African Journal of Food Science Vol. 4(5), pp. 248-253, May 2010
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 © 2010 Academic Journals

Full Length Research paper

Functional and sensory properties of wheat (*Aestium triticium*) and taro flour (*Colocasia esculenta*) composite bread

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Accepted 12 May, 2010

Functional and sensory properties of wheat (*Aestium triticium*) and taro (*Colocasia esculenta*) composite bread were investigated. Unblanched and blanched flour were produced from taro tubers. These were separately used to formulate composite flour blends with wheat flours in ratios of 70:30, 80:20 and 90:10. Functional properties, water absorption capacity (WAC), oil absorption capacity (OAC), packed bulk density (PBD), loose bulk density (LBD), least gelation concentration (LGC) and swelling capacity (SC) of the blends and the reference samples were assayed using known standard methods. Bread samples produced from the various composite flour blends using standard recipes were subjected to sensory evaluation. Results showed that there was a significant difference (P < 0.05) in all the functional properties amongst the blends and the control. However, the values for the functional properties for 90:10 samples blends for both unblanched and blanched compared favourably with the control. Bread sample from 90:10 unblanched blend had the highest sensory score for mouth feel, flavor, colour, taste, crumb texture aroma and overall acceptability. The finding suggests that acceptable bread could be produced from addition of unblanched taro flour to wheat flour at 10% level. This would significantly reduce the cost of production of bread and other allied products.

Key words: Taro, wheat, functional property, sensory property, bread, composite flour.

INTRODUCTION

Bread is a major wheat based product, which has gained wide consumer's acceptance for many years in Nigeria (Abulude et al., 2005). The product is basically made of hard wheat flour, yeast, fat sugar, salt and water. Bread is a good source of nutrients, which are required by the body for metabolic function. The consumption of bread in Nigeria as a staple food has steadily been on the increase, especially with explosions in population and changing life style patterns. It is interesting to note that bread is one food that knows no social stratification, as such is consumed by all and sundry irrespective of their per capita income.

Bread from the wheat flour has certain desirable aesthetics due to its gluten content (Nickerson and Ronsivalli, 1980). Wheat flour is essentially imported into the country resulting in the high cost of bread and other baked products. According to the world grain magazine (2006), Nigeria is the largest single market for the world's largest wheat USA exporter (USA). Currently, the federal government of Nigeria is increasing its effort to reduce the cost of producing bread and other confectioneries, through the inclusion of locally available starchy food crops into wheat flour e.g. cassava, taro etc.

Taro (*Coloacasia esculenta*) L. Schoct, a member of the Arecea family is an ancient crop grown throughout the humid tropics for its edible corms and leaves. About 60% (58 million metric ton) of the world production of 10.6 million metric ton is grown in Africa with Nigeria having the largest production (UNFAO, 2002). Taro is a fairly good source of protein, but rich in carbohydrate, vitamins and the essential amino acids such as lysine, leucine, isoleucine (Bradury and Hammer, 1988). Despite the high starch content of edible aroids, they have higher content of protein and amino acids than any tropical root crops (Key, 1987). Taro, though widely available is greatly underutilized and so is a potential source for

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composite flour with wheat. Based on the foregoing, the aim of the research is to evaluate the functional and sensory properties of taro and wheat composite flour based bread. This research is very significant as it would help to provide information on how to reduce the cost of bread and other allied products and hence increase the commercial utilization of taro.

MATERIALS AND METHODS

Sample collection

Fresh taro tubers and wheat flour were purchased from the local market in Calabar, Nigeria. The taro tubers were stored in a well-ventilated room 24 h before they were processed into flour, while the wheat flour was packed after purchase in an airtight container and then stored at 4℃.

Taro flour production

Taro flour was prepared by peeling and slicing the corms (1 mm thickness) and cornels and then washing the slices thoroughly in portable tap water so as to remove as much mucilaginous material as possible. After washing, the slices were soaked overnight in portable tap water (1:2 volume of water), then washed again and finally immersed for 3 h in 0.25% sodium bisulphate solution. The slices were then divided into two batches (blanched and unblanched). The batch for blanching was immersed in boiling water for 4 min, drained and then the samples dried in an oven drier at 60℃ (Sijovetel, 1860) model for 12 h. The dried slices were milled, sieved to pass 60 mesh screen sieve (British standard) to give a sieve size of 0.250 mm and then packed in an airtight container. The unblanched samples were spread on a metal tray and oven dried at 60℃ overnight to a constant weight. The dried samples were milled and sieved as was treated for blanched samples and then stored in an air tight container.

