and pasting properties of flour blends from wheat and cannellini cowpea to be used in the production of bread.

Materials and methods

Source of raw materials

The cannellini cowpea (*Phaseolus vulgaris*) samples used in this study were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria. The wheat flour and other ingredients used for production of composite bread were purchased from a local market in Offa, Kwara State, Nigeria.

Processing of cannellini cowpea into flour

The cannellini cowpeas were processed into flour using the modified method developed by Abiodun and Adepeju (2011). They were sorted to remove defective portions and then roasted at 135°C for 15 min, after which the roasted cowpeas were allowed to cool and then subjected to size reduction using the attrition mill (Munson Machinery Company Inc., USA). The detached coats were winnowed away and the resulting inner portions were milled using hammer mill machine (Tigerextruda 6.5 hp, UK) to obtain cannellini cowpea flour, CBF (about 250 micron particle size) which was packaged in polyvinyl chloride bags.

Preparation of flour blends from wheat and cannellini cowpea

Flour blends were obtained by mixing flours of wheat and cannellini cowpea in the respective proportions of 95:5 (WCBF-95:5), 90:10 (WCBF-90:10), 85:15

(WCBF-85:15) and 80:20 (WCBF-80:20). The whole wheat flour (WholeWF) was used as control, and the wheat flour used was of 'hard type'.

Determination of functional properties of the flour blends from wheat and cannellini cowpea

Water absorption capacity and bulk density were determined using the respective methods developed by Mbofung *et al*. (2006) and Wang and Kinsella (1976). Foaming capacity and gelation capacity were determined by methods proposed by Okezie and Bello (1988) and Abulude (2001) respectively.

Oil absorption properties of the flour blends were determined following the method developed by Sathe *et al*. (1981). A quantity of the flour (2 g) was mixed with 20 ml of oil in a Moulinex blender (Model dePC 3, France) at high speed for 30 sec. The sample was allowed to stand at 30°C for 30 min and then centrifriged at 10,000 rpm for 30 min. The volume of supernatant in a graduated cylinder was noted. The density of oil was determined to be 0.93 g/ml. The swelling index was determined using the method created by Tharise *et al*. (2014).
All determinations were carried out in triplicates.

Determination of pasting properties of the flour blends from wheat and cannellini cowpea

The pasting characteristics of the various flour blends were determined using a Rapid Visco Analyzer (Model RVA 3D+, Newport Scientific, Australia). About 2.5 g of flour were weighed into a dried empty canister, followed by the addition of 25 ml of distilled water. The solution was thoroughly mixed and the container fitted into the RVA unit according to manufacturer's instructions. The slurry was heated from 50 to 95^{o}C with a holding time of 2 min. The rate of heating and cooling was at a constant temp of 11.25^{o}C per min. The peak viscosity, trough viscosity, breakdown viscosity, final viscosity, set back viscosity, peak time and pasting temperature were obtained from the pasting profiles with the aid of thermocline for Windows software connected to a computer generating the data from the RVA unit (Newport Scientific, 1998). The viscosities were expressed in terms of Rapid Visco Units (RVU), equivalent to 10 centipoises.

Production of bread from the flour blends from wheat and cannellini cowpea

The method of AACC (1984) was used for production of bread from the different flour blends, involving a bulk fermentation process. A quantity of 200 g from each of the flour samples was weighed and the addition of the required amount of water was performed to obtain dough; this was kneaded on a pastry-board to smoothen. The dough was initially fermented for 2 h at 30^{o}C before subsequently kneaded to expel carbon dioxide and then the dough tightened up to ensure improvement in the textural properties of the product (bread). The dough was sized and moulded into the baking pans for final proofing at 30^{o}C for 2 h. The baking of the dough was carried out in a forced air convection electric oven (380V, ROHS Deck Baking Oven, Hangzhou 311121, China) at 230^{o}C for 30 min.

Determination of proximate components of flour blends and composite bread samples

The proximate components of moisture, ash, fat, and protein contents of the different flour blends and composite bread samples produced from them were determined using the methods of the Association of Official Analytical Chemists (2005). Carbohydrate was determined by difference.

Sensory evaluation of composite bread samples produced from the flour blends

The bread samples produced from the flour blends of wheat and cannellini cowpea were subjected to sensory evaluation for the attributes of crust, aroma, appearance, internal texture, taste and general acceptability. A semi trained twenty member panel was used, and scores were allocated by the panelists based on a 9-point hedonic scale, ranging from 1 (dislike extremely) to 9 (like extremely). The data collected were subjected to statistical analysis to determine possible differences among samples.

