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Functional Qualities of Thermally Processed Finger Millet (Eleusine Coracana L. Gaertn) Flour

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Abstract: *The objective of this work is to investigate the effects of different thermal processing methods on the functional properties of finger millet flour. The finger millet sample was manually cleaned to remove foreign material and then divided into sample A, B, C and D. Sample A was milled unprocessed and it served as the control, while samples B, C and D were thermally processed by roasting, steaming, and boiling respectively at three different time intervals. Sample B was divided into three (3) parts (B1, B2 and B3) and roasted at 140^oC for (5mins, 10mins, 15mins) respectively, left to cool before milling into flour. Sample C was divided into three parts (C1, C2 and C3) and steamed at 100^oC for 20mins, 30mins and 40mins respectively, after which it was dried in an air oven and milled to flour. Sample D was also divided into three (3) parts (D1, D2 and D3) and boiled at 100^oC for 20mins, 30mins, 40mins respectively. The boiled samples was dried in an air oven and milled into flour. The functional properties of the sample were evaluated using standard methods. The untreated finger millet flour (control) had Bulk Density (BD) 0.79, Water Absorption Capacity (WAC) 0.93 and Oil Absorption Capacity (OAC) 0.85. Flour processed by roasting finger millet at 140^oC had BD ranging from 0.65 - 0.78, WAC ranging from 1.23-1.29 and OAC ranging from 1.09 - 1.13. Flour processed by steaming finger millet at 100^oC had BD ranging from 0.62 - 0.80, WAC ranging from 1.26-1.38 and OAC ranging 1.13 -1.35. Flour processed from boiled finger millet at 100^oC had bulk density ranging from 0.59-0.76, WAC ranging from 1.25-1.35 and OAC ranging from 1.09 - 1.15. It can be concluded that thermal processing of finger millet into flour will enhance its utilization for food formulation with little retrogradation, suitability for dough making, higher degree of flavor retention and higher storage stability.*

Keywords*: Finger millet, bulk density, oil absorption capacity, water absorption capacity*

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I INTRODUCTION

Finger millet (*Eluesine Corocana*) also known as *tamba* is classified under the category of minor millet with superior nutritional quality and antioxidant activity (Renu and Sarita, 2015). Its superior nutritional quality can be attributed to the high amount of calcium which is an essential micro- nutrient for infants, growing children, pregnant mothers and the elderly. Finger millet is tiny in size, very rich in polyphenols and mostly consumed without dehulling (Gull *et al*., 2015). It is also reported to be very rich in essential amino acids (Jideani, 2012). Finger millet flour proteins do not form gluten making it useful to dilute wheat flour to form dough that is less tough and easier to form into sheets in baked products such as cookies (Omah and Okafor, 2015). Incorporation of finger millet flour in conventionally used refined flour can improve the nutritional quality of the baked products. Functional properties determine the baking properties of flour. Studies have shown that finger millet flour has high water and fat absorption capacity due to its high fiber and protein content (Renu and Sarita, 2015). Thermal processing of finger millet prior to its processing into flour may enhance its use in value added products. The main objective of this work is to evaluate the effect of thermal processing methods duration on some selected functional properties of finger millet flour.

II MATERIALS AND METHODS

2.1 Sample preparation and experimental setup

Two thousand four hundred grams (2400 g) of the finger millet seeds was purchased at *Nyanyan* Market in Federal Capital Territory of Nigeria. The millet was manually cleaned to remove foreign material such as chaff, dirt and other foreign matters. Initial moisture content of the millet was determined using the Approved Methods of the American Association of the Cereal Chemists (AACC, 1999). The experiment was carried out using a Completely Randomized Design (CRD) of three thermal processing methods (Roasting, steaming and boiling) and three processing duration done in triplicate (3 x 3 x 3 = 27). Two thousand four hundred gram (2400 g) of finger millet was cleaned and divided into sample A, B, C and D of 600 g each. Sample A was milled unprocessed and packaged as the control sample. Sample B, C and D were then thermally processed to flour and kept for further analysis. The functional properties of the flour were determined using standard methods. Data collected were analysed statistically to determine the effect of thermal processing methods on the nutritional, anti-nutritional and functional properties of finger millet flour.

