

Effects of Toasting Time on Functional and Visco-Elastic Properties of Cassava Flour

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Abstract: The effect of toasting time on the functional and visco-elastic properties of cassava flour was investigated. Cassava tubers were grated, dewatered and toasted for 2, 4, 6, 8 and 10min durations. The flour samples produced from these treatments were subjected to functional and viscosity analyses. The result of the analyses revealed that the flour samples produced from 6min toasting time was superior to those from other samples in relation to most of the indices relevant to their use in the baking industry. The 6min toasting time gave the highest peak viscosity value which is significantly different ($p \leq 0.05$) from other toasting times except that of 2 min toasting time. The 10min toasting time produced flour with the lowest breakdown viscosity which is significantly different ($p \leq 0.05$) from the values obtained in other samples while the final viscosity values of samples from 4mins and 6mins toasting time were higher than the rest. For the functional properties, the swelling power of samples obtained from 8min toasting time was significantly higher ($p \leq 0.05$) than the values from other samples followed by the value of samples from 6min toasting time. The values of water binding capacity and solubility index of samples from 6min toasting time was significantly higher than the values from other samples while the values of the water absorption capacity of samples from 4min toasting time was significantly higher than others followed by the values obtained from 6min toasting time. It was generally observed from the result of the analyses that the flour samples produced from the 6min toasting time was superior to those from other toasting duration periods in respect to the indices relevant to their use in the baking industry.

Keywords: cassava, functional, *Manihot* spp., toasting, viscosity.

I. Introduction

Cassava (*Manihot* spp.) is a very important staple food in the tropics and is ranked the sixth most important source of calories in human diet with an estimated annual global production of about 250 million tonnes of which about 54% is produced in Africa [1-3]. It is a very versatile crop and its ability to tolerate drought, store its root underground for a long time, grow in low nutrient and marginal soils where other crops cannot grow well has earned it the status of a famine crop [4]. Its storage roots have high starch content which can produce a major source of intermediate products such as flour, dextrans and confectioneries for the food and industries. Cassava flour can perform most of the functions currently performed by maize, rice and wheat and has many remarkable characteristics such as high paste viscosity, high freeze-thaw stability and high single stage swelling which are advantageous to many industries [5].

Utilization of starch-based food like cassava is affected by its physio-chemical properties which includes its ability to swell as is the case in bread and other forms of baked products, and its water binding capacity which is extremely beneficial for baking powder amongst other uses [6]. The pasting properties of starch such as peak, trough, setback and final viscosities as well as the pasting temperature are good quality indicators for starch and a wide range of flour for use in the food and other industries.

The method used to produce cassava flour has been reported to have significant effect on the functional and visco-elastic properties of the flour and consequently the quality of the baked products from it [7]. Defloor et al., [8] reported that a larger amount of water is needed in preparation of dough with roasted cassava flour to obtain similar dough characteristics as with other cassava flours. Eduardo et al. [7] in their work further observed that the partially swollen starch granules in toasted cassava flour resulted in significantly higher water absorption capacity of 236% more than the flour from fermented cassava (102%) and sun-dried cassava (136%). Eduardo et al., [7] further reported that the effect of toasting on the functional and pasting properties of cassava flour on addition of H-M pectin influenced the production of composite bread with better volume and crumb structure relative to bread from fermented and sun-dried flour.

In all these studies, duration of toasting was not considered by the researchers. The toasting time is expected to have effect on the level of modification of the starch granules and hence the functional and pasting properties of the flour, and consequently the quality of baked food and other products from the flour. The

objective of the present study was therefore to investigate the effect of the duration of toasting on the functional and visco-elastic properties of cassava flour in relation to its use as a composite baking material.

II. Materials And Methods

2.1 Materials

The cassava tubers adopted for these studies were obtained from the Crop Research Institute Fumesua, Kumasi; Ghana. They were of the *Ampong* Variety harvested 18 months after planting.

2.2 Methods

The cassava tubers were peeled shortly after harvest. The peeled tubers were washed and grated using a locally fabricated cassava grater. The mash obtained from the grating was dewatered inside a porous sack placed under load for 18h to about 50% moisture content (wet basis). The dewatered mash was divided into five different portions. Each portion was toasted for a specific period of time ranging from 2min to 10min at 2min interval. The mash was continuously stirred during toasting to prevent formation of lumps. The average toasting temperature was maintained at approximately 90°C. At the end of each toasting period, the samples were dried in a mechanically ventilated oven at 70°C to a constant weight. The dried samples were milled in an attrition mill and then sieved using a 250µm sieve [9].

