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EFFECT OF DRYING METHOD AND VARIETY ON QUALITY OF CASSAVA STARCH EXTRACTS

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ABSTRACT

Cassava tubers are main sources of calories and dietary fibre for Nigerians. Cassava tubers are highly perishable and need to be processed immediately after harvest. Cassava can be used for human consumption, livestock feed or industrial purposes. Cassava starch is one of the main industrial products of cassava processing. The long drying times for cassava starch production during sun drying have necessitated the need for alternative drying methods. However, the quality of the starch obtained from these alternative drying methods needs to be investigated. Starch was produced from four different varieties (TME 1, TMS 30572, TMS 01/1235 and TMS 01/1181) of cassava using two drying methods (sun and oven drying at 40^{o}C). The physical (yield and moisture content), functional (water binding capacity, swelling power and solubility) and pasting properties of the starch produced were investigated. The moisture content varied from 9.24 to 10.48%, with oven dried TME 1 having the lowest values and sun dried TMS 01/1181 having the highest value. The yield of starch obtained from drying the four varieties using the two drying methods increased from 458.5 to 687.2g per kg of cassava tuber. The water binding capacity, swelling power and solubility increased from 97.97 to 99.83 g water/g sample, 11.69–14.19 g/ml and 10.20 – 12.96% (g soluble solids/ g DM of whole starch sample) respectively, for the different varieties dried using the two drying methods. Peak viscosity, trough, break down, final viscosity, peak time and pasting temperature values for the four cassava varieties were in the range of 335.76–619.89 RVU, 135.67–192.35 RVU, 199.38–433.99 RVU, 196.01–257.72 RVU, 3.23–3.91 min and 70.05–72.95^{o}C, respectively for the two drying methods. The values obtained from the cassava varieties considered were generally significantly different (except colour) which shows significant effect of cassava variety used on starch properties. Also, cassava starch samples dried at lower temperature have better functional and pasting properties. This indicates that alternative drying methods should be used at temperatures lower than 40^{o}C in order to obtain products of high quality.

Key words: Physico-chemical properties, Drying, Cassava, variety

INTRODUCTION

Cassava is a versatile crop and has been identified as a famine crop because it has the ability to grow on marginal lands where cereals and other crops do not grow well. It is easy to cultivate and its roots can be stored in the ground for up to two years. It can tolerate drought and can grow in low nutrient soil. Cassava provides a basic daily source of dietary energy and is a main source of calories for people in West Africa and Nigeria especially.

Cassava can be processed into a number of products which includes garri, tapioca, cassava chips, cassava flour and starch for human consumption while the leaves can be cooked and eaten as vegetable. Cassava can also be fed in a raw or boiled form to pigs, goats, horses or cattle. The main industrial uses of cassava are in the manufacture of starch and subsequently alcohol in some cases. Starch is a major component of Cassava (*Manihot esculenta Crantz*) and can be isolated in a pure form with least contamination with non-starch constituents. Cassava starch reportedly has a unique granular property that exhibits considerably high single-stage swelling and peak viscosity. However, one of the limiting factors of cassava starch is the inability of the swollen, gelatinized granules to retain a stable structure, collapsing instantaneously [1]. Cassava starch has many remarkable characteristics, including high paste viscosity, high paste clarity, and high freeze-thaw stability, which are advantageous to many industries. Cassava starch can perform most of the functions where maize, rice and wheat starch are currently used.

Utilization of starch is based on its physico-chemical properties which include its ability to swell when used to make bread or other forms of baked products, its moisture binding capacity which is extremely beneficial for baking powder amongst other uses [2]. Other important properties of starch that affect its utilization in the food and textile industries include solubility, pasting properties which include its gelatinization, particle size and colour. The pasting properties of starch which include peak, setback, final and trough viscosities, as well as peak time and temperature are good indicators of its quality. Slurry of starch and water is heated from 60 – 95^{o}C in 6 min and stirred. Starch viscosity is indicated by measuring resistance of starch and water slurry to stirring action of a paddle. The peak viscosity is the maximum viscosity recorded in the test. The breakdown viscosity is a measure of resistance to heating and shear thinning while the final viscosity is the viscosity at the end of the test and the setback viscosity indicates the paste viscosity upon cooling. The peak time is the time the product takes to form a paste or reach peak viscosity. The peak temperature is the temperature at which the first detectable viscosity is measured (that is when temperature of stirred slurry begins to rise) and it gives an indication of the minimum temperature needed to cook the sample.

