

**EFFECT OF LOCAL PRESERVATIVES ‘ABAFE’  
(*Piliostigma thonningii*) AND ‘AGEHU’ (*Khaya ivorensis*)  
LEAVES ON THE PASTING PROPERTY OF  
TRADITIONAL DRY-YAM (GBODO)**

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**ABSTRACT**

The effect of local preservatives ‘abafe’ (*Piliostigma thonningii*) and ‘agehu’ (*Khaya ivorensis*) leaves on the pasting property of traditional dry-yam (gbodo) was studied. During the production of dry-yam, yams were treated with varied quantities of fresh and dried leaves, used singly and or combined form respectively while the untreated yam served as the control. The samples were milled into flour respectively and analysed for pasting characteristics. Although there were significant differences ( $p < 0.05$ ) in the paste viscosities of the treated samples compared with the untreated sample, the values (especially for peak and final viscosities) obtained were all higher than the values reported in the literature for the dry-yam. The peak, trough and final viscosities decreased while the breakdown and the setback values increased as the levels of treatments were increased. Sample treated with 10g of dried abafe leaves (D-AB10-Y) had the highest peak and final viscosities as 418.67 RVU and 498.50 RVU respectively while lowest peak and final viscosities were 300.83 RVU for CF50-Y and 376.10 RVU for D-AG50-Y respectively.

**Key words:** Preservatives, *Piliostigma thonningii*, *Khaya ivorensis*, Pasting characteristics, yam flour

**INTRODUCTION**

One major concern the world has today is the provision of food for the rapidly increasing population to deal with the impending threat of food insecurity (Ogunsumi *et al.*, 2005). Food and Agriculture Organisation, FAO, (1995) reported that about 800 million people representing 20 percent of the developing world population are food insecure and this situation might accelerate especially in sub Sahara Africa identified as the hot spot of food insecurity. The food crisis in most tropical nations, especially sub-Sahara Africa is not only due to low production but the preser-

vation of the available ones during the surplus (FAO, 2006). Yam (*Dioscorea spp*) is a widely distributed tuber crop in West Africa. More than 95% of the world’s yams are produced in Africa with the remainder grown in the West Indies and part of Asia and South and Central America (Purseglove, 1988; 1991). Production of yam in Africa is largely confined to the “yam zones” comprising Cameroon, Nigeria, Benin, Togo, Ghana and Cote d’Ivoire where approximately 90% of the world’s production takes place (FAO 2006). Nigeria alone accounts for considerably more than half of the world total production of yam (Ihekoronye and Ngoddy, 1985).

Yam suffers high degree of post harvest losses due to high moisture content ranging between 65-85% of the weight of the tuber (Kordylas, 1990). Therefore, to overcome the high perish-ability of the yam tuber due to its high moisture content and seasonal nature of their production, yams are processed into flour using well established method (Ige and Akintunde, 1981; Akissoe *et al.*, 2001 and Bricas *et al.*, 1997) which involves processing the yams into dry-yam tubers/slices and flour (Bricas *et al.*, 1997). In some West African countries such as Nigeria and Republic of Benin, the age old traditional method is still being used for yam processing to produce dry-yam 'Gbodo'. The dry-yam tubers/slices are processed by peeling, slicing, blanching in hot water (40 to 60 °C for 1 to 3 h), steeping (24 h) and sun-drying, into a product called "Gbodo" by the Yorubas of south-west Nigeria (Onayemi and Potter, 1974). When Gbodo has been milled into flour, it is called "Elubo" which when stirred into boiling water makes a thick paste known as "Amala" eaten with vegetable soup by the consumers (Akissoe *et al.*, 2001).

The preservation of foods by drying is based upon the fact that micro-organisms and enzymes need water in order to be active (Jay, 1986). Therefore, control measure such as reducing water activity, adjusting pH, correcting storage temperature and additional factors such as modified atmosphere packaging, heat treatment or the presence of preservatives may be required to prevent food spoilage (Transter, 1994). Due to humid tropical climate in sub Saharan Africa, coupled with poor facilities and technical knowhow, food preservation problem persists thus resulting in food crisis in the region (Adisa, 1998). Dry-yam tuber/slices and yam flour prices fluctuate