2.2 Methods

a. Roasting

Sample B (600 g) was sub divided into 3 parts of 200 g each (B1, B2, and B3). Each sample were evenly spread on an aluminum tray, and roasted in a roaster oven preheated to 140 °C. The roasting temperature of 140^{o}C and roasting duration of 5, 10 and 15 minutes were selected based on previous works and preliminary investigations (Griffith and Castell-Perez, 1993). Roasting temperature was kept constant while roasting time was varied. B1 was heated for 5 minutes; B2 was heated for 10 minutes while B3 was heated for 15 minutes. After which it was removed and kept to cool, the samples (B1, B2 and B3) were then milled respectively into flour and stored in air-tight plastic bags for further analysis

b. Steaming

Sample C (600 g) was sub divided into 3 parts of 200 g each (C1, C2 and C3). Each sample were evenly spread on a wire mesh (sieve) and suspended on a tripod stand in a water bath preheated to 100^{o}C. This was done to achieve direct contact with steam. Steaming temperature was kept constant while the steaming time was varied. C1 was heated for 20 minutes; C2 was heated for 30 minutes, while C3 was heated for 40 minutes respectively. Each steamed sample was withdrawn and transferred to an air oven and dried at 100^{o}C for 2 hrs. Each dried steamed sample was then milled into flour and packed in air tight plastic bags for further analysis.

c. Boiling

Sample D (600 g) was sub divided into 3 parts of 200 g each (D1, D2 and D3). Each sample was respectively placed in a beaker, and then 400 ml of distilled water was added to the sample after which it was placed in a water bath preheated to 100^{o}C. Boiling temperature was kept constant while the boiling time was varied. D1 was heated for 20 minutes; D2 was heated for 30 minutes, while D3 was heated for 40 minutes respectively. Each boiled sample was withdrawn, decanted and transferred to an air oven and dried at 100^{o}C for 4 hrs. Each dried boiled sample was then milled into flour and packed in air tight plastic bags for further analysis.

2.3 Sample analysis

Bulk density was determined using the methods prescribed by Edema *et al*., (2005) and water absorption capacity was determined using the method described by Ayinadis and Adamu (2010). The method described by Adeleke and Odedeji (2010) was used for oil absorption capacity while the foaming capacity and stability were determined according to the method reported by Coffman and Garcia as modified by Adebowole and Maliki, (2011). For each of the functional properties, a one-way variance analysis (ANOVA) was performed to compare the variations between the thermal treatments using SPSS IBM software. Duncan's multiple range test was used to separate means and significance was accepted at $P \leq 0.05$.

III RESULTS AND DISCUSSION

The results on the functional properties of thermally processed finger millet flour are presented in Table 1, while the ANOVA are as presented in Table 2.

Bulk density quantifies the heaviness of flour and is generally affected by the particle size and the density of the flour. It is very important in determining the packaging requirement, material handling, packing cost of the dried products and application in wet processing in the food industry (Upadhyaya *et al.,* 2006). High bulk density indicates that the flour can be used for food preparation while low bulk density indicates that the flour is suitable to use in the preparation of weaning food formulation (Akpata and Akubor, 1999). The bulk density of all thermally processed finger millet flour decreased significantly with thermal processing except for sample processed by steaming for 40 minutes. The control sample was significantly different from other thermally processed flour with the exception of the flour produced from steamed finger millet at 40 minutes as shown in Table 1. The bulk density of the unprocessed finger millet flour was 0.79 g/cm^3 while that of the thermally processed finger millet flour ranged from 0.59 -0.80 g/cm^3. The bulk density of the roasted finger millet flour ranged 0.65- 0.78 g/cm^3, while the range of the steamed finger millet flour was 0.62- 0.80 g/cm^3 and that of the boiled finger millet flour was 0.59 - 0.76 g/cm^3. The result from statistical analysis showed that there was a significant difference ($p \leq 0.05$) among the thermally processed finger millet flour (Table 2).