Production of cassava starch can be done by peeling of the fresh cassava roots, wet milling, screening, centrifugation, washing and drying. Most producers of starch depend on sun drying due to its advantages which are mainly: simplicity in drying and its low capital investment. However, a fast and optimum drying process will reduce the occurrence of the undesirable biochemical changes which could result in subsequent contamination and spoilage of the final product. This implies that despite the advantages of sun-drying, the contamination and spoilage of products is inherent thus making sun drying inappropriate for high quality products. In addition to the above other disadvantages of sun drying include; changes in weather conditions, slowness of the sun drying process and the subsequent loss in quality of the final product due to contamination with dust and insects as well as enzyme and microbial activity. There is, therefore, a need for alternative drying methods that will dry the product faster. Alternative methods which include the use of solar and hot-air dryers have been suggested [3, 4]. These dryers have the advantages of a rapid rate of drying and hygienic finished products while hot-air drying has an extra advantage of providing uniformity of drying [5, 6, 7]. This study is aimed at evaluating the effect of variety and drying on the physico-chemical properties of cassava starch.

MATERIALS AND METHODS

Experimental Procedure

Three cassava varieties TMS 30572, TMS 01/1235 and TMS 01/1181 were obtained from the International Institute of tropical agriculture, Ibadan, Oyo State, Nigeria while another local variety TME 1 was obtained from a farm in Apata area in Ibadan, Oyo State, Nigeria. For each of the varieties 12kg of tubers were processed.

The cassava varieties were peeled and then washed with tap water. After peeling and washing, the cassava was grated using a cassava grater developed by IITA. The grated cassava pulp was mixed with water in a ratio of 1:5 [8]. The resultant slurry was screened using a No. 70 screen to separate the starch milk from the fibrous material. The suspension was centrifuged at 1,173 *x* g for 10 min for it to settle and the residue was twice washed in water and dewatered by placing residue in a clean bag and applying pressure on the bag using a press. The residue obtained was dried either by placing in a tray directly in the sun or by drying in an oven at 40^{o}C (Fig 1). The experiment was carried out in May 2009 when the ambient temperature ranged from 28 to 34^{o}C.

Determination of nutritional properties

The solubility and swelling power of the cassava starch samples were determined using the method of Charles and Guy [9]. The water binding capacity was determined using the method of Medicalf and Giller [10]. The pasting characteristics were determined using a modified method of the Brabender Amylograph procedure known as the Rapid Visco-Analyser (RVA). This is as indicated in the operation manual for the 3 series Rapid Visco-Analyser [11]. The unit for the pasting characteristics is RVU (Rapid Viscosity Units). The experiments were done in duplicates and the mean value reported.

The colour was obtained using a Color-meter (ColorTec PCMTM Colour Tee Associates, Chicago). The colorimeter was first standardized and then used to determine the colour parameters. The hue (H) and Chroma (C) were determined by the following equations:

$H = \tan^{-1}(b/a)$ and $C = \sqrt{a^2 + b^2}$ [12]
where a and b are degree of redness and yellowness, respectively.