during the off season as a result of low shelf life. Therefore it becomes necessary to explore low cost and highly effective preservative (antimicrobial) method that will complement drying and suited to humid tropical climate. However, the increasing public awareness of the real and imagined effect of chemical preservatives in foods has stimulated a growing interest in the development of natural antimicrobial/preservatives and spoilage control measures (Jay, 1986). Babajide, (2005, 2007) reported that local processors of traditional dry-yam in south-west Nigeria use local preservatives such as 'Abafe' (*Piliostigma thonningii*) and 'Agehu' (*Khaya ivorensis*) leaves during yam blanching to improve storage life of the dry-yam 'Gbodo'. The extracts from plant leaves such as *Piliostigma thonningii* (Ibewuiké *et al.*, 1997) and *Khaya ivorensis* (Adekunle, *et al.*, 2003 and Samir *et al.*, 2005) have been reported to have antimicrobial effects. Varied quantities of *Piliostigma thonningii* (abafe) and *Khaya ivorensis* (agehu) leaves have been used respectively to treat (preserve) dry-yams by Babajide *et al.*, (2008a). The treated samples had lower microbial loads ( $>10$  to  $10^4$  cfu/g) (total plate count, fungal count and staphylococcal count) compared to that of untreated sample ( $<10^6$  cfu/g) (Babajide *et al.*, 2008a).

*Piliostigma thonningii* (Schum.) Milne-Rech is a small tree with large two-lobed simple leaves and without thorns or spines. Akinpelu and Obuotor, (2000) found that extract of *Piliostigma thonningii* stem bark exhibited bactericidal activity against bacteria isolates. Similarly, *Khaya ivorensis* commonly referred to as African mahogany is one of the plant species cultivated in the Centre for Scientific Research (CSR) arboretum at Ayikuma in the GaDangbe District of Ghana for medical purposes (Laira, 2000; Ameyaw and Ampaw, 2004). The stem barks of *K. ivorensis* A. Juss.

are commonly used by the traditional medical practitioners (because of resistance to fungal decay) and other alcoholic beverage brewers in Ghana in preparing tonics for anaemia and appetizers (Samir *et al.*, 2005).

The focus of this research is to determine the effects of varied quantities of *Piliostigma thonningii* and *Khaya ivorensis* leaves on pasting properties of traditional dry-yam (gbodo) samples.

## MATERIALS AND METHODS

### Raw Materials

White yam tuber of local variety 'Tjedo' (*Dioscorea esculenta*) were purchased from Odo-Oba Market in Oyo, Nigeria. 'Afafe' (*Piliostigma thonningii*) and 'Agehu' (*Khaya ivorensis*) leaves were plucked from the herbarium of the University of Agriculture, Abeokuta and Ogun-Osun River Basin Development Authority, Abeokuta respectively. Both leaves were authenticated at the Forestry Research Institute of Nigeria, Jericho, Ibadan, Nigeria where voucher specimens have been deposited.

### Dry-yam (gbodo) processing

The processing of yam tubers to dry-yam 'Gbodo' was carried out following the method described by Ige and Akintunde (1981) with some modifications (Babajide, 2005; Babajide *et al.*, 2007). The yam tubers were peeled manually by using sharp knife and the peeled yams which were washed in clean water were cut into 2 – 3 cm thick slices to hasten the process of drying. Sliced yam tubers (1.5 kg each) in 1.3 litre of clean water for each sample were blanched at 50°C for 2 h in water baths (Clifton, England). The fixed quantities of yam and water were obtained from the preliminary studies on processors' 'gbodo' (Babajide *et al.*, 2007). Predeter-

mined measurements of fresh and dried *abafe* and *agehu* leaves were added singly and in combinations of 10g, 20g, 30g, 40g and 50g respectively during blanching. The different measurements of leaves were also obtained by varying the quantities - two levels above and below the approximate average quantity (30 g) obtained during the preliminary study. In all, 31 treatments including the control/untreated (sample without leaves) were obtained. These consisted of: 5 levels of samples treated with fresh *abafe* leaves (F-A,B-Y), 5 levels of samples treated with dried *abafe* leaves (D-A,B-Y), 5 levels of samples treated with fresh *agehu* leaves (F-AG-Y), 5 levels of samples treated with dried *agehu* leaves (D-AG-Y), 5 levels of samples treated with fresh combined leaves (CF-Y), 5 levels of dried combined leaves (CD-Y) and the untreated sample. The blanched yam slices were steeped in the blanching water for 24 h to become flabby, after which the water and leaves were drained for each sample and the yams were dried at 60°C in a LEEC cabinet dryer (Nottingham – Model 11), the drying samples were weighed at intervals until a constant weight (average moisture content of 8%) was obtained at the 2nd day. The dried yam slices were milled into flour in a locally fabricated plate mill, sieved with 0.2 mm wire mesh screen and packaged in High Density Polyethylene (HDPE) bags and stored at ambient temperature ( $32 \pm 2^\circ\text{C}$ ) prior to further analyses.