The low bulk density achieved from processing thermally indicates that finger millet flour can be used for food formulation with less fear of retrogradation (Omah and Okafor, 2015). While finger millet steamed for 40mins make it more suitable for food preparation rather than weaning foods.

Table 1: The effect of thermal processing on some functional quality of finger millet flour

Samples	Bulk Density (g/cm3)	WAC (g/100g)	OAC (ml/100g)	Foaming capacity(%)
A	$0.79^{e} \pm 0.06$	$0.93^{a} \pm 0.00$	$0.85^{a} \pm 0.01$	$1.65^{b} \pm 0.02$
B1	$0.78^{de} \pm 0.02$	$1.29^{cd} \pm 0.02$	$1.13^{b} \pm 0.01$	$2.23^{e} \pm 0.03$
B2	$0.65^{b} \pm 0.03$	$1.23^{b} \pm 0.04$	$1.13^{b} \pm 0.03$	$2.15^{de} \pm 0.14$
B3	$0.72^{c} \pm 0.02$	$1.27^{bcd} \pm 0.01$	$1.09^{b} \pm 0.01$	$2.08^{d} \pm 0.02$
C1	$0.73^{cd} \pm 0.00$	$1.30^{d} \pm 0.02$	$1.13^{b} \pm 0.02$	$2.17^{de} \pm 0.00$
C2	$0.62^{ab} \pm 0.02$	$1.26^{bcd} \pm 0.02$	$1.13^{b} \pm 0.01$	$2.11^{d} \pm 0.08$
C3	$0.80^{e} \pm 0.02$	$1.38^{e} \pm 0.02$	$1.35^{c} \pm 0.33$	$2.17^{de} \pm 0.00$
D1	$0.72^{c} \pm 0.01$	$1.34^{e} \pm 0.02$	$1.14^{b} \pm 0.01$	$1.98^{c} \pm 0.02$
D2	$0.59^{a} \pm 0.02$	$1.35^{e} \pm 0.03$	$1.15^{b} \pm 0.03$	$1.33^{a} \pm 0.03$
D3	$0.76^{d} \pm 0.04$	$1.25^{bc} \pm 0.04$	$1.09^{b} \pm 0.03$	$1.36^{a} \pm 0.03$

All values are means of three replicate $\pm$ standard deviation Means with same letters for a particular measurement along the same column are not significantly different ($p \leq 0.05$).
BD- Bulk density, WAC- Water absorption capacity, OAC- Oil absorption capacity, FC-foaming capacity

Table 2: The ANOVA of the effect of thermal processing on some functional quality of finger millet flour

		Sum of squares	df	Mean squares	F	Sig.
BD	Between groups	0.15	9	0.02	18.17	0.00
	Within groups	0.02	20	0.00		
	Total	0.17	29			
WAC	Between groups	0.44	9	0.04	81.91	0.00
	Within groups	0.01	20	0.00		
	Total	0.45	29			
OAC	Between groups	0.39	9	0.04	3.81	0.01
	Within groups	0.23	20	0.01		
	Total	0.62	29			
FC	Between groups	3.20	9	0.36	114.43	0.00
	Within groups	0.06	20	0.00		
	Total	3.26	29			

BD- Bulk density, WAC- Water absorption capacity, OAC- Oil absorption capacity, FC-foaming capacity