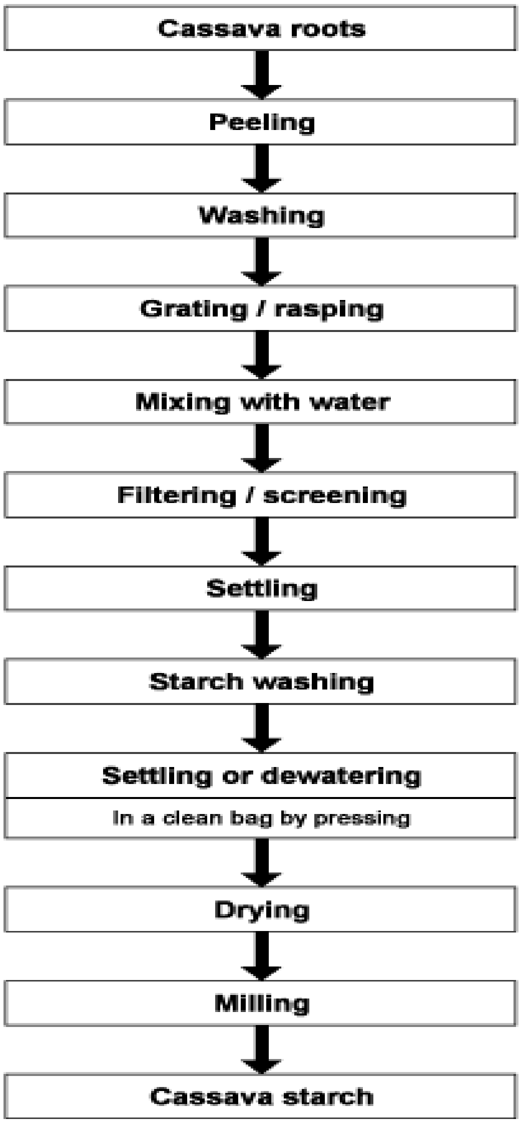


Figure 1: Simple process for cassava starch production

RESULTS

Functional properties

The effect of drying method on some functional properties of cassava starch is shown in Table 1. The moisture content of the oven dried samples was lower than that of the sun dried samples. The moisture content varied from 9.24 to 10.48% with the lowest value being for oven dried TME 1 and highest value was for sun dried TMS 01/1181 variety. The yield for oven-dried samples was also generally lower than that of the sun dried method. The yield for oven drying varied from 458.5g to 681g per kg of cassava tuber while that of sun drying varied from 461.9g to 687.2g. The highest value was that of oven dried TMS 01/1235 and lowest value that of sun dried TMS 30572. In both drying methods the lowest yield was obtained from TMS 01/1235 while the highest was obtained from TMS 30572. The cassava starch yield values were significantly different at $p < 0.05$ for the variety while the drying method had no significant effect on the yield. The swelling power varied from 11.69 to 14.19% while the solubility varied from 10.21 to 12.96% with the lowest value in both cases being that of sun dried TMS 01/1235 and highest value that of oven dried TMS 30572. The swelling power and solubility increased slightly with the oven drying method as compared with the sun drying method (Fig 2). Swelling power and solubility values varied significantly at $p < 0.05$ with drying method while the values obtained for varieties were not significantly different ($p < 0.05$) generally. This is an indication that an increase in temperature weakened the starch granules by allowing interaction between the amylose (water soluble fraction) molecules located in the bulk amorphous regions and the branched segment of amylopectin (water-insoluble fraction) in the crystalline regions [13]. The same trend of higher values for oven dried samples occurred for water binding capacity (Fig 3). The water binding capacity varied from 97.97 to 99.83g water/g sample with the lowest value also that of sun dried TMS 01/1235 and highest value being that of oven dried TMS 30572. Determination of the level of significance of variety and drying method on water binding capacity of the cassava starch extract was carried out. It was observed that some of the water binding capacity values for drying method among cassava flour samples were significantly different ($P < 0.05$), while values obtained for the different varieties were not significantly different.