### Pasting viscosity measurements of treated and untreated dry-yam flour samples

The pasting properties of the flour samples were determined using a Rapid Visco Analyser (RVA, Newport Scientific, Narrabeen, Australia) on an 8% dry matter suspension. A 3.00 g yam flour sample was weighed into a weighing vessel prior to transfer into the

canister. Twenty-five (25.00) ml water was dispensed into the canister containing the sample. The paddle was placed into the canister and its blade was jogged vigorously through the sample up and down ten times. If any flour lumps remain on the water surface or adhere to the paddle, the jogging action is repeated. The paddle was placed into the canister and both were inserted to the RVA assembly firmly into the paddle coupling so that the paddle is properly centered. The measurement cycle is initiated by depressing the motor-power of the instrument. The suspension was heated from 35°C to 95°C at a rate of 6°C min<sup>-1</sup>, maintained at 95°C for 4 min, then cooled to 50°C at the same rate. Peak viscosity was measured at the start of the plateau (95°C), trough viscosity is the minimum viscosity after the peak, normally occurring around the commencement of sample cooling while the final viscosity was measured at the end of the test after cooling to 50°C, in Rapid Visco Unit (RVU). The peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting were read from the pasting profile with the aid of ThermoLine for Windows Software connected to a computer (Newport Scientific, 1995).

#### **Statistical Analysis**

Means of triplicate readings were obtained, subjected to Statistical Analysis of Variance (ANOVA) and were separated by Duncan Multiple Range Test using SPSS (15.0 version) statistical package.

## **RESULTS**

### ***Pasting Properties of Yam flour obtained from yam treated with fresh abafe leaves***

In Table 1, the untreated yam had the highest peak viscosity and trough of 406.75 and 290.17 RVU respectively while the sample

treated with 50 g fresh 'abafe' leaves (F-AB50-Y) had the lowest value of 355.92; 249.08 RVU respectively thus as the treatment with fresh 'abafe' leaves was increased, the peak and trough viscosities reduces. There was no significant difference ( $p>0.05$ ) in peak viscosities of F-AB10-Y to F-AB40-Y samples (362.16 to 380.75 RVU), except for the F-AB50-Y sample (355.92 RVU) and the untreated sample (406.75 RVU). Sample treated with 30 g fresh abafe leaves (F-AB30-Y) had the highest breakdown viscosity as 119.58 RVU while the sample treated with 10 g fresh 'abafe' leaves (F-AB10-Y) had the lowest value of 99.92 RVU. There was no significant difference ( $p>0.05$ ) in the breakdown viscosities of the untreated yam and the samples treated with 20 g and 30 g fresh 'abafe' leaves (F-AB20-Y and (F-AB30-Y). All the treated and untreated samples had high final viscosities (above 450 RVU) with F-AB40-Y having the highest value as 472.00 RVU which was not significantly different ( $p>0.05$ ) from that of F-AB50-Y and the untreated yam as 468.42 and 471.34 RVU respectively. The setback viscosities of fresh abafe treated yam samples (F-AB-Y) and the untreated yam (183.42 to 196.39 RVU), though increased gradually as the treatment increased, were not significantly different ( $p>0.05$ ) from each other, except for F-AB50-Y sample (221.33 RVU). The peak time (4.71 - 4.96 min) and the pasting temperature (83.90 – 84.60 °C) respectively were not significantly different at  $p>0.05$  (Table 1). The inclusion of fresh abafe leaves 10 – 40 g during the blanching stage of dry-yam (gbodo) processing could reduce the peak viscosity, trough viscosity; gradually increase setback viscosity but have less effect on the breakdown, final viscosity, peak time and pasting temperature.

