Rheological Characterization of raw yam tubers for potential industrial utilization

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Introduction

Yams produce edible starchy storage tubers which are of cultural, economic and nutritional importance in Nigeria. It is a significant and highly prized crop in West and Central Africa but largely underutilized industrially

Rheological profile of the yam tubers (G', G'' Tan δ) may be used as a basis for understanding the changes that are taking place during tuber gelatinization, cooking and cooling of starches in yam.

Storage modulus (G') is a measure of deformation energy stored in the material during the shear process, It represents the elastic behavior of the sample. Loss modulus (G'') is a measure of the deformation energy lost per cycle of sinusoidal deformation, it represents the viscous behavior of the material. Loss tangent (Tan δ) or damping factor (G''/G'), indicates the physical behavior of a system thus showing the $_{ratio}$ of the viscous and the elastic portion of the viscoelastic deformation.

Viscoelastic properties of raw tubers from four yam species; *Dioscorea rotundata , D.alata , D.bulbifera* and *D. dumetorum* were studied to determine their potential industrial utilization.

Materials and methods

Materials

Sixteen varieties of yam from four commonly cultivated species in Nigeria; *Dioscorea rotundata* (5*), D.alata* (5*), D.bulbifera* (5) and *D. dumetorum*(1) obtained from yam germplasm of International Institute of Tropical Agriculture (IITA)

Method

The viscoelastic characteristics of the raw yam tubers were determined by means of a rheometer using a modified method of Singh *et al*., 2008. About 1mm thick slices of the samples were cut by means of ham cutter. Then a cork borer was used to cut out round slices which were used for the rheological analysis. The samples were then hermetically stored in plastic containers prior to rheological characterization using a Physica MCR 301 rheometer with a serrated flat probePP25 (25mm probe). The viscoelastic range for each yam variety were checked by normal force sweep (0.5 to 100N), strain sweep (0.01 to 100%)) prior to analysis at 3.5N, 7% strain and 1Hz frequency Isothermal for 1min at 35° C (7% strain, 1Hz and using FN 3.5N).

Results

•Rheological profile of the tubers are shown in Figs 1 a-d.

• G' of the tubers decreased initially during the heating period due to thermal softening as a result of loss of turgor, cellular disorganization loss structural integrity or tuber rigidity (Bu-Contreras and Rao, 2001 Otegbayo et al., 2005).

•,After some time G' increased as a result of swelling of the starch granules, it indicates transition from the liquid system with dispersed particles to a system nearly packed with deformed particles, (Keetels et al, 1996).

•After the maximum G' the G' decreased again due to reduced swelling of the granules as a result of crystalline melting and separation of amylose and amylopectin

•In all the cultivars G' was higher than the G'' indicating they behave like an elastic solid.

D.rotundata had the highest G' among the four species but had the lowest gelatinization temperature (T_{gel}) and took a shorter time (867s-958s) to reach the G'max compared to other species (Table 1)

•All the *D.bulbifera* cultivars started with very high initial G' before decreasing to a minimum and increasing to the G'_{max} This is due to the strength and rigidity of the tubers. They tubers did not rupture or loose their structural integrity easily compared with other species neither did they show a distinct and clear gelatinization curve. This is very similar to what was reported about the profile of waxy potato cultivar by Singh et al., 2008.

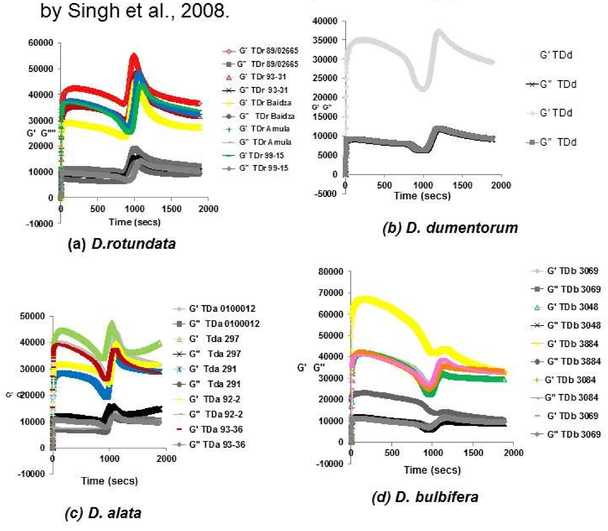

Fig 1 : Rheological profile of yam tubers

Table 1: Gelatinization temperature, swelling power, storage modulus and time taken during oscillatory rheological profiling of raw yam tubers

Species Cultivar	Gelatinization temp (T_{gel}) oC	Swelling power	Minimum G' (G'_{min}) (Pa)	Maximum G'(G'_{max}) (Pa)	Time taken to swell (Pa)	Time taken for gel rutpure (Pa) (Pa)
D.dumetorum						
	83.5	4,400	22,600	37,000	1030	1220
D.rotundata						
TDr 89/02665	75.3	18,300	36,700	55,000	867	989
TDr 93-31	76.2	17,600	30,500	48,100	886	1020
TDr 99-15	79.8	18,600	25,000	43,600	958	1100
TDr Baidza	76.7	21,000	23,800	44,800	895	1030
TDr Amula	78.6	20,000	20,000	48,000	934	1070
D.alata						
TDa 291	80.9	13,900	21,000	36,000	980	1090
TDa 297	75	9000	34,500	47,000	901	1060
TDa 001/0012	81	16,000	28,000	44,000	987	1111
TDa 92-2	87.5	14,500	25,000	39,800	1010	1111
TDa 93-36	80.1	11,400	25,600	37,000	963	1140
D. bulbifera						
TDb 3069	81.6	8,700	28,000	36,700	994	116
TDb 3084	82	8,100	23,900	32,000	1000	115
TDb 3884	84.3	1,000	42,000	43,000	10500	1210
TDb 3048	82.5	8,100	26,900	35,500	10100	1170
TDb 3059	81.6	10,900	27,600	38,500	994	1170

(a) (b) (C)

(a) D. rotundata, (b) D.bulbifera (c) D. alata

Conclusions

• *D. rotundata* cultivars generally had a lower gelatinization temperature (T_{gel}) (75.3oC-79.8oC) and took a shorter time (867s-958s) to reach the G'max compared to other species. This temperature can be an index of their gelatinization or pasting temperatures.

• it may be stated that among *D.rotundata* and *D.alata*, the higher the G'_{max} the lower the T_{gel} this can be a very useful indicator in the industrial utilization of the starches from these yam tubers.

•Thus a high initial G' may indicate a yam tuber with strong and rigid structure.

• The difference in height between the minimum G'(the G' after the loss of structural integrity) and the G'_{max} can indicate the swelling power of the starch in the tubers.

Literatures cited

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