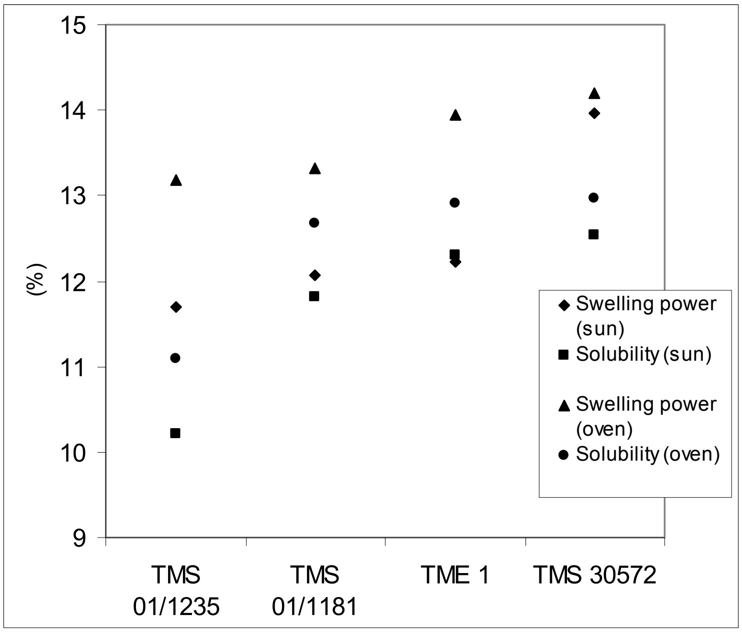


Figure 2: Swelling power (%) and solubility (%) of sun and oven dried cassava starches

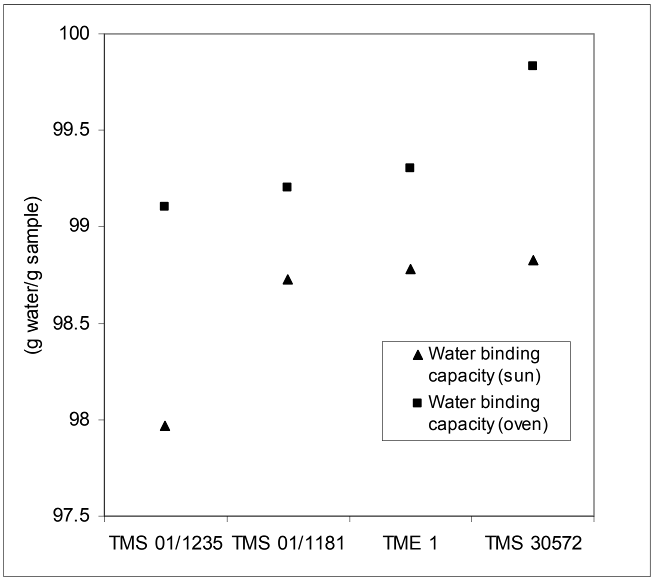


Figure 3: Water binding capacity (g water/g sample) of sun and oven dried cassava starches

Pasting properties

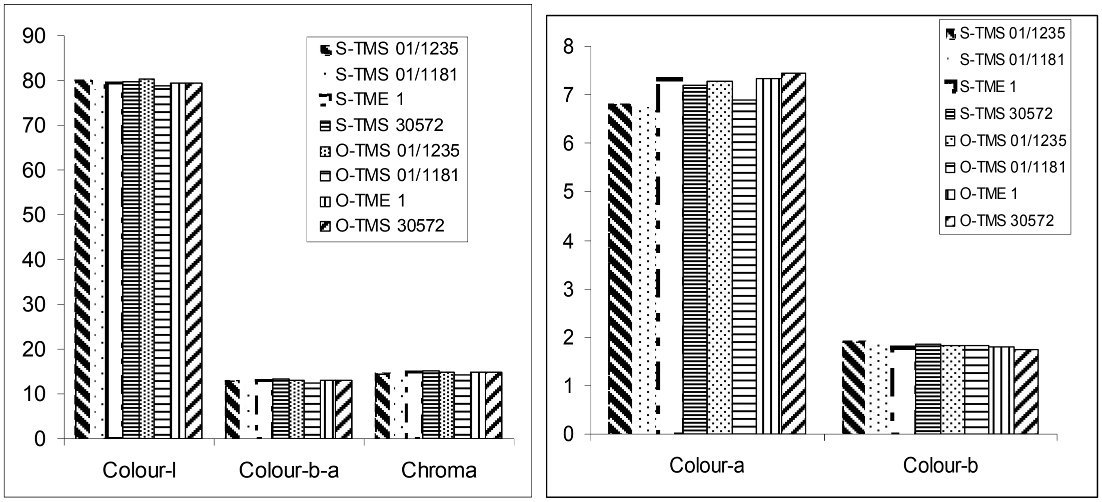
The effect of drying on the pasting properties of cassava starch is shown in Table 2. The peak viscosity varied from 335.76 to 619.89 RVU for the cassava starches with TMS 30572 having the lowest value of 335.76 RVU and oven dried TMS 01/1235 having the highest of 619.89 RVU. The peak viscosity values for oven dried samples are significantly higher ($p< 0.05$) than that of sun dried samples. The trough viscosity value for the cassava starches ranged from 135.67 to 192.35 RVU (Table 2). The oven dried samples had higher trough viscosity than sun dried samples for every cassava variety. There were significant differences ($P < 0.05$) in trough among cassava flour samples.