**Table 1: Pasting properties of yam flour obtained from yam treated with fresh *abafe* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Break-down (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (°C)
Untreated	406.75 <sup>a</sup>	290.17 <sup>a</sup>	114.58 <sup>a</sup>	471.34 <sup>a</sup>	183.42 <sup>b</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
F-AB10-Y	375.58 <sup>b</sup>	268.67 <sup>b</sup>	99.92 <sup>b</sup>	456.00 <sup>b</sup>	185.33 <sup>b</sup>	4.80 <sup>a</sup>	84.15 <sup>a</sup>
F-AB20-Y	378.83 <sup>b</sup>	269.21 <sup>b</sup>	113.75 <sup>a</sup>	452.83 <sup>b</sup>	186.75 <sup>b</sup>	4.96 <sup>a</sup>	84.20 <sup>a</sup>
F-AB30-Y	383.25 <sup>b</sup>	260.67 <sup>b</sup>	119.58 <sup>a</sup>	448.50 <sup>b</sup>	189.83 <sup>b</sup>	4.71 <sup>a</sup>	83.90 <sup>a</sup>
F-AB40-Y	380.75 <sup>b</sup>	274.92 <sup>b</sup>	109.83 <sup>ab</sup>	472.00 <sup>a</sup>	193.08 <sup>b</sup>	4.87 <sup>a</sup>	84.50 <sup>a</sup>
F-AB50-Y	355.92 <sup>c</sup>	249.08 <sup>c</sup>	104.83 <sup>ab</sup>	468.42 <sup>a</sup>	221.33 <sup>a</sup>	4.90 <sup>a</sup> ns	84.05 <sup>a</sup> ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ). ns = not significantly different

Untreated= untreated yam, F-AB10-Y= yam treated with 10g fresh *Abafe*, F-AB20-Y= yam treated with 20g fresh *Abafe*, F-AB30-Y= yam treated with 30g fresh *Abafe*, F-AB40-Y= yam treated with 40g fresh *Abafe*. F-AB50-Y= yam treated with 50g fresh *Abafe*.

***Pasting properties of yam flour obtained from yam treated with dried 'abafe' leaves***

There were significant differences ( $p < 0.05$ ) in the peak viscosities of the untreated sample (406.50 RVU) and the dried *abafe* leave treated samples (D-AB-Y). D-AB10-Y had the highest peak viscosity (418.67 RVU) while D-AB50-Y had the lowest value of 381.30 RVU. The trough viscosity of the untreated sample (290.17 RVU) was not significantly different ( $p > 0.05$ ) from that of D-AB40-Y (295.60 RVU). The breakdown viscosity of the untreated sample was not significantly different ( $p > 0.05$ ) from those of D-AB10-Y to D-AB40-Y (112.18 to 119.24 RVU) but significantly increased to 152.22 RVU for D-AB50-Y. There was no significant difference ( $p > 0.05$ ) in the final viscosities untreated yam, D-AB20-Y and D-AB30-Y samples (471.83, 479.23 and

469.54 RVU respectively). D-AB10-Y had the highest final viscosity of 498.50 RVU while the untreated yam had the lowest value of 471.83 RVU. The setback viscosity of dried *abafe* leaves treated samples (D-AB-Y) increased gradually from 183.42 RVU for untreated yam to 265.20 RVU for D-AB50-Y. No significant difference ( $p > 0.05$ ) occurred in the peak time (4.50 to 4.93 min) and in pasting temperature (83.95 to 84.60 °C) respectively. It could be inferred that the inclusion of dried *abafe* leaves beyond 40 g could reduce the peak and final viscosities of yam flour but had no effect on the peak time and pasting temperature (Table. 2).

**Table 2: Pasting properties of yam flour obtained from yam treated with dried *abafe* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (oC)
Untreated	406.75 <sup>ab</sup>	290.17 <sup>b</sup>	114.58 <sup>b</sup>	471.83 <sup>b</sup>	183.42 <sup>c</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
D-AB10-Y	418.67 <sup>a</sup>	305.60 <sup>a</sup>	112.18 <sup>b</sup>	498.50 <sup>a</sup>	191.20 <sup>bc</sup>	4.93 <sup>a</sup>	83.95 <sup>a</sup>
D-AB20-Y	394.56 <sup>bc</sup>	276.02 <sup>c</sup>	115.65 <sup>b</sup>	479.23 <sup>b</sup>	201.32 <sup>b</sup>	4.60 <sup>a</sup>	84.05 <sup>a</sup>
D-AB30-Y	402.88 <sup>b</sup>	288.51 <sup>bc</sup>	112.50 <sup>b</sup>	469.56 <sup>b</sup>	181.84 <sup>c</sup>	4.75 <sup>a</sup>	84.30 <sup>a</sup>
D-AB40-Y	414.43 <sup>a</sup>	295.60 <sup>b</sup>	119.24 <sup>b</sup>	496.54 <sup>a</sup>	204.70 <sup>b</sup>	4.80 <sup>a</sup>	84.55 <sup>a</sup>
D-AB50-Y	381.30 <sup>c</sup>	229.25 <sup>d</sup>	152.22 <sup>a</sup>	494.38 <sup>a</sup>	265.20 <sup>a</sup>	4.50 <sup>a</sup> ns	84.35 <sup>a</sup> ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ). ns = not significantly different

