Modelling the Effect of Toasting Time on the Functional Properties of Brachystegia eurycoma Flour

* Ikegwu, O.J.¹, Okechukwu, P.E.², Ekumankama, E.O.¹, Okorie, P.A.¹ and Odo, M.O.¹

ABSTRACT
The effect of toasting time on the functional properties of Brachystegia eurycoma flour was investigated. The water absorption capacity, swelling power and solubility index of the flour increased with increase in toasting time, while the oil absorption capacity and amylose content of the flour decreased with increase in toasting time. The peak viscosity, final viscosity, break down and setback viscosity increased from 134.67 to 176.24 RVU, 460.33 to 650.43 RVU, 57.83 to 120.33 RVU and 405.70 to 581.17 RVU respectively, as the toasting time increased. The pasting temperature decreased from 88.25 to 78.32°C, as the toasting time increased from 0 to 12 min. Regression models that could be used to adequately express the relationships existing between the functional properties of the flour and toasting time were established.

Keywords: Brachystegia eurycoma flour, pasting properties, toasting time.

Introduction
In West Africa, dietary pattern vary and is influenced by the vegetation belt. For example, in the northern parts of Nigeria, cereals dominate, while in the South, legumes, nuts, seeds and starchy roots or tubers are the main food components (Ene-Obong and Carnoalue, 1982). However, processing of the cereals and starch roots into a form of paste and eaten with soups is the general practice. Among the legumes used in soups, mainly for emulsification and stabilisation of soups are Brachystegia eurycoma (achi), Detarium microcapum (ofor), Mucuna pruins (ukpo), Mucuna flagellipes (okobo) Afzelia africana (akpalata) and Irvingia gabonensis (ogbono). Each of the soup thickeners have individual characteristic flavours imparted to soups and often choice is dependent on individuals. Irvingia gabonensis (ogbono) is the most common in domestic cooking in all parts of the country. Uhegbu et al., (2009) reported that among the lesser known legumes, Brachystegia eurycoma is one of the favorite soup thickeners in south Eastern Nigeria.

Brachystegia eurycoma belongs to the family caesalpiniaceae, phylum spermatophyte and other fabaceae. It is a dicotyledonous plant, classified as legume and grows commonly along river banks. The seed flour of Brachystegia eurycoma have gelation properties and imparts a gummy texture when used in soups, which is one of the desirable functional quality necessary for the eating of garri, pounded yam, etc., (Ikegwu and Okoli, 2011).

The functional properties of food additives and thickeners are factors to consider before their choice. These properties are often affected by the conditions under which the ingredient is applied or processed. Traditionally, Brachystegia eurycoma is either processed by boiling it in water or by toasting it; after which it is grinded into flour to thicken and flavour soups. Brachystegia eurycoma seed needs to be toasted under conditions that will not have

¹ Department of Food Science and Technology, Ebonyi State University, Abakaliki, Nigeria
² Department of Food Technology, Federal Polytechnic, Oko, Anambra State, Nigeria
* corresponding author: onyxj12@yahoo.com
any adverse effect on the functional properties as that could lead to impaired functionality. These functional properties include the water absorption capacity, gelatinisation temperature, swelling power and solubility and paste viscosity. In order to control and establish the toasting conditions for Brachystegia eurycoma seed that will yield the functional property needed for a particular application, there is the need to determine the response of the properties to toasting time. Previous processing, such as heating time, temperature, alkali processing, disulphide linking, etc. have been reported to influence the functional and rheological properties (Iwe, 2003; Visser and Thomas, 1987).

There are no well documented information on the effect of toasting time on the functional properties of Brachystegia eurycoma “achi” flour. The study was, therefore, undertaken to investigate the effect of toasting time on the functional properties of Brachystegia eurycoma flour with a view to establishing the relationship existing between the functional properties and toasting time. This study will provide information towards the effective toasting and utilization of Brachystegia eurycoma seed in the food industry.

Materials and Methods
Samples of Brachystegia eurycoma “achi” seeds were purchased from Eke-Aba market in Abakaliki, Ebonyi State, Nigeria. The seeds were screened to eliminate the bad ones. Cleaned seeds were divided into two parts of 1 kg each. One part was conditioned to 25% moisture content by the addition of distilled water and held for 2 h with occasional stirring. The conditioned sample was sun dried to final moisture of approximately 10%. The dry seeds were dehulled for 2 min using disc attrition mill (No 1A Premier). The dehulled seeds were milled in an attrition mill, sieved and packaged as above.

Determination of functional properties
The swelling power and solubility index of Brachystegia eurycoma flours were determined according to the methods described by Tester and Morrison (1990) and Anderson et al. (1996) respectively. The method of Beuchat (1977) was used to determine the water and oil absorption capacities of the Brachystegia eurycoma flours, while the methods of Williams et al. (1970) was used to determine the amylose content.

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 2.5 g of Brachystegia eurycoma flour samples were weighed into a dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998). Results are means of triplicate determinations.

Statistical analysis
The relationship existing between Brachystegia eurycoma and toasting time was established using the linear regression procedure in SPSS 16 for Windows.