Statistical analysis

The effect of blending wheat and cannellini cowpea flours in different ratios was determined on the quality of the flour blends and composite bread samples by subjecting the data obtained to the analysis of variance (ANOVA) using the statistic software, Design expert, Stat-Ease Inc., East Hennepin Ave, Minneapolis, Version 6.0.6 (SPSS, 1999). Significant differences were determined at $p<0.05$.

Results and discussion

The result regarding the functional properties of the different flour blends indicates that the WholeWF sample had the highest bulk density (1.13 g/ml), while the lowest of 0.77 was recorded for the WCBF-80:20 counterpart (Table 1). Regarding foaming capacity, the highest value of 29.02 ml/g was recorded for WholeWF, whereas the lowest (24.09 ml/g) for WCBF-80:20 sample. Bulk density, water absorption capacity, oil absorption capacity, and swelling index decreased with a corresponding increase in the ration of cannellini cowpea flour; gelation capacity however showed a contrary trend and this may be attributed to the characteristic nature of carbohydrate in cannellini cowpea (Segura-Campos *et al.*, 2014). There was however slight variation in the functional properties of bulk density, foaming capacity and water absorption capacities which could be due to varietal and environmental differences. The result concerning the functional properties of the flour blends obtained in this study is supported by the findings of other research investigators (Igbabul *et al*. (2013; Adebayo-Oyetoro *et al.,* 2011; Ramezani *et al.*, 2013; Segura-Campos *et al.*, 2014). Functional properties are important quality characteristics of flours that contribute significantly to their potential use in the preparation of various food products, especially baked foods (Ogunlakin *et al.*, 2013).

Table 2 shows the proximate compositions of the different wheat and cannellini cowpea flour blends. Ash recorded the highest and the lowest values of 1.82% and

1.63% in the flour blend sample containing 20% cannellini cowpea flour - WCBF-80:20 and whole wheat flour – WholeWF, respectively.

Table 1. Functional properties of flour blends obtained from wheat and cannellini cowpea

Functional properties	WholeWF		WCBF-95:5		WCBF-90:10		WCBF-85:15		WCBF-80:20	
	Value	SD	Value	SD	Value	SD	Value	SD	Value	SD
Foaming capacity (ml/g)	29.02^{a}	2.37	28.01^{a}	1.73	27.04^{a}	3.28	25.84^{a}	2.37	24.09^{b}	3.69
Bulk density (g/ml)	1.13^{a}	0.04	0.93^{a}	0.08	0.87^{ab}	0.05	0.81^{b}	0.17	0.77^{b}	0.19
Water absorption capacity (%)	3.01^{a}	0.21	2.93^{a}	0.37	2.77^{ab}	0.26	2.62^{bc}	0.63	2.41^{c}	1.07
Oil absorption capacity (g/g)	3.51^{a}	0.37	3.42^{a}	0.26	3.17^{b}	0.08	2.92^{bc}	0.31	2.63^{c}	0.53
Gelation capacity (%w/v)	2.69^{b}	0.36	2.79^{b}	0.29	2.88^{b}	1.02	2.99^{ab}	0.37	3.18^{a}	1.26
Swelling index (%)	6.98^{a}	0.37	6.94^{a}	0.75	6.86^{b}	1.73	6.73^{b}	1.09	6.56^{c}	0.97

Table 2. Proximate composition of flour blends obtained from wheat and cannellini cowpea

Proximate components (%)	WholeWF		WholeWF		WCBF-95:5		WCBF-90:10		WCBF-85:15		WCBF-80:20	
	Value	Value	SD	SD	Value	SD	Value	SD	Value	SD	Value	SD
Ash content	1.63^{c}	0.34	3.97^{a}	0.16	1.69^{c}	0.12	1.73^{b}	0.31	1.77^{b}	0.42	1.82^{a}	0.18
Crude fibre	1.57^{b}	0.17	3.68^{a}	0.25	1.51^{b}	0.17	1.49^{b}	0.09	1.43^{b}	0.36	1.37^{c}	0.08
Crude fat	2.69^{a}	0.18	1.98^{c}	0.08	2.53^{b}	0.25	2.73^{ab}	0.18	2.87^{a}	0.26	3.26^{a}	1.48
Crude protein	11.93^{c}	1.35	22.02^{a}	1.24	13.32^{b}	1.07	13.48^{b}	1.22	13.68^{b}	0.39	13.83^{b}	0.24
Carbohydrate	70.62^{a}	4.25	56.77^{b}	4.39	70.35^{a}	2.17	70.55^{a}	3.25	69.72^{a}	2.37	69.91^{a}	2.15
Moisture content	11.17^{c}	1.23	11.58^{b}	0.95	11.95^{a}	1.51	10.49^{c}	1.83	11.58^{b}	1.29	11.26^{c}	2.36

Table 3. Pasting properties of flour blends obtained from wheat and cannellini cowpea