Composite flour formulation

Various ratios of the composite flour, 70:30, 80:20 and 90:10 of wheat and taro flour (blanched and unblanched) were formulated separately using guidelines of Quatropro and Gapez (1997) for formulating blends. The appropriate amounts of wheat and taro flours were weighed using an electronic balance (J. T., series, Japan) to give the various ratios of the composite flour, mixed and stored in air tight containers for use.

Functional properties of flour samples

The various composite flour samples were used for the analyses in triplicates.

Water absorption capacity (WAC)

Water absorption capacity was determined using the centrifuge method of Sosulki (1962). Samples of different flour blends (1.5 g) were each weighed into a centrifuge tube and 1.8 ml distilled water added. The content of the centrifuge tube was stirred for 30 s, with a glass rod. The suspension was given a 10 min rest during which period the sample particles adhering to the sides of the tubes were scrubbed down with the glass rod. The suspension was mixed 7 additional time, each period of mixing lasting for 20 s with 10 min rest period after each mixing. The tube was then centrifuged at 5100 rpm (bench top centrifuge, model MSE England) for 25 min. The water was decanted and percentage of water absorbed was calculated as ratio of the weight retained and weight of sample multiplied by 100.

Oil absorption capacity (OAC)

The method of Sosulki et al. (1976) was used for oil absorption capacity. Instead of water being used, refined soybean oil with density of 0.92 g/ml was used. One gram of flour blends each was weighed into a 50 ml centrifuge tube and 10 ml of oil was added. The content of the centrifuge tube was stirred for 5 min using a magnetic stirrer in a 50 ml centrifuge tube and then centrifuged at 3,500rmp for 30 min. The amount of oil separated as supernatant was measured using 10 ml cylinder. The difference in volume was taken as the oil absorbed by the sample and was expressed in percentage.

Bulk density (packed bulk density and loose bulk density)

The method of Akpapunam and Markakis (1981) was used for the determination. Two gram of each sample was weighed into a 5 ml measuring cylinder(W_1). For packed bulk density (PBD), it was gently taped to eliminate air spaces between the flour sample in the cylinder and the volume was noted as the volume of the sample used (W_2). The mass of the sample and the cylinder was recorded. PBD expressed in g per 100 ml was calculated as the differencial in weight. For loose bulk density (LBD), space was not eliminated by tapping but the sample contained in the cylinder was left to stand for 10 min before weighing and was calculated as for PBD.

Least gelation concentration (LGC)

The least gelation concentration (LGC) of the flour samples was determined using the modified method of Coffman and Garcia (1977). Sample suspension of 2, 4, 6, 8, 12, 14, 16, 18 and 20% (m/v) were prepared in 10 ml distilled water in test tubes. The tubes containing the suspensions were then heated for 1 h in a gentle boiling water bath model (Tecmel, Texas, USA), after which the tubes were cooled rapidly for 2 h. Each tube was then inverted one after the other. The LGC was taken as the concentration when the sample from the inverted test tube did not fall or slip.

Swelling capacity

The method described by Leach et al. (1959) was used with slight modifications. One gram of the sample was weighed and transferred into a clean dry test tube and then weighed (W_1). The mix was then dispersed in 50 ml of distilled water using a magnetic stirrer. The resulting slurry was heated at desired temperatures of 40, 50, 70, 80 and 90℃ for 30 min in a thermostat water bath model (Techmel and Tecmel, Texas, USA). The mixture was cooled to room temperature (25℃) and then centrifuged at 2,200 rpm for 15 min. The residue obtained after centrifugation with the water it retained was re-weighed (W_2). Swelling index was calculated as the difference between W_2 - W_1 divided by weight of flour and multiplied by 100.

Production of bread

Bread was baked using various composite flour samples. All

Table 1. Product formulation ingredients.