The Water Absorption Capacity (WAC) of the untreated finger millet flour was 0.93 g/100g which is in the range of 0.93-1.23ml/g reported by Ramashia *et al*, 2018 for various kind of finger millet grain flour found in sub-Saharan Africa while that of the thermally processed finger millet flour ranged from 1.23 -1.38 g/100g. The WAC of the roasted finger millet flour ranged 1.23- 1.29 g/100g, while the range of the steamed finger millet flour was 1.26- 1.38 g/100g and that of the boiled finger millet flour was 1.25- 1.35 g/100g. Statistical analysis showed that there was a significant difference at ($p \leq 0.05$) among the thermally processed finger millet flour (Table 2). Water absorption capacity gives an indication of the amount of water available for gelatinization and the ability of flour to absorb water, and it determines if the flour can be incorporated into aqueous food formulation especially in dough making (Ramashia *et al*, 2018). It also describes flour water association ability under limited water supply (Singh, 2001). Flour produced from steamed and boiled millet respectively had higher WAC than that produced from roasted finger millet flour. According to Adebowale *et al*, 2012, high WAC shows that the loose structure of the starch polymers while low WAC signifies compactness of the structure. Flour with low WAC has a higher protein water interaction making it possible to be used for gruels. Therefore steaming and boiling loosens the structure of starch polymer.

The Oil Absorption Capacity (OAC) of the unprocessed finger millet was 0.85 ml/100g, while it ranged from 1.09 -1.35 ml/100g. The OAC ranged from 1.09-1.13 ml/100g for roasted finger millet flour, 1.13- 1.35 ml/100g for steamed finger millet flour and 1.09-1.15 ml/100g (Table 1). There was a significant difference ($P \leq 0.05$) in the OAC for all thermally processed finger millet flour with the exception of that processed by steaming for 40 minutes that were not significantly different (Table 1). Oil absorption capacity gives a measure of the oil absorbed by the flour (Priyanka, 2013). The oil absorption capacity of flour is equally important as it improves the mouth feel and retains the flavor (Abulude *et al*., 2006). It was observed that thermal processing increased the OAC of the finger millet flour. This is similar to the report that the OAC of the roasted and boiled sorghum-peanut composite flours were higher than that of the native ones (Singh *et al*., 2004). A higher OAC in the case of the thermally processed flour implies that the flour may have a higher degree of flavour retention and mouth –feel (Priyanka, 2013). According to Yadahally *et al*., 2008, high oil absorption capacity of the flour can positively influence the flavor and fat content in food thereby making it have the best organoleptic property in foods and baked products.

The foaming capacity of the unprocessed finger millet was 1.65 %, while it ranged from 1.36- 2.23 % for thermally processed finger millet flour. The foaming capacity of the roasted finger millet flour ranged from 2.08-2.23 %, steamed finger millet flour ranged from 2.11-2.17 %, while the foaming capacity of boiled finger millet flour ranged 1.33-1.98 %. Statistical analysis shows that thermal processing had a significant effect ($P \leq 0.05$) on the foaming capacity of the finger millet flour (Table 2). Foaming depends primarily on the rate of protein absorption. Foam obtained with a higher concentration of protein is denser and more stable in case of increase in thickness of intrafacial films (Sangeetha and Devi, 2012). Low foaming capacity of certain meals could affect their stability during storage (Gull *et al*, 2015).

The result shows that steaming and roasting increased the foaming capacity of the flour respectively, while boiling caused a decrease (Table 1). The roasted finger millet flour had the highest foaming capacity. This implies that the roasted finger millet flour had a higher concentration of protein and may be more stable during storage. Flour processed thermally by boiling would be less suitable for baked product as the stability of the product during storage would not be guaranteed (Gull *et al*, 2015).

IV CONCLUSION

It is concluded that thermal processing alters the functional qualities of finger millet flour making it more suitable for food formulation. Roasting increased the WAC, OAC and foaming capacity of the finger millet flour. Steaming increased the WAC, OAC, and foaming capacity but reduced the bulk density of the flour. Thermally processed finger millet flour can also serve as an alternative to wheat flour in bread making and other confectionary products since it has a more compact starch polymer structure

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