Pasting properties (RVU)	WholeWF		WCBF-95:5		WCBF-90:10		WCBF-85:15		WCBF-80:20	
	Value	SD	Value	SD	Value	SD	Value	SD	Value	SD
Trough viscosity	79^{a}	6.35	74^{a}	3.75	68^{b}	3.36	59^{b}	3.35	45^{c}	2.18
Peak viscosity	159^{a}	7.37	154^{b}	2.39	147^{bc}	2.39	140^{cd}	10.07	127^{d}	9.9
Breakdown viscosity	105^{a}	9.05	105^{a}	15.66	98^{ab}	2.15	91^{bc}	9.2	88^{c}	10.24
Final viscosity	807^{a}	13.27	756^{a}	9.74	696^{b}	16.26	634^{c}	12.36	524^{d}	12.26
Setback viscosity	95^{a}	2.36	86^{ab}	3.84	75^{bc}	4.08	70^{cd}	1.78	64^{d}	5.47
Peak time (min)	5.51^{c}	0.73	5.63^{bc}	1.09	5.98^{b}	1.26	6.36^{a}	0.93	6.99^{a}	1.13
Pasting temp (°C)	63^{b}	6.58	67^{b}	2.19	69^{ab}	1.29	71^{a}	10.12	74^{a}	9.02

Values are means of three replicates of samples; Values across rows with different superscript letters are significantly different ($p<0.05$). WholeWF, whole wheat flour; WCBF-95:5, flour blends produced from 95% wheat and 5% cannellini cowpea; WCBF-90:10, flour blends produced from 90% wheat and 10% cannellini cowpea; WCBF-85:15, flour blends produced from 85% wheat and 15% cannellini cowpea; WCBF-80:20, flour blends produced from 80% wheat and 10% cannellini cowpea; RVU, rapid visco units; SD, standard deviation.

The ash contents of all samples containing cannellini cowpea flour, WCBF-90:10, WCBF-85:15 and WCBF-80:20 were significantly higher ($P < 0.05$) than others.

A similar trend was assumed by crude fiber, crude fat and crude protein contents of the flour blends, where a progressive increase was observed with the corresponding addition of cannellini cowpea flour. The observation suggests that higher contents of the different parameters may be found in cannellini cowpea than wheat. In a similar research investigation, it was shown that protein, crude fibre and ash contents were higher in flour obtained from a grain legume than the one from wheat (Nwosu, 2013); thus justifying the result of the present study. Nwosu (2013) however reported higher fat content in wheat flour than the grain legume flour, which was contrary to the result of the study being reported. This may possibly be due to the difference in the legume grains used in the studies. In another study, Abu-Salem and Abou-Arab (2011) reported higher values for fat, protein, fiber and ash in flour from a legume compared to wheat flour, and this is in support of the result obtained in the present study. The increase observed in the food components of the composite flours suggests that food products made with composite flours of wheat and cannellini cowpea could be of nutritional advantage than using only wheat flour. Significant difference ($P < 0.05$) was noted in the ash, crude fat and crude protein contents of cannellini cowpea and whole wheat flours. The higher contents of protein, ash, and fibre observed in the cannellini cowpea flour than WholeWF are supported by the reports made by Ramezani *et al.* (2013) and Seleem and Omran (2014).

Average means between 10.49 and 11.95 were observed for moisture contents (%) of the various flour blends, with the WCBF-95:5 sample having the highest value while WCBF-90:10 had the lowest. The moisture contents of the flour blends were supportive of those reported by Alozie *et al.* (2009) and Ramezani *et al.* (2013), the former recorded values between 10.75 and 11.12 in the composite flours of wheat/grain legume, while the latter obtained a range of 8.5 to 13 in wheat/cowpeas. Olaoye *et al.* (2006) and Olaoye and Onilude (2008) have noted that moisture plays very important roles in the keeping quality of food products and values may adversely affect storage stability of dry foods, especially vegetable flours. In the present report, reduced moisture content of less than 11.95 was recorded, and this may contribute positively to enhancing storage stability and shelf life of the different flour blends.

The result concerning the pasting properties of the flour blends indicates that the WholeWF sample had the highest peak viscosity of 159 RVU while the lowest value (127) was recorded for WCBF-80:20 (Table 3). Significant difference ($P < 0.05$) was recorded in the peak viscosities of WholeWF and other flour blends. It was also indicated that no decrease occurred in trough viscosity, breakdown viscosity and final viscosity despite partial replacement of WholeWF with cannellini cowpea flour. The WCBF-80:20 had the highest peak time of 6.99 min, and this was observed to decrease with the corresponding decrease in the addition of cannellini cowpea flour. The highest and lowest pasting temperatures (^oC) of 74 and 63 were recorded for WCBF-80:20 WholeWF flour samples respectively, and this was in support of the findings reported by Abiodun and Adepeju (2011).