	Control	Composite flour		
		70:30	80:20	90:10
Wheat flour (g)	1000	700	800	900
Taro flour (g)	-	300	200	100
Water (ml)	430	430	430	430
Salt (g)	20	20	20	20
Sugar (g)	140	140	140	140
Fat (g)	20	20	20	20
Yeast (g)	10	10	10	10
Milk (g)	30	30	30	30

Table 2. Functional properties of wheat / taro composite flour.

Parameters	Unblanched			Blanched			Control
	70:30	80:20	90:10	70:30	80:20	90:10	
WAC (g/g)	98.40±0.10^{g}	109.60±0.05^{e}	113.70±0.10^{d}	105.20±0.10^{f}	115.40±0.10^{c}	122.40±0.10^{b}	130.70±0.10^{a}
OAC (g/g)	118.10±0.10^{c}	111.10±0.57^{a}	107.30±0.20^{f}	98.80±0.08^{a}	110.70±0.05^{e}	185.50±0.07^{a}	153.20±0.07^{b}
LBD(g/100 ml)	0.47±0.02^{b}	0.50±0.01^{a}	0.53±0.02^{b}	0.40±0.02^{b}	0.48±0.01^{a}	0.49±0.03^{a}	0.56±0.02^{a}
PBD(g/100 ml)	0.58±0.10^{b}	0.57±0.02^{b}	0.56±0.03^{b}	0.47±0.01^{c}	0.50±0.02^{b}	0.52±0.01^{b}	0.60±0.01^{a}
LGC (%)	6.0^{c}	8.0^{b}	8.0^{b}	8.0^{b}	6.0^{c}	6.0^{c}	10.0^{a}
SC	3.10±0.10^{a}	3.30±0.30^{a}	3.20±0.20^{a}	2.40±0.10^{c}	2.7±0.10^{b}	2.8±0.10^{b}	3.40±0.10^{a}

*Means within the same column with the same superscript are not significantly different (P < 0.05).

ingredients as shown in (Table 1) were mixed in a Hobart dough mixer. The dough was kneaded manually for 10 min at 43°C, allowed to rise for 40 min followed by 2 min of punching and leveling of the dough. The procedure was repeated 2 more times and the dough then put into baking pans (50 g) and baked for 35 min at 235°C. Wheat flour (100%) (reference) was used to produce bread using the same recipe.

Sensory evaluation

The first batch of sensory evaluation was carried out on each of the samples using the method of Larmond (1977). The panelists rated the samples for appearance, flavor, mouth feel, colour, texture and overall acceptability using the preference test for multiple comparison analysis. The sample was given to 15 panelists in a random order and were asked to rate them using freshly baked sample as reference. A hedonic scale of 1 - 7 was used where 7 was extremely acceptable and 1 extremely unacceptable. The second evaluation was carried out using the method of Pyler (1973). Samples were given to nine trained panelists in a random order and were asked to rate them. Each expert scored each sample twice. The parameters evaluated and the maximum scores were texture (15), crumb colour (10), crumb texture (10), aroma (10) and taste (10). Bread produced from commercial wheat flour (100%) was used as the reference sample for the analysis. Each evaluation was carried out in duplicates in a well lit individual sensory booth in the Biochemistry Department, of University of Calabar.

Statistical analysis

Data was analyzed using analysis of variance. Duncan multiple range test was used to determine significant difference among the various samples. Data were analyzed using the software, statistical package for social science (SPSS) version 11.00 SPSS inc., Chicago, IL, USA at the 0.05 level using the one-way analysis Of variance (ANOVA) test.

RESULTS AND DISCUSSION

Functional properties

Table 2 shows the functional properties of the flour samples. There was a significant difference amongst the samples (P < 0.05).

