

## Pasting Properties of Heat-Moisture Treated Starches of White and Yellow Yam (*Dioscorae species*) Cultivars

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**Abstract:** Starches of white and yellow yam cultivars (*Dioscorae species*) were extracted, physically modified by means of heat-moisture treatment (HMT) and evaluated for pasting properties, such as gelatinization temperature, paste viscosity, retrogradation and stability by using Rapid Visco-Analyzer (RVA). The modified white yam starch samples exhibited lower values than the native starch sample in terms of viscosity and stability while an opposite trend was obtained in terms of pasting time and gelatinization. Heat-Moisture treated white yam starch at 18% moisture content exhibited the least tendency to retrograde among the starch samples. As heat-moisture treatment increased, there was a noticeable progressive decrease in the values of pasting viscosity and stability for yellow yam starch coupled with a sequential increase in terms of retrogradation, pasting time and gelatinization temperature. An inverse proportionality between the values of retrogradation and paste stability of the starch samples was observed. However, the native yellow yam starch possessed relatively higher paste stability (312 RVU) than the corresponding native white yellow yam (308 RVU). The heat-moisture treated samples seemed to be more applicable in pastries than the native starch samples.

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### 1. Introduction

Starch, the food reserve homopolysaccharide of plants (Malcolm, 1990), is a biocompatible, biodegradable, nontoxic polymer (Welsen and Welsen, 2002), which occurs widely in nature and most commonly used with a host of advantages: low density, cost effectiveness, abundant supply and environmental amity. It is widely used in food, paper-making, fine chemicals, packing materials, pharmaceuticals, rubber and plastic industries (Huaiguo et. al., 2006). This is partly because of the wide range of functional properties it can provide in its various natural and modified forms, and partly because of its low cost relative to alternatives (Sanderson, 1981).

A large amount of the commercially available starch is not used in its native form, but rather is chemically or physically modified to improve its functionality for use in modern product formulations. Chemical modification begins by separating the starch molecules from each other by heating, shearing, or mixing it with certain chemical reagents in the presence of water.

Pregelatinization, annealing and heat-

moisture treatment are physical methods of modifying starch properties. While pregelatinization causes granules disruption, annealing and heat-moisture treatments (HMT) acquire modified properties without rupturing the granules (Glicksman, 1969; Doublier et. al., 1986; Bhattacharya et. al., 1999; Adebowale et. al., 2005). These physical treatments can change certain starch properties using simple and environmentally safe processes. The physical properties of a heat-moisture treated starch depend on the starch origin and treatment conditions used (Adebowale et. al., 2005).

This research work is aimed at studying the effect of heat-moisture treatment on the pasting properties of native starches from selected yam tubers with the view to expanding their industrial applications for both food and non-food products.

### 2. Materials and Methods

#### 2.1 Sample Preparation

Tubers of white and yellow yam cultivars were purchased at Uchi Market, Auchi. All the chemicals used were analar grade. Starches were extracted from the tubers as described in an earlier research work (Oladebeye et. al., 2009).

Heat-moisture treated starch samples were prepared from the raw starch samples using the standard chemical method described by Franco et. al. (1995). The moisture levels of the starch samples were increased to 18, 21, 24, and 27% by adding the appropriate amount of distilled water. The mixtures were stirred; the sealed samples in glass jars were heated in an air oven at 100°C for 16 h. After cooling, the jars were opened and the starch samples were air dried to a moisture content of 10%.

## 2.2 Methodology

Rapid Visco-Analyzer (Model 3-D, Newport Scientific) with ThermoLine for windows software was used to evaluate the pasting properties such as gelatinization temperature, paste viscosity, paste stability and retrogradation of the starch samples as described by Deffanbaugh and Walker (1989). Test runs were conducted following standard profile 1 which include 1 min of mixing, stirring, and warming up to 50°C, 3 min and 42 sec of heating at 12°C/min up to 95°C, 2.5 min of holding at 95°C, 3 min and 48 sec of cooling down to 50°C, at the same rate as the heating (12°C/min) and 2 min holding at 50°C, where the process ends after 13 minutes. Starch gelatinization (pasting) curves were recorded on RVA and viscosity was expressed in terms of Rapid Visco Units (RVU) which is equivalent to 10 centipoises.