2.2.1 Swelling power and solubility

The solubility and swelling power of the cassava flour were determined using the method of Leach et al., [10]. 1g of the sample was weighed into a 50ml centrifuge tube and water added to give a total volume of 40ml. The tube and its contents were heated for 30min in a water bath at a temperature of 85°C with constant stirring. The sample was then centrifuged for 15min using Hermle 2206A centrifuge of 5cm radius at a speed of 2200rpm (271 x g) after cooling to room temperature. The supernatant was poured into a glass crucible and the weight of the sediment noted. The supernatant in the glass crucible was evaporated in an oven at 105°C for 24h and the residue weighed. The solubility and swelling power were calculated using equations (1) and (2) respectively:

$$\text{solubility}(\%) = \frac{\text{weight of residue}}{\text{weight of sample}} \times 100 \quad (1)$$

$$\text{Swelling power}(\%) = \frac{\text{weight of sediment}}{\text{weight of sample} \times (100 - \% \text{ solubility})} \times 100 \quad (2)$$

2.2.2 Water binding capacity (WBC)

The WBC of the flour was determined using the modification of Sathe and Salunkle [11]. 2.0g of cassava flour sample was dissolved in 40ml of distilled water. The aqueous suspension formed was agitated for about 1h in a water bath (OLS 200, UK) after which it was centrifuged for 10min using Hermle 2206A centrifuge of 5cm radius at 2200rpm (271 x g). The free water was decanted from the wet sample and drained for 10min. The WBC was then calculated using equation (3):

$$\text{WBC}(\%) = \frac{\text{bound water}}{\text{weight of sample}} \times 100 \quad (3)$$

2.2.3 Water absorption capacity (WAC)

The WAC of the flour was determined by using the modification of Sathe and Salunkle [11]. 10ml of distilled water was measured into a 50ml centrifuge tube containing 1g of the cassava flour sample and then mixed for 3min in the Rota Mixer 7023. The resulting suspension was centrifuged for 30min at 500 rpm (14 x g) using a Hermle, z 206A centrifuge of 5cm radius. The water density was taken as 1.0g.ml⁻¹. The water absorbed was then calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant.

2.3 Pasting properties

The pasting properties of toasted cassava flour were determined using the Brabender Viscogrph –E Type 80256 (Brabender Instrument Inc. Duisburg, Germany) equipped with 100cmg sensitivity cartridge. The moisture content of the samples was first determined and the values obtained entered into the software which gives the required sample weight and the volume of distilled water to be added. The required volume of distilled water was thoroughly mixed with the flour sample in a beaker and the solution dispensed into a canister well fitted in the equipment as recommended in the operating manual. The slurry was then heated from 50°C to 95°C and held at 95°C for 15min after which it was cooled to 50°C and again held for 15min. The heating and cooling was at a constant rate of 1.5°C/min. The peak temperatures, peak time, break-down, set-back and final viscosity

values were read from the pasting profile (Fig.1) using the software Thermocline for Windows. The viscosity was expressed in Brabender Units (BU).

2.4 Statistical analyses

The generated data from the functional analysis and viscosity measurements were statistically analyzed using Genstat12th Edition. Significance of treatment means was tested at 5% probability level using Duncan's New Multiple Range Test (DN MRT).

III. Results And Discussion

Functional and visco-elastic properties of flours present useful information on effective utilization of different types of flour for various purposes in the food and other related industries. A sample of pasting profile of the toasted cassava flour is presented in fig.1 while the data of mean values of the visco-elastic and functional properties of the flour are presented in Tables 1 and 2 respectively.