Water absorption capacity (WAC)

The WAC values for the blends ranged from 98.40 ± 0.10 - 113.70 ± 0.10 g/g (unblanched) and from 105.2 ± 0.10 - 122.4 ±0.10 g/g (blanched). There was a significant difference (P < 0.05) in the WAC of the samples. The blanched samples had higher WAC than the unblanched samples. Proteins consist of subunits structure and dissociates on heating as observed by Catsimpodas and Meyer (1970). Dev and Quensil (1988) reported that protein subunit have more water binding sites (increase in the number of hydrophilic groups which are the primary sites of water binding of protein). Thus, the higher WAC of the blanched samples could be due to the dissociating of the protein subunits during the blanching regimen. However the control sample had the highest WAC value of 130.70 ± 0.10, while the least WAC value was 70:30 wheat, taro unblanched sample. This result suggests that addition of taro flour to wheat flour affected the amount of water absorption. This could be that the molecular structure of the taro starch inhibited water absorption, as could be seen from the lower values of WAC, with increase in taro flour. Amongst the treated samples, 90:10 wheat, taro (blanched) had the highest value of 122.4 ± 0.10 for WAC.

Oil absorption capacity (OAC)

There were significant differences (P < 0.05) in the values of OAC of the samples. The OAC values of the samples ranged from 107.30± 0.10 to 118.10 ± 0.20 g/ml (unblanched) and from 98.80 ± 0.20 to 185.50 ± 0.10 g/g (blanched). There was a significant (P < 0.05) decrease in the OAC of the blanched samples as the ratio of taro level increased from 10 to 30%. This reduction could be attributed to the configurational changes in the constituents of samples as affected by blanching. However, the highest value for OAC was for 90:10 (blanched) sample followed by the value for the control samples (153.29 ± 0.10) while the least value was 98.8 ± 0.30 for 70:30 blanched samples. Oil retention has been attributed to the physical entrapment of the lipid by the protein (Quin and Benchat, 1975; Padmashree et al., 1987). OAC is the ability of the flour protein to physically bind fat by capillary attraction and it is of great importance, since fat acts as flavor retainer and also increases the mouth feel of foods, especially bread and other baked foods (Kinselle, 1976). Addition of taro flour to wheat flour at 10% level would not negatively affect the OAC.

Bulk density (loose and packed bulk density)

The bulk density (BD) is a reflection of the load the samples can carry if allowed to rest directly on one another. The LBD represents the lowest attainable density with compression. There was a significant difference (P < 0.05) in the LBD values of both the unblanched and blanched samples. Increase in the level of taro flour in the unblanched and blanched, resulted in decrease in the LBD values. This may be due to the influence of molecular structure of taro starch. However, the control sample had the highest value (0.54 ± 0.01 g/100 ml). The blend sample with lower values of LBD are more desirable, as the samples would pack better during storage without loosing volume, however, the values were comparable.

The packed bulk density (PBD) represents the highest attainable density with compression. There was no significant difference (P < 0.05) in the values of PBD amongst the samples except for blanched 70:30 blend and the control. Increase in the level of taro followed a similar trend as for the LBD in the blanched samples. These lower values indicate that blanching affects the molecular integrity of the taro starch, thus resulting in better packing. The blend with the lowest PBD value was 70:30 wheat, taro blanched the highest PBD value was 0.61 ± 0.01 (control). The low density values of the formulated composite flour indicate that the volume of the blends in the package will not decrease excessively during storage or distribution. The difference between the LBD and the PBD was slight indicating that taro flour incorporation would not significantly cause a decrease on the bulk densities of flour blends.

Least gelation concentration

The lower the least gelation concentration (LGC), the swelling ability of flour was enhanced. The LGC of wheat, taro blend ranged from 6 - 8%, when compared with 100% wheat flour (control) which had a high LGC of 10%, the blends had better gelling ability. The value of the control was significantly different (P < 0.05) from LGC of the composite samples. The LGC of the wheat, taro flour blends was higher than the value reported for great northern bean (*Phaseolus vulgaris)* 4% (Sathe and Salunkle, 1981), pigeon flour 2% (*Cajanus cajan*) (Oshiodi and Ekperigin, 1989). This variation in LGC could be attributed to the relative ratios of different constituent's proteins, carbohydrates and lipids in flour samples. Sathe et al., (1982) reported that interaction between such component play a significant role in the functional properties.