Untreated = Untreated yam, D-AB10-Y = yam treated with 10g dried *Abafe*, D-AB20-Y = yam treated with 20g dried *Abafe*, D-AB30-Y = yam treated with 30g dried *Abafe*, D-AB40-Y = yam treated with 40g dried *Abafe*, D-AB50-Y = yam treated with 50g dried *Abafe*.

#### ***Pasting properties of yam flour obtained from yam treated with fresh *agehu* leaves***

There were significant difference ( $p < 0.05$ ) in peak and trough viscosities of the untreated yam (406.75; 290.17 RVU respectively) compared to all the F-AG-Y (samples treated with fresh *agehu* leaves) (Table. 3) which reduced as the treatment was increased. Thus F-AG50-Y had the lowest peak and trough values of 320.13 and 212.64 RVU respectively. The breakdown viscosities ranged from 101.41 RVU for F-AG50-Y to 126.16 RVU for F-AG30-Y. The breakdown viscosity of the untreated sample (114.58 RVU) was not significantly different ( $p > 0.05$ ) from that of F-AG10-Y (116.83 RVU). There were significant differences ( $p < 0.05$ ) in the final viscosities of untreated sample and all the F-AG-Y samples with F-AG30-Y having the lowest value of 435.93 RVU while the un-

treated yam had the highest value of 471.83 RVU. The setback viscosity increased gradually from 183.42 RVU for the untreated yam to 229.72 for F-AG50-Y sample. There was no significant difference ( $p > 0.05$ ) in the peak time (4.82 to 5.10 min) of untreated sample and the F-AG-Y samples, likewise for the pasting temperature (84.60 to 85.10°C). The pasting viscosities of F-AG-Y samples reduced as the level of inclusion of fresh *agehu* leaves increases, compared with the values of untreated sample except for the setback values (Table 3).

#### ***Pasting properties of yam flour obtained from yam treated with dried *agehu* leaves***

There were significant differences ( $p < 0.05$ ) in the peak and trough viscosities of the dried *agehu* leaves treated samples (D-AG-Y) compared with the untreated sample (406.75 and 290.17 RVU) respectively which decreased as the treatment was increased. The

**Table 3: Pasting properties of yam flour obtained from yam treated with fresh *agehu* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Break-down (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (oC)
Untreated	406.75 <sup>a</sup>	290.17 <sup>a</sup>	114.58 <sup>ab</sup>	471.83 <sup>a</sup>	183.42 <sup>c</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
F-AG10-Y	384.81 <sup>b</sup>	269.75 <sup>b</sup>	116.83 <sup>ab</sup>	457.56 <sup>b</sup>	191.33 <sup>b</sup>	4.85 <sup>a</sup>	84.65 <sup>a</sup>
F-AG20-Y	375.55 <sup>c</sup>	250.92 <sup>c</sup>	121.45 <sup>a</sup>	443.60 <sup>c</sup>	193.67 <sup>b</sup>	5.10 <sup>a</sup>	85.10 <sup>a</sup>
F-AG30-Y	368.49 <sup>c</sup>	239.33 <sup>d</sup>	126.16 <sup>a</sup>	435.93 <sup>d</sup>	196.48 <sup>b</sup>	4.90 <sup>a</sup>	84.60 <sup>a</sup>
F-AG40-Y	324.16 <sup>d</sup>	218.05 <sup>c</sup>	108.44 <sup>b</sup>	439.28 <sup>cd</sup>	221.11 <sup>a</sup>	4.82 <sup>a</sup>	84.85 <sup>a</sup>
F-AG50-Y	320.13 <sup>d</sup>	212.64 <sup>c</sup>	101.41 <sup>b</sup>	447.20 <sup>c</sup>	229.72 <sup>a</sup>	4.69 <sup>a</sup>	84.70 <sup>a</sup>
						ns	ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ), ns= not significantly different

Untreated = Untreated yam, F-AG10-Y = yam treated with 10g of fresh *Agehu*, F-AG20-Y = yam treated with 20g of fresh *Agehu*, F-AG30-Y = yam treated with 30g of fresh *Agehu*, F-AG40-Y = yam treated with 40g of fresh *Agehu*, F-AG50-Y = yam treated with 50g of fresh *Agehu*.