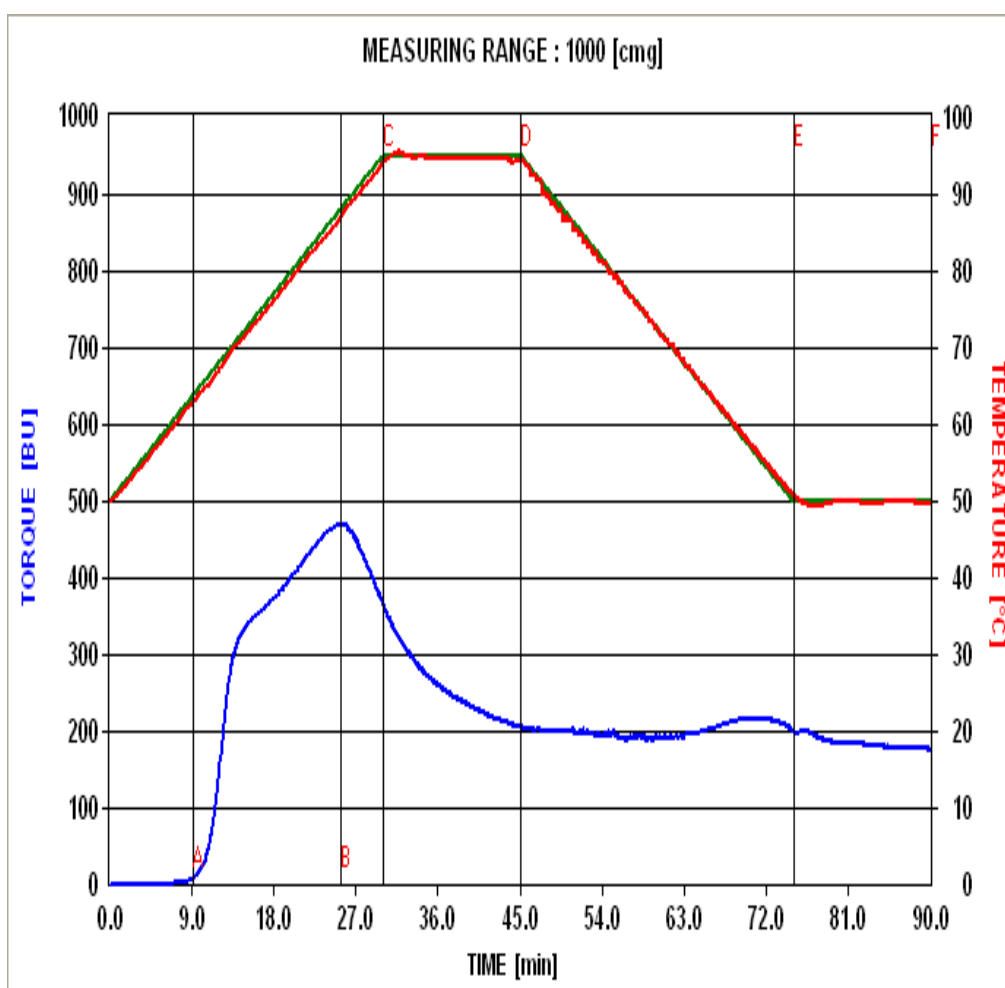


Fig. 1 A sample of the pasting profile of cassava flour toasted for 6min. A-Beginning of gelatinization; B-maximum viscosity; C-starting of holding period; D-start of cooling period; E-end of cooling period; F-end of final holding; (B-D)—breakdown viscosity; (E-D)—setback viscosity.

Table1. Mean values of the visco-elastic properties of toasted cassava flour at different toasting durations.

Toasting Time (min)	Pasting Time (min)	Pasting Temperature (°C)	Start of gel (BU)	Peak viscosity (BU)	Breakdown viscosity (BU)	Setback viscosity (BU)	Final Viscosity (BU)
2 min	25.3 ^{cd}	87.17 ^{cd}	11.13 ^a	481.0 ^a	248.0 ^b	- 75.00 ^c	169.0 ^c
4 min	25.35 ^c	87.20 ^c	11.27 ^a	458.0 ^b	230.0 ^c	- 2.00 ^a	244.0 ^a
6 min	25.25 ^d	87.00 ^d	11.37 ^a	483.3 ^a	267.3 ^a	- 5.00 ^a	206.7 ^b
8 min	26.15 ^a	88.20 ^a	10.17 ^b	423.0 ^c	217.0 ^d	- 55.00 ^b	146.0 ^d
10 min	25.5 ^b	87.60 ^b	9.37 ^c	378.0 ^d	179.0 ^e	3.00 ^a	201.0 ^b
LSD	0.0814	0.1879	0.2530	13.15	7.34	17.85	18.13

Means with different letters in the same column are significantly different at 5% level

Table2. Mean values of the functional properties of toasted cassava flour at different toasting durations.

Toasting Time (min)	Solubility (%)	Swelling power (%)	Water absorption capacity (g/g)	Water binding capacity (%)
2 min	4.33 ^a	9.60 ^b	4.233 ^c	213.3 ^e
4 min	4.07 ^{ab}	9.87 ^{ab}	4.900 ^a	389.7 ^c
6 min	4.27 ^a	10.13 ^{ab}	4.600 ^b	487.3 ^a
8 min	4.50 ^a	10.37 ^a	4.300 ^c	415.3 ^b
10 min	3.30 ^d	10.20 ^{ab}	4.233 ^c	353.3 ^d
LSD	0.6807	0.934	0.2896	14.52

Means with different letters in the same column are significantly different at 5% level

3.1. Visco-elastic properties

Visco-elastic properties of flour/starch are of great importance to food industry because they influence the texture, stability and digestibility of starch foods and hence determine the application and use of starch/flour in various food products [12]. They are important indices very vital in determining the cooking and baking qualities of flours from various crops and their use for other industrial purposes [13].