Results and Discussion
The ability to absorb water or oil is a very important property of all flours used in food preparations (Ikegwu et al., 2010). Water binding capacity is a measure of the strength of starch intergranular bond. Low water binding capacity is attributable to tight association (Soni et al., 1993), while high
water binding capacity is indicative of a loose
association of native starch polymers or low lipid
content (Nwokoche and Ogunmola, 2005). The
water absorption capacity of *Brachystegia eurycoma*
flour from *Brachystegia eurycoma* seed toasted at
120°C increased with increase in toasting time, with
flour from 12 min toasting having the highest water
absorption capacity (Figure 1). This implies that
increase in toasting time may have resulted in some
weakening of the starch granule integrity.

The relationship existing between water absorption
capacity (WAC,%) and toasting time (T, min) was
found to be linear and can be represented with the
following equation:

\[
WAC(\%) = 9.086T + 82.46 \quad (R^2 = 0.996)
\]  

where WAC is water absorption capacity (%),
T = toasting time (minutes).

The swelling power which is a measure of the ability
of flour to imbibe water and swell was toasting
time dependent. The swelling power of the flours
increased with increase in toasting time (Figure 3).
Iwe (2003) reported that swelling is often affected
by processing time. This may explain the differences
in swelling power of the flours from *Brachystegia
eurycoma* seeds when subjected to different toasting
time. The increase in swelling power of *Brachystegia
eurycoma* flour with increase in toasting time could
be due to decrease in amylose content of the flour
with toasting time. This can be seen from the fact
that flour from 12 min toasting which has a lower

The effect of toasting time on the oil absorption
capacity of *Brachystegia eurycoma* flour

The relationship existing between oil absorption
capacity (OAC,%) and toasting time (T, min) was

\[
OAC(\%) = -3.171T + 192.3 \quad (R^2 = 0.942)
\]  

where OAC is oil absorption capacity in (%).
T = toasting time (minutes).

The swelling power which is a measure of the ability
of flour to imbibe water and swell was toasting
time dependent. The swelling power of the flours
increased with increase in toasting time (Figure 3).
Iwe (2003) reported that swelling is often affected
by processing time. This may explain the differences
in swelling power of the flours from *Brachystegia
eurycoma* seeds when subjected to different toasting
time. The increase in swelling power of *Brachystegia
eurycoma* flour with increase in toasting time could
be due to decrease in amylose content of the flour
with toasting time. This can be seen from the fact
that flour from 12 min toasting which has a lower

![Fig. 1: Effect of toasting time on the water absorption capacity of *Brachystegia eurycoma* flour](image1)

![Fig. 2: Effect of toasting time on the oil absorption capacity of *Brachystegia eurycoma* flour](image2)

![Fig. 3: Effect of toasting time on the swelling power of *Brachystegia eurycoma* flour](image3)
Amylose content exhibited higher swelling power. It is generally accepted that amylose acts as a restraint to swelling capacity (Noosuk et al., 2003; Sasaki et al., 2003).

The solubility index of *Brachystegia eurycoma* flour increased linearly with toasting time (Figure 4). The solubility index was found to have a similar relationship with swelling power as toasting time increased. The increase of solubility with swelling power showed that a part of the linear component of the flour was involved in the micellar network while the rest was free from entanglement and preferentially solubilised (Soni et al., 1993).

The swelling power (Sp, %) increased with increase in toasting time (T, min) in a relationship that was found to be linear and could be represented by the following equation:

\[ Sp \, (\%) = 0.313T + 11.95 \quad (R^2 = 0.901) \]

where SP is swelling power (%).

T = toasting time (minutes).

The flour solubility (Si, %) increased with increase in toasting time (T, min) in a linear relationship that could be expressed using the following equation:

\[ Si \, (\%) = 0.225T + 10.29 \quad (R^2 = 0.950) \]

where Si is solubility index (%).

T = toasting time (minutes).

The ratio of amylose to amylopectin within a given type of starch is of important consideration with respect to starch functionality in foods as it affects the granule architecture, gelatinisation and pasting profiles, and textural attributes (Thomas and Atwell, 1999). The result reveals that the amylose content of the flours decreased with increase in toasting time (Figure 5). This implies that as toasting time increased, amylose available for protein-amylose complex decreases resulting to decrease in solubility index as observed. Raja and Ramakrisma (1990) reported that heat treatment causes a reduction in the amylose content.

The relationship existing between amylose content and toasting time (T, min) was found to be parabolic and could be expressed using the following equation:

\[ \text{Amylose content (\%) } = -0.002T^2 - 0.001T + 19.65 \quad (R^2 = 0.995) \]

T = toasting time (minutes).

Pasting properties of starch are used in assessing the suitability of its application in food and other industrial products. The most important pasting characteristic of granular starch dispersion is its viscosity. High paste viscosity suggests suitability as a thickening agent in food (Rapaille and Vanhemelrijck, 1999). The peak viscosity which is the maximum viscosity developed during or soon after the heating portion of *Brachystegia eurycoma* flour increased with increase in toasting time (Figure 6). Peak viscosity has been reported to be closely
associated with the degree of starch damage and high starch damage results in high peak viscosity (Sanni et al., 2001). This implies that *Brachystegia eurycoma* flour from 12 min toasting might have the highest starch damage.