**Table 4: Pasting properties of yam flour obtained from yam treated with dried *agehu* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Break-down (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (oC)
Untreated	406.75 <sup>a</sup>	290.17 <sup>a</sup>	114.58 <sup>d</sup>	471.83 <sup>a</sup>	183.42 <sup>d</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
D-AG10-Y	378.41 <sup>b</sup>	239.30 <sup>b</sup>	139.67 <sup>c</sup>	451.18 <sup>b</sup>	213.27 <sup>c</sup>	4.68 <sup>a</sup>	84.25 <sup>a</sup>
D-AG20-Y	374.23 <sup>b</sup>	188.53 <sup>c</sup>	184.55 <sup>b</sup>	426.60 <sup>c</sup>	238.54 <sup>ab</sup>	4.51 <sup>a</sup>	84.45 <sup>a</sup>
D-AG30-Y	359.87 <sup>c</sup>	161.90 <sup>d</sup>	200.10 <sup>b</sup>	408.56 <sup>d</sup>	243.90 <sup>a</sup>	5.15 <sup>a</sup>	84.65 <sup>a</sup>
D-AG40-Y	353.13 <sup>c</sup>	158.27 <sup>d</sup>	195.40 <sup>b</sup>	400.82 <sup>d</sup>	231.21 <sup>b</sup>	4.92 <sup>a</sup>	83.85 <sup>a</sup>
D-AG50-Y	349.91 <sup>d</sup>	128.50 <sup>e</sup>	221.08 <sup>a</sup>	376.10 <sup>e</sup>	248.01 <sup>a</sup>	4.65 <sup>a</sup>	84.70 <sup>a</sup>
						ns	ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ), ns= not significantly different

Untreated = Untreated yam, D-AG10-Y = yam treated with 10g of dried *Agehu*, D-AG20-Y = yam treated with 20g of dried *Agehu*, D-AG30-Y = yam treated with 30g of dried *Agehu*, D-AG40-Y = yam treated with 40g of dried *Agehu*, D-AG50-Y = yam treated with 50g of dried *Agehu*.

breakdown viscosity of the untreated sample (114.58 RVU) was significantly lower ( $p < 0.05$ ) than those of D-AG-Y treated samples and increased as the treatment was increased. The final viscosity of the untreated sample (471.83 RVU) was significantly higher than those of the treated samples at  $p < 0.05$  which reduced as the treatment increased. The setback viscosity of the untreated sample (183.29 RVU) was also significantly different ( $p < 0.05$ ) from those of D-AG-Y samples with D-AG50-Y having the highest setback viscosity of 248.01 RVU. There was no significant difference ( $p > 0.05$ ) in the peak time (4.51 to 5.15 min) of the untreated sample compared with the D-AG-Y samples, which also applies to the pasting temperature (83.85 to 84.70 °C). The peak, trough and final viscosities of D-AG-Y samples reduced while the breakdown and setback values increased as the level of inclusion of fresh agehu leaves was increased, compared with the values of untreated sample (Table 4).

***Pasting properties of yam flour obtained from yam treated with combined fresh abafe and agehu leaves***

The peak, trough, breakdown and final viscosities of the untreated sample were significantly different ( $p < 0.05$ ) from those of the samples treated with combined fresh leaves respectively (Table 5). There was no significant difference ( $p > 0.05$ ) in the setback values of the untreated sample, CF10-Y, CF20-Y and CF30-Y (180.71 to 190.59 RVU) which increased gradually as the treatment increased. The peak time (4.54 to 4.86 min) and the pasting temperature (83.80 to 84.65 °C) of the untreated sample were not significantly different ( $p > 0.05$ ) from those of CF-Y samples respectively. The peak, trough and final viscosities in-

creased while the breakdown and setback values increased as the level of combined fresh leaves treatment was increased (Table 5).