3.1.1 Pasting temperature

Pasting temperature refers to the temperature at which irreversible swelling of starch granules is obtained leading to formation of a viscous paste in an aqueous solution [14]. The pasting temperature of a flour sample gives an indication of the minimum temperature required to cook the sample [13, 15]. Lower pasting temperature in flour samples is usually associated with lower paste stability and such samples are generally considered to be easier to cook as confirmed by the lower pasting time. Low pasting temperature and paste stability implies that fewer associative forces and Gross-links are present within the starch granule [16, 17]. The cassava flour samples obtained from 6min toasting time have the lowest pasting temperature which is significantly lower ($p \leq 0.05$) than the pasting temperature of the other four samples as shown in Table 1.. This implies that this sample has a faster cooking quality.

3.1.2 Peak viscosity

Peak viscosity of flour mixtures indicates the strengths of paste formed during processing [18]. It shows the viscosity of the cooked starch and reflects its ability to freely swell before their physical breakdown [13, 19]. Peak Viscosity is a measure of the highest value of viscosity attained by the slurry during the heating cycle. Various researchers have positively linked high peak viscosity with baking qualities of flour [7, 20]. The peak Viscosity Values of the flour samples produced from 2min and 6min toasting period were significantly higher ($p \leq 0.05$) than the values from the other samples while those produced from 10min toasting time had the least value. Although the peak viscosity values of the flour from 6 min toasting time was higher than those from 2 min toasting time, there is no significant difference between the two.

3.1.3 Breakdown viscosity

Breakdown Viscosity is an indicator of the resistance to heating and shear-thinning. Investigations have shown that the cohesiveness of starch is attributed to the breakdown viscosities of its molecules during heating and stirring [13, 21, 22]. Early gelatinization of starch predisposes it to breakdown since it undergoes a longer period of shear. Breakdown Viscosity is significantly affected by the toasting time. The cassava flour that was toasted for 6min had the highest value of breakdown while those toasted for 10min had the least value.

3.1.4 Setback viscosity

Setback viscosity gives an idea of the retrogradative potential of food products. Food products with lower setback viscosity have greater tendency for retrogradation while high setback value is associated with a cohesive paste and has been reported to be significant in most domestic products such as pounded yam, which requires high paste stability, high viscosity and high setback [13, 17, 18]. Flour samples obtained from 4min, 6min and 10min toasting time gave higher setback viscosity relative to those obtained from 2min and 8min toasting time as indicated in table 1.

3.1.4 Final viscosity

Final viscosity is important in determining the ability of a flour sample to form gel or paste on cooling and also indicates the strength of cooked paste [13, 15, 18]. The highest value of final viscosity observed in this research was 244 BU for 4min toasting time followed by 206 BU for 6min toasting time while the least value was 146Bu for 8min toasting time as shown in table 1.

3.2 Functional properties

The functional properties determine the potentials of flour samples for use in various industries [23]. Water absorption capacity measures the extent of water retention in flours hence affects the ability of the flour to form paste. In bread baking, flour with high water absorption capacity have greater potentials for producing dough that give a high yield of bread [24, 25]. The water absorption capacity of flour samples produced from 4min and 6min toasting was significantly higher ($p \leq 0.05$) than the values obtained from other samples. Low water absorption capacity as reported by Lorenz and Collin [26] is attributed to a close association of polymers in the native starch granules.

Swelling power and solubility index provide evidence of the magnitude of interaction between starch chains with the amorphous and crystallize domains and also evidence of association bonding within the granules [27]. The values of solubility index and swelling power obtained in flour samples from 6min and 8min toasting was higher than the values from other flour samples. Soni et al., [28] attributed the high solubility indices in starches to the easy solubility of the linear fraction (amylose) which is loosely linked to the rest of the macro molecular structure, and released during the swelling process.

Water binding capacity is equally a very important functional property in relation to the application of flour products in the food industry. It is an indicator to the usefulness of particular flour in food system such as bakery products which requires hydration to improve handling characteristics. Giami and Alu [29] reported that water binding capacity of 125% and above is an indication of good baking material. In this research work, the value of the water binding capacity of the flour from 6min toasting time is significantly higher than the values obtained from the other flour samples with the exception of that from 2min toasting time as shown in table 2. The WBC of all the 5 samples were however higher than the benchmark value reported by Giami and Alu [29].

IV. Conclusion

The toasting time of grated and dewatered cassava tubers significantly affected the functional and visco-elastic properties of the flour produced from it. The lower pasting temperature and higher peak viscosity value of flour samples from 6min toasting time gave the sample an economic advantage in terms of the cooking time and the quality of the food products from it especially in the baking industry. The higher final viscosity values of samples from 6mins and 4mins toasting time make these samples more suitable for production of food products with firm gels rather than viscous paste after cooling. The higher values of water absorption capacity of samples from 4min and 6min toasting time make them more suitable for production of dough that will give higher yield of bread while the higher value of water binding capacity of flour from 6mins toasting time will give a better kneading characteristics of dough for bread production.

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