The breakdown viscosity varied from 199.38 to 433.99 RVU (Table 2). The highest values were obtained with oven dried cassava starches. The final viscosity varied between 196.01 and 257.72 RVU with the starch from sun dried varieties having the lowest and that from oven dried varieties having the highest viscosity value, respectively (Table 2). The setback viscosity varied between 50.82 to 77.05 RVU with the oven dried samples having the highest values generally.

The peak time varied from 3.23 to 3.91min with the sun dried TMS 30572 cassava having the lowest value and oven dried TMS 01/1235 cassava having the highest value (Table 2). The values for the oven dried cassava varieties were generally higher than those of the sun dried varieties. The peak temperature varied from 68.92 to 73.41^{o}C, with sun dried samples from TMS 30572 variety having the lowest temperature while oven dried TMS 01/1235 variety had the highest temperature as shown in Table 2.

Sample colour

From Fig 4, the L* values show that the differences were most obvious between varieties than for the two drying methods for the cassava starches. The L values obtained for the two drying methods were also not significantly different ($P < 0.05$) while the highest value was obtained from cassava TMS 01/1235 variety. The b* value, indicating the yellowness was higher for sun dried cassava starches than for oven dried starches though the values were not significantly different at $P < 0.05$ (Fig 4).



(a) **(b)**

Figure 4: Colour parameters of the (a) sun and (b) oven dried cassava starches

DISCUSSION

The lower moisture content for oven dried samples is expected since the higher drying temperature for oven drying results in a higher percentage removal of moisture during drying. The lower yield for oven-dried samples may be due to the effect of the lower quantity of moisture in the oven dried samples.

The higher swelling power and solubility values for oven dried samples are due to the strength and character of the micellar network within the starch granules being a major factor contributing to the swelling behaviour of starch [14]. Thus a highly associated starch with extensive strongly-bonded micellar structure is readily resistant to swelling. This indicates that the increase in temperature for oven drying results in a decrease in strength and character of the micellar network. This is similar to the observations of Elizabieta *et al*. [15] for pinto and navy bean starch in relation to temperature. Hoover [16] also observed that swelling power and solubility are associated with binding force and degree of association of the granules. Thus, the relative increase in swelling power as temperature of drying increased suggests that starch structural damage is directly proportional to increase in drying temperature.

The increase in solubility as drying temperature increased may be due to the fact that there is a higher granule swelling permitting the exudation of amylose. The organization of the starch granule was observed to affect swelling behaviour and invariably solubility. Thus the higher the structural damage, the easier the breakdown of starch. This maybe because the high swelling power which is obtained with higher drying temperature resulted in the weakening of associated forces thus increasing swelling power as indicated by Moorthy *et al*. [17].

The water binding capacity of a starch as reported by Olanipekun *et al*. [14] is an indication of the amount of water held by the starch extract and this describes the ability of the starch to associate with water under conditions of limitation of water dough and pastes. This increase in water binding capacity for starch samples obtained from oven drying may also be due to the presence of ionisable esterifies phosphate groups which result in mutual electrical repulsion which weakens the association between starch molecules thus increasing water binding capacity [18].

The peak viscosity is an indication of the ability of starch to swell freely before its physical break down. It also indicates that the water-binding capacity of the starch or mixture in a product, correlates with final product quality and also provides an indication of the viscous load likely to be encountered by a mixing cooker [19]. The increase in peak viscosity for oven dried samples which has a higher drying temperature may be attributed to starch degradation or debranching to simpler units which is an indication of starch structural damage. The increase in peak viscosity values with increase in drying temperature is high and it indicates that the starch samples may be suitable for products requiring high gel strength and elasticity.