***Pasting properties of yam flour obtained from yam treated combined dried 'abafe' and 'agehu' leaves***

There were significant differences ( $p < 0.05$ ) in peak, trough, breakdown, final and setback viscosities of the untreated sample and the samples treated with dried combined leaves respectively. The peak time (4.68 to 5.09 min) and pasting temperature (83.75 to 84.70 °C) of the CD-Y samples were not significantly different ( $p > 0.05$ ) from each other and the untreated sample, respectively. The peak, trough and final viscosities increased while the breakdown and setback values increased as the level of combined dried leave treatment was increased (Table 6).

## DISCUSSION

When heat is applied to starch based foods in the presence of water, a series changes occur known as gelatinisation and pasting. There is increase in viscosity that occurs when starch or starch materials are sufficiently heated in sufficient water thus result in swelling of starch granules during gelatinization. Gelatinization is an order-disorder phase transition that involves diffusion of water into starch granules, hydration and swelling, uptake of heat, loss of birefringence, crystalline melting, starch solubilization, and amylose leaching (Olkku and Rha 1978; Biliaderis *et al.* 1980). These properties affect the texture and digestibility as well as the end use as starchy foods (Adebowale *et al.*, 2005). There were significant differences ( $p < 0.05$ ) in the pasting profiles of the treated yam samples compared with the untreated yam. Peak viscosity is the ability of starch to swell freely before their physical



**Table 5: Pasting properties of yam flour obtained from yam treated with combined fresh *abafe* and *agehu* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Break-down (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (oC)
Untreated	406.75 <sup>a</sup>	290.17 <sup>a</sup>	114.58 <sup>c</sup>	471.83 <sup>a</sup>	183.42 <sup>b</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
CF10-Y	369.42 <sup>b</sup>	240.53 <sup>b</sup>	131.33 <sup>b</sup>	412.50 <sup>b</sup>	180.71 <sup>b</sup>	4.86 <sup>a</sup>	83.80 <sup>a</sup>
CF20-Y	373.08 <sup>b</sup>	225.08 <sup>c</sup>	154.25 <sup>a</sup>	402.16 <sup>b</sup>	188.86 <sup>b</sup>	4.67 <sup>a</sup>	84.65 <sup>a</sup>
CF30-Y	350.92 <sup>c</sup>	200.25 <sup>d</sup>	146.65 <sup>ab</sup>	393.48 <sup>c</sup>	190.59 <sup>b</sup>	4.54 <sup>a</sup>	84.00 <sup>a</sup>
CF40-Y	328.67 <sup>d</sup>	182.42 <sup>e</sup>	142.83 <sup>ab</sup>	405.58 <sup>b</sup>	229.47 <sup>a</sup>	4.65 <sup>a</sup>	84.45 <sup>a</sup>
CF50-Y	300.83 <sup>e</sup>	159.87 <sup>f</sup>	152.67 <sup>a</sup>	390.72 <sup>c</sup>	231.50 <sup>a</sup>	4.84 <sup>a</sup>	84.40 <sup>a</sup>
						ns	ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ), ns= not significantly different

Untreated = Untreated yam, CF10-Y = yam treated with fresh 10g *Abafe* and 10g *Agehu*, CF20-Y = yam treated with fresh 20g *Abafe* and 20g *Agehu*, CF30-Y = yam treated with fresh 30g *Abafe* and 30g *Agehu*, CF40-Y = yam treated with fresh 40g *Abafe* and 40g *Agehu*, CF50-Y = yam treated with 50g *Abafe* and 50g *Agehu* fresh leaves.