Contained in Table 4 are the proximate components of the bread samples produced from the flour blends; it was shown that samples containing cannellini cowpea flour recorded ash, crude fat and crude protein contents higher than those made from whole wheat flour alone (i.e WholeWF). The result correlated with those recorded for the same components in the flour blends (Table 2), implying that bread samples made from composite flours of wheat and cannellini cowpea may be nutritionally advantageous.

Table 4. Composite bread produced from the flour blends and their percentage proximate components

Component (%)	WholeWF		WCBF-95:5		WCBF-90:10		WCBF-85:15		WCBF-80:20	
	Value	SD	Value	SD	Value	SD	Value	SD	Value	SD
Ash content	0.78c	0.13	0.75b	0.25	0.89ab	0.33	0.95a	0.17	1.07a	0.25
Crude fibre	0.12b	0	0.15b	0.04	0.17ab	0.06	0.20a	0.04	0.25a	0.06
Crude fat	0.75b	0.04	0.81b	0.02	0.85ab	0.05	0.90a	0.05	0.97a	0.07
Crude protein	4.69c	0.43	5.53b	1.02	5.89b	0.05	6.37a	0.37	6.97a	1.82
Carbohydrate	65.34b	4.35	64.73a	2.17	64.35a	2.43	63.76a	1.27	62.34b	1.29
Moisture content	30.24a	3.2	29.98a	3.05	30.06a	2.18	30.98a	1.08	32.37a	2.37

Values are means of three replicates of samples; Values across rows with different superscript letters are significantly different ($p<0.05$). WholeWF, whole wheat flour; WCBF-95:5, flour blends produced from 95% wheat and 5% cannellini cowpea; WCBF-90:10, flour blends produced from 90% wheat and 10% cannellini cowpea; WCBF-85:15, flour blends produced from 85% wheat and 15% cannellini cowpea; WCBF-80:20, flour blends produced from 80% wheat and 10% cannellini cowpea; SD, standard deviation.

Table 5. Composite bread produced from the flour blends and their sensory attributes

Sensory attributes	WholeWF		WCBF-95:5		WCBF-90:10		WCBF-85:15		WCBF-80:20	
	Value	SD	Value	SD	Value	SD	Value	SD	Value	SD
Crust	8.01a	0.23	7.72a	1.27	7,36b	0.96	6.85b	1.53	6.04b	1.02
Aroma	7.95a	2.12	7.45a	1.08	6.86b	0.75	6.01b	0.09	5.69b	1.07
Appearance	8.25a	1.26	8.11a	0.06	7.34ab	1.22	6.85bc	1.07	5.96c	0.73
Internal texture	8.12a	0.84	7.77a	0.93	7.23ab	0.72	6.73bc	1.03	6.02c	0.65
Taste	7.86a	0.77	7.46ab	1.26	6.97b	0.83	6.56bc	0.59	5.96c	0.53
Gen.Acceptability	8.25a	0.25	8.19a	1.08	7.65b	2.05	7.06b	0.94	6.41b	0.73

Values are means of three replicates of samples; Values across rows with different superscript letters are significantly different ($p<0.05$). WholeWF, whole wheat flour; WCBF-95:5, flour blends produced from 95% wheat and 5% cannellini cowpea; WCBF-90:10, flour blends produced from 90% wheat and 10% cannellini cowpea; WCBF-85:15, flour blends produced from 85% wheat and 15% cannellini cowpea; WCBF-80:20, flour blends produced from 80% wheat and 10% cannellini cowpea; SD, standard deviation; Gen.Acceptability, general acceptability.

The composite bread samples and their mean scores of sensory attributes showed that sample made from WholeWF had higher scores than others in all the attributes tested (Table 5). Scores generally decreased in the bread samples with the corresponding increase in the addition of cannellini cowpea flour. There was no significant difference ($P > 0.05$) between bread samples made from WholeWF and WCBF-95:5 in the sensory attributes that were evaluated. The bread sample made from WCBF-90:10 did not differ significantly ($P > 0.05$) from the WholeWF counterpart, and hence they have similar sensory characteristics.

Conclusions

This study concluded that the minimal substitution of wheat flour with cannellini cowpea flour between 5 and 15% resulted in flour blends having comparable pasting and functional properties with whole wheat flour. Composite bread samples produced from these flour blends were also acceptable to consumers in terms of the sensory attributes tested. Furthermore, the addition of cannellini cowpea flour up to 15% to wheat flour may be used in producing composite bread with enhanced nutritional value; if this practice is adopted commercially, it may help promote food security in developing countries where wheat cultivation is known to be poor because of climatic conditions.

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