## 3. Results and Discussion

Table 1 shows the pasting properties of native and heat-moisture treated starches of white yam (*Dioscorae spp*). Comparing the results obtained, it is observed that heat-moisture treatment could alter the crystalline structure of starch and affect its pasting properties. The heat-moisture treated white yam starches exhibit lower values of viscosity and stability than the

native starch of the same origin whereas an opposite trend is observed in terms of their pasting time, gelatinization temperature and retrogradation. These changes in pasting characteristics are probably as a result of interó and intraó molecular hydrogen bonds of amylose chain and amylase-lipid complexes, which occurred during heat-moisture treated. Since the structures of treated starch granules become stronger, they, therefore, become extremely heat- and shear- resistant during pasting time (Hoover and Manuel, 1996). However, with decrease in gelatinization temperature from 75.93 to 71.15°C, heat-moisture treated white yam starches possess increase in viscosity from 368.08 to 411.92 RVU, accompanied with a drop in viscosity after retrogradation (Figures 1 ó 3). The stability of the starch samples appears to increase as percentage of heat-moisture treatment increases. This may be due to leaching of amylase, resulting from the swelling of the granules.

The pasting time, gelatinization temperature, final viscosity and retrogradation of heat-moisture treated yellow starches exhibit higher values than the corresponding native starch while an opposite trend is obtained in terms of their paste viscosity and stability (Figures 4 ó 6). Unlike in the modified white yam starches, there is lowering of values in terms of paste viscosity and stability as the percentage of modification increases. This may suggest that after heat-moisture treatment, the granules become less shear resistant, indicating high level of amylose units, which oppose the swelling of granules. It is generally observed that the lower the paste stability, the higher the retrogradation for each of the starch samples. This is in line with the earlier report by Oladebeye et. al. (2009) for the pasting properties of red cocoyam and sweet potato.

Table 1: Pasting Properties of White Yam Starch Samples

Sample	Pasting Time (mins)	Gelatinization Temperature (0°C)	Viscosity (RVU)	Final Viscosity (RVU)	Stability (RVU)	Retrogradation (RVU)
WYS	3.53	68.65	464.50	224.92	308.33	68.75
WYS <sub>18</sub>	3.93	75.93	368.08	249.25	186.58	67.75
WYS <sub>24</sub>	3.67	71.15	411.92	215.00	273.92	77.00