**Table 6: Pasting properties of yam flour obtained from yam treated combined dried *abafe* and *agehu* leaves**

Sample	Peak viscosity (RVU)	Trough (RVU)	Break-down (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (oC)
Untreated	406.75 <sup>a</sup>	290.17 <sup>a</sup>	114.58 <sup>d</sup>	471.83 <sup>a</sup>	183.42 <sup>c</sup>	4.83 <sup>a</sup>	84.60 <sup>a</sup>
CD10-Y	358.39 <sup>c</sup>	224.42 <sup>b</sup>	132.59 <sup>c</sup>	430.87 <sup>c</sup>	207.71 <sup>d</sup>	4.68 <sup>a</sup>	83.90 <sup>a</sup>
CD20-Y	363.17 <sup>bc</sup>	220.55 <sup>b</sup>	141.28 <sup>bc</sup>	465.51 <sup>a</sup>	238.84 <sup>c</sup>	4.93 <sup>a</sup>	83.75 <sup>a</sup>
CD30-Y	372.80 <sup>b</sup>	209.38 <sup>c</sup>	158.41 <sup>b</sup>	457.43 <sup>ab</sup>	249.22 <sup>b</sup>	5.09 <sup>a</sup>	83.80 <sup>a</sup>
CD40-Y	343.24 <sup>d</sup>	150.05 <sup>d</sup>	189.97 <sup>a</sup>	394.70 <sup>d</sup>	252.43 <sup>b</sup>	4.82 <sup>a</sup>	83.80 <sup>a</sup>
CD50-Y	315.38 <sup>e</sup>	121.69 <sup>e</sup>	196.80 <sup>a</sup>	388.03 <sup>d</sup>	270.55 <sup>a</sup>	5.04 <sup>a</sup>	84.70 <sup>a</sup>
						ns	ns

Mean values followed by the same letters in a column are not significantly different ( $p > 0.05$ ), ns= not significantly different

Untreated = Untreated yam, CD10-Y = yam treated with dried 10g *Abafe* and 10g *Agehu*, CD20-Y = yam treated with dried 10g *Abafe* and 20g *Agehu*, CD30-Y = yam treated with dried 30g *Abafe* and 30g *Agehu*, CD40-Y = yam treated with dried 40g *Abafe* and 40g *Agehu*, CD50-Y = yam treated with dried 50g *Abafe* and 50g *Agehu*.

breakdown (Sanni *et al.*, 2004). High peak viscosity is an indication of high starch content (Osungbaro, 1990). The relatively high peak viscosities of all the treated and the untreated samples, though reduced as the treatment increased, is an indication that the yam flours have gelling strength and elasticity (Adebowale *et al.*, 2005). The peak and final viscosities are considered to be the most important paste viscosities, especially with regard to products' ability to paste/ gel after cooking. Akissoe *et al.* (2003) reported that the commonly used varieties for dry-yam slices in Benin Republic (Deba and Banioure) had peak and final viscosities ranged from 203 to 208 RVU and 242 to 248 RVU respectively. Babajide *et al.*, (2008b) reported high peak (358 RVU) and final (378 RVU) viscosities for *D. esculenta* 'Ijedo' yam variety which was used for this study in which higher peak viscosity values were obtained (highest value of 418.67 RVU for F-AB10-Y and lowest value of 300.83 RVU for CF50-Y).

The trough is the minimum viscosity in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling ranged between. As the level of treatment was increased, the trough reduced leading to increase in the breakdown viscosities. The breakdown viscosity value is an index of the stability of starch (Fernandez and Berry, 1989) thus as the level of treatment was increased, the stability of the yam paste increased. D-AG50-Y had the highest breakdown value of 221.08 RVU while F-AB10-Y had the lowest value of 99.92 RVU. The final viscosity is the change in viscosity after holding cooked starch at 50 °C. The final viscosity is the most common parameter used to define the quality of a particular starch-based sample as it indicates the abil-

ity of the material to form a viscous paste after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990). Virtually all the treated and the untreated samples had high final viscosities, though reduced as the treatments were increased with D-AB10-Y having the highest value of 498.50 RVU while D-AG50-Y had the lowest value of 376.10 RVU. Setback value of CD50-Y was the highest (270.55 RVU) and F-AG10-Y had the lowest value of 163.33 RVU. The higher the setback value, the lower the staling rate of the product made from the flour (Adeyemi and Idowu, 1990). There was no significant difference ( $p>0.05$ ) in the peak time and the pasting temperature of all the treated and untreated yam respectively. D-AG30-Y had the highest peak time and pasting temperature as 5.15 min; 85.10 °C while D-AB50-Y had the lowest as 4.50 min; 83.20 °C respectively. The peak time which is the measure of the cooking time while the pasting temperature gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable increase in viscosity is measured and is an index characterized by the initial change due to the swelling of starch (Emiola and Delarosa, 1981).

## CONCLUSION

The paste viscosities of the treated samples compared with the untreated sample, (especially for peak and final viscosities) were all higher than the reported values. Generally, the peak, trough and final viscosities increased while the breakdown and setback values increased as the level of treatments were increased at insignificant difference in peak time and pasting temperature. In conclusion, sample treated with 10g of dried *abafe* leaves (D-AB10-Y) had the highest peak and final viscosities as 418.67 RVU and

498.50 RVU respectively.

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