Swelling capacity

There was a significant difference (P < 0.05) in the SC values of the samples. The swelling capacity values of the blends ranged from 2.40 ± 0.10 to 3.30 ± 0.30. The control sample had the highest swelling capacity value of 3.40 ± 0.10, while the blanched 70:30 blend had least value. Addition of taro flour to wheat flour did affect the swelling capacity of the blends, but the values of the unblanched blends compared favorably with the control value. However, blanching had a remarkable effect on the swelling capacity. This could be that heat treatment applied during blanching disrupted the tissues, thereby reducing their water binding capacity and consequently lowering the swelling capacity. Furthermore this observation may be attributed to starch degradation into dextrin by blanching, as dextrins do not swell (Marero et. al., 1988). Increase in the ratio of taro flours showed a significiant (P < 0.05) reduction in the SC of the blanched samples. This observation could be attributable to the

Table 3. Panelists hedonic score rating of bread samples.

Sensory indicators	Unblanched			Blanched			Control
	70:30	80:20	90:10	70:30	80:20	90:10	
Appearance	2.76^c±0.44	3.75^b ±0.27	3.76^b±0.29	2.14^e±0.38	2.27^d±0.30	2.04^f±0.90	3.79^a±0.27
Mouth feel	1.98^f±0.18	2.74^d±0.33	3.04^b±0.27	1.88^g±0.37	2.36^e±0.48	2.80^c±0.24	3.78^a±0.41
Flavour	2.34^e±0.13	2.42^d±0.23	2.98^c±0.16	2.28^f±0.28	2.28^f±0.17	3.16^b±0.20	3.88^a±0.30
Taste	1.94^g±0.12	2.36^e±0.37	2.83^d±0.13	2.25^f±0.27	2.88^c±0.17	3.27^b±0.19	3.68^a±0.38
Colour	3.24^d±0.20	3.40^c±0.23	3.44^b±0.23	2.93^f±0.21	2.97^e±0.19	3.50^a±0.21	3.26^d±0.22
Overall acceptability	1.86^g±0.14	3.85^d±0.20	3.95^b±0.29	2.24^f±0.38	2.28^e±0.20	3.92^c±0.33	4.27^a±0.12

*Higher values indicates greater preference, *Means within the same column with the same superscript are not significant ($P < 0.05$).

Table 4. Panelists maximum score rating of bread sample.

Sensory indicators	Unblanched			Blanched			Control
	70:30	80:20	90:10	70:30	80:20	90:10	
Crumb colour	4.22^g±1.42	5.85^d ±0.41	6.82^c±1.66	4.98^f±0.31	5.69^e±0.31	8.20^b±0.61	9.32^a±0.61
Crumb texture	4.10^f±0.59	4.38^e±0.39	7.59^c±0.42	3.76^g±0.41	4.61^d±0.41	8.44^b±0.34	9.61^a±0.19
Aroma	5.04^f±0.62	5.88^d±0.36	6.76^b±0.82	4.29^g±0.44	5.61^e±0.58	6.57^c±1.48	8.58^a±0.28
Taste	7.66^e±0.73	8.10^d±0.57	9.00^b±0.37	5.91^f±1.03	5.50^g±0.51	8.92^c±0.76	9.88^a±0.95
Texture	6.80^f±0.45	7.18^e±0.67	8.90^b±1.15	5.88^g±0.99	7.26^d±1.53	8.82^c±1.57	10.82^a±0.92

*Higher values indicates greater preference, *Means within the same column with the same superscript are not significant ($P < 0.05$).

decreased protein solubility as a result of denaturation of water binding sites (King and Puwastien, 2006).

Sensory evaluation

Results (Tables 3 and 4) showed significant difference ($P < 0.05$) between the control and the composite samples in all the sensory attributes evaluated. However, the panelists scores for the blend in some attribute were comparable to the control. Bread produced from unblanched 90:10 blend had the highest panelists ratings in appearance, aroma, taste and in overall acceptability, this suggest that this blend was more acceptable to the panelists in these parameters. Though the control sample was rated higher in all the attributes, however the bread sample from 90:10 unblanched blend produced desirable organoleptic quality. The 90:10 unblanched wheat, taro blend could be further enhanced with flavour additive to increase its consumer acceptability.

Conclusion

Our result showed that the addition of taro flour to wheat at a ratio of 10:90 produced acceptable bread and also the functionality of the flour was not affected. Incorporation of taro flour to wheat would therefore be an effective method of cost reduction of bread and other allied products in Nigeria.

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