WYS = Native starch of white yam

WYS<sub>18</sub> = Modified starch of white yam at 18% moisture content

WYS<sub>24</sub> = Modified starch of white yam at 24% moisture content

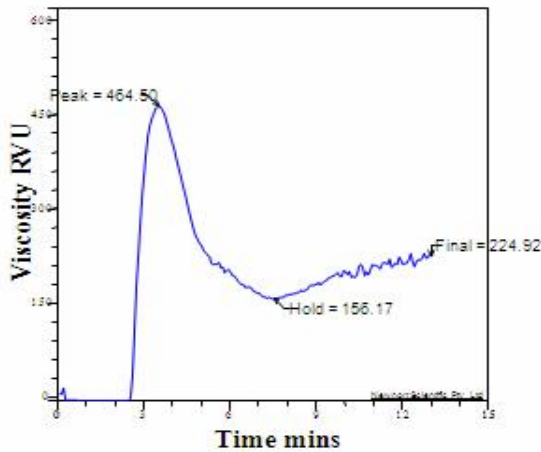


Figure 1: RVA Curve for WYS

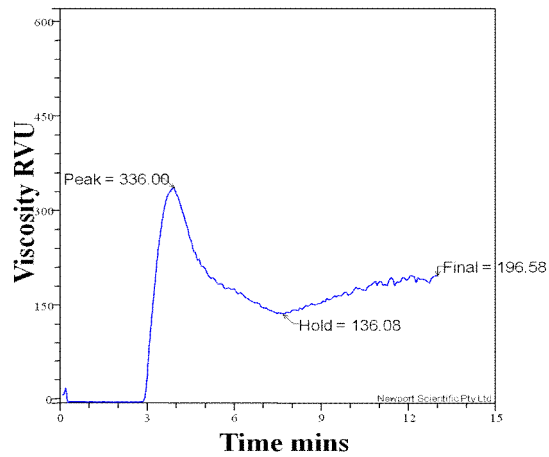


Figure 2: RVA Curve for WYS<sub>18</sub>

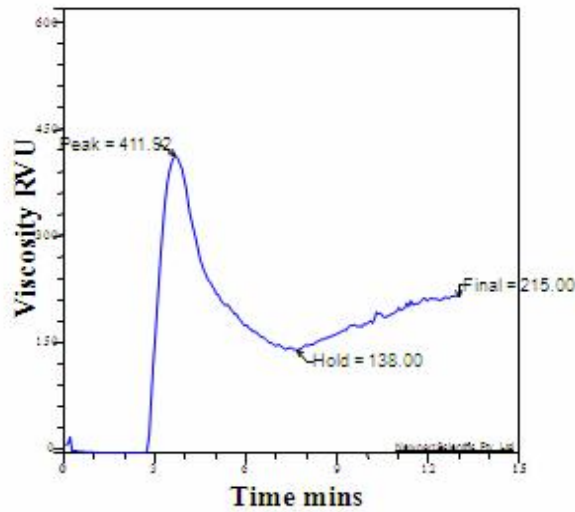


Figure 3: RVA Curve for WYS<sub>24</sub>

Table 2: Pasting Properties of Yellow Yam Starch Samples

Sample	Pasting Time (mins)	Gelatinization Temperature (0°C)	Viscosity (RVU)	Final Viscosity (RVU)	Stability (RVU)	Retrogradation (RVU)
YYS	3.67	70.30	496.58	238.75	312.00	54.17
YYS <sub>18</sub>	4.47	72.55	316.92	253.67	129.67	66.42
YYS <sub>24</sub>	5.53	75.55	249.50	283.08	41.00	74.53

YYS = Native starch of yellow yam

YYS<sub>18</sub> = Modified starch of yellow yam at 18% moisture content

YYS<sub>24</sub> = Modified starch of yellow yam at 24% moisture content

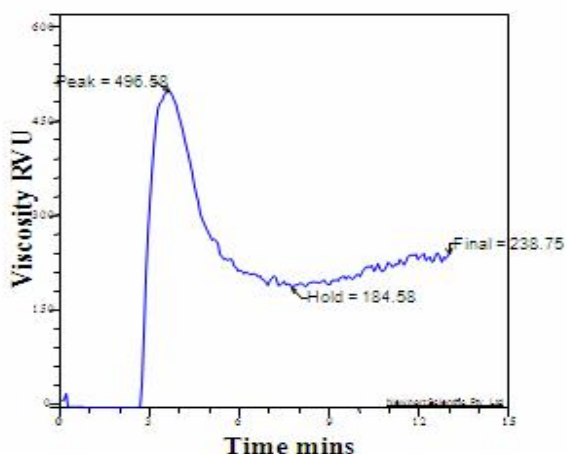
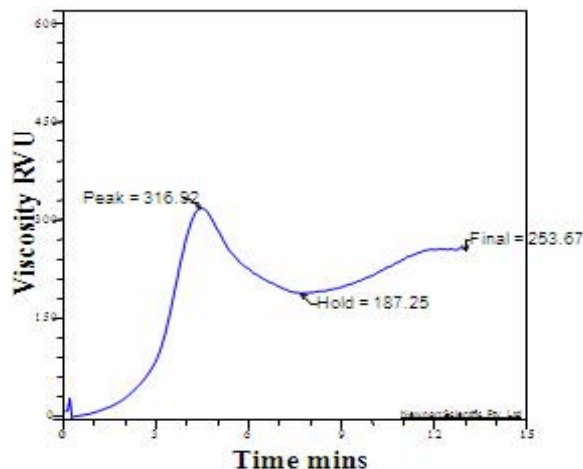
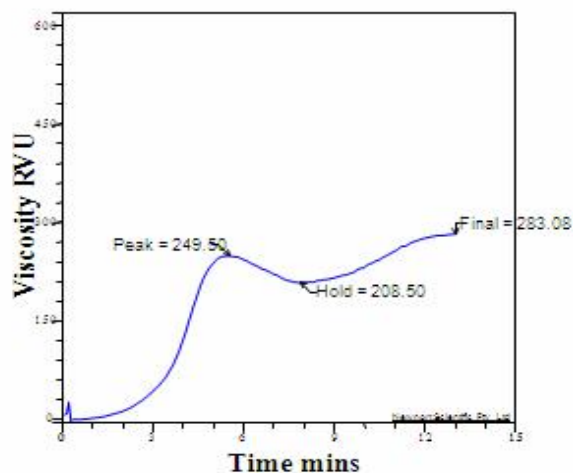


Figure 4. RVA Curve for YYS

Figure 5. RVA Curve for YYS<sub>18</sub>Figure 6. RVA Curve for YYS<sub>24</sub>

#### 4. Conclusion

This study has shown that heat-moisture treatment is capable of altering the crystalline structure of starch. The properties and functionality of starches can be tailored by carefully modify them. The information obtained from this research work can be found applicable in pastries and other related products.

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