The relationship existing between peak viscosity (P, RVU) and toasting time (T, min) was found to be polynomial of the second order and could be expressed with the following equation:

\[ P = 0.192T^2 + 1.411T + 133.8 \quad (R^2 = 0.941) \quad 6 \]

where PV is peak viscosity (RVU).

\[ T = \text{toasting time (minutes)}. \]

The final viscosity which indicates the ability of starch to form a viscous paste or gel after cooking and cooling increased with increase in toasting time of *Brachystegia eurycoma* (Figure 7), with the flour from 12 min toasting having the highest final viscosity. Hence flour from 12 min toasting has a higher ability of forming a viscous paste, while the raw *Brachystegia eurycoma* flour might be less viscous. Thus, flour from 12 min toasting might be used as thickening and stabilizing agents in baked products.

The relationship existing between final viscosity (F, RVU) of *Brachystegia eurycoma* and toasting time (T, min) was found to be parabolic and could be expressed using the following equation:

\[ F = 1.335T^2 + 31.27T + 462.1 \quad (R^2 = 0.983) \quad 7 \]

where FV is final viscosity (RVU).

\[ T = \text{toasting time (minutes)}. \]

The variation of the break down viscosity of *Brachystegia eurycoma* with toasting time shows that it increased with increase in toasting time (Figure 8), in a relationship that was found to be parabolic. The higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking, hence, the flour from 12 min toasting might exhibit less stability to heating and shear stress of flour paste due to the high value of breakdown viscosity. The variation observed in the breakdown viscosity might be as a result of variation in the toasting time.

\[ BD = 0.162T^2 + 7.215T + 57.64 \quad (R^2 = 0.998) \quad 8 \]

where BD is break down viscosity in RVU.

\[ T = \text{toasting time (minutes)}. \]
The set back viscosity of *Brachystegia eurycoma* flour increased from 405.70 RVU to 581.17 RVU as the toasting time increased from 0 min to 12 min. The *Brachystegia eurycoma* flour from 12 min toasting had the highest (581.17 RVU) and raw Brachystegia eurycoma flour was the lowest (405.70 RVU). The setback viscosity is a stage where retrogradation or re-ordering of starch molecules occurs. Sanni *et al.* (2005) stated that lower setback during the cooling of the paste indicates greater resistance to retrogradation. Hence, raw *Brachystegia eurycoma* flour might show greater resistance to retrogradation. The variation of setback viscosity with toasting time is shown in Figure 9.

![Fig. 9: Effect of toasting time on the set back viscosity (RVU) of *Brachystegia eurycoma* flour](image)

The relationship existing between set back viscosity (SB, RVU) and the toasting time (T, min) was found to be parabolic and can be expressed with the following equation:

\[
SB = 1.763T^2 + 35.34T + 407 \quad (R^2 = 0.991) \quad 9
\]

where SB is set back viscosity (RVU).

The variation of pasting temperature with toasting time is presented in Figure 10. The figure shows that the pasting temperature of *Brachystegia eurycoma* flour decreased with increase in the toasting time. The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and stability of other components (Shimelis *et al.*, 2006). This implies that flour from 12 min toasting will require less time to cook and low energy cost because of the low pasting temperature value compared to the raw *Brachystegia eurycoma* flour.

![Fig. 10: Effect of toasting time on the pasting temperature of *Brachystegia eurycoma* flour](image)

A parabolic relationship between pasting temperature and toasting time was obtained and can be expressed using equation 10:

\[
PT = -0.104T^2 + 0.457T + 88.16 \quad (R^2 = 0.987) \quad 10
\]

where PT is pasting temperature (°C).

The predictive models (equations 1-10) were appropriate for describing the experimental data for the functional and pasting properties of flour from toasted *Brachystegia eurycoma* seeds with the $R^2$ values, which is a measure of the goodness of fit, higher than 0.900. The suitability of equations 1 to 10 for predictive purposes was verified using the percentage root mean square of error (% RMS), which were found to be generally low (<10%). According to Ikegwu (2011), low percentage of RMS values indicate good fit and suitability of a model for practical purpose. According to these authors, the smaller the percentage RMS, the better a model fits experimental data. The difference in the equations explains the influence of toasting time on the functional properties of *Brachystegia eurycoma* flour dispersions.
Conclusion
The water absorption capacity, swelling power and solubility index of the *Brachystegia eurycoma* flour increased with increase in toasting time, while the oil absorption capacity and amylose content decreased with increase in toasting time. The peak viscosity, final viscosity and breakdown increased with increase in toasting time, while pasting temperature and setback decreased with increase in toasting time.

The relationships existing between the functional and pasting properties of the flour and toasting time have been expressed with regression equations. These equations were appropriate for describing the experimental data for the functional and pasting properties of *Brachystegia eurycoma* flour. The suitability of the equations for predictive purpose was verified using the percentage root mean square of error (%RMS), which was found to be less than 10%.

References