Peak viscosity values obtained in this study was higher than the range (172.25–340.00 RVU) reported by Adebowale *et al.* [20] for instant yam–bread fruit composite flour and that of 145.28 and 228.11 RVU for flour from germinated tiger nut [20]. The value of peak viscosity of the dried cassava starch indicates that low drying temperature results in reduced peak viscosity values. This shows that reducing the drying temperature reduces the cooking time of the starches. Olanipekun *et al.* [14] reports the observations that low viscosity is desirable in weaning foods since it gives a resultant increase in nutrient and energy densities without an excessive increase in viscosity. This implies that cassava starches dried at low temperatures can be utilized during the formulation of weaning food. Also the high values of peak viscosity indicate that the starch samples can be used for products requiring high gel strength and elasticity.

Trough value is the maximum viscosity value in the constant temperature phase of the RVA profile and measures the ability to withstand breakdown during cooling. The decrease in trough viscosity with decrease in drying temperature may also be attributed to starch degradation which caused a decrease in its value. The range of values obtained for cassava starch is similar to the range of 120.96 to 203.04 RVU for tiger nut flour from germinated seeds [21].

The higher values of breakdown viscosity for oven dried samples indicate that breakdown increased with increase in drying temperature. Breakdown viscosity value is an index of the stability of the starch and is also a measure of the ease with which the swollen granules can be disintegrated [22, 23]. Cohesiveness of paste is attributed to the extent of breakdown of starch molecules during heating and stirring. The lower breaks for sun dried samples indicate its cohesiveness and subsequently higher paste stability as compared with oven dried samples.

The final viscosity indicates the ability of a material to form a viscous paste. It is also the change in the viscosity after holding cooked starch at 50°C [20]. The increase in final viscosity with increase in drying temperature thus indicates that drying the starch samples at the higher temperatures increases the ability to form more viscous pastes or food products. The increase in setback value which indicates the tendency of the starch to retrograde on cooling with increase in drying temperature suggests a reduction in tendency to retrograde for samples dried at low temperatures.

The peak time provides an indication of the minimum temperature required to cook flour. In this study, its value showed a gradual increase with drying temperature. Peak time values reported in this study are lower than the peak time of 5.01 to 6.83 min, 5.13 to 5.80 min and 6.88 to 8.91 mins for germinated tiger nut flour, instant yam–bread fruit composite flour and fermented soybean flours respectively [14, 20, 21]. This is collaborated with the high swelling power obtained for oven dried samples. Olanipekun *et al*. [14] reported that high swelling necessitates that weakening of associative forces and thus easier breakdown of starch. This is also associated with the reduction in cohesiveness of the paste obtained from oven dried cassava varieties.

The Peak temperature is the temperature indicated at the time of maximum peak value of RVA, it gives an indication of the gelatinization time during processing [21]. It is also 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 [24]. The higher pasting temperatures for sun-dried cassava varieties compared with oven-dried cassava samples indicates that for sun-dried samples there is the presence of starch highly resistant to swelling which is in agreement with the low swelling power values of sun-dried cassava samples. The values obtained are similar to 63.85 - 65.47°C, 64.25–64.85°C and 73.1– 75.2°C reported for tigernut, mumu and different pea cultivars, respectively [19, 21, 25].

The L value which indicates the degree of whiteness usually corresponds to consumer preference for products such as starch or flour. The L values for varieties were not significantly different ($P < 0.05$). The b* value obtained for the dried samples implies that oven dried samples have less yellow and subsequently have more blue and thus are judged to be whiter than sun-dried samples. This will result in a greater preference in terms of color for oven dried samples as compared with sun dried samples. However, since the colour values obtained for cassava starches obtained from the different varieties and drying methods are different but not significant, the differences in colour between the starches could be as a result of the difference in their physico-chemical composition as influenced by their botanical origin [26].

CONCLUSION

The values of the properties obtained differ significantly with cassava variety used, an indication that the variety used for starch production has an effect on its properties and thus variety is an important factor in production of starch for various uses. Generally, sun-dried samples gave lower values for most of the properties than oven-dried samples which are probably due to the lower drying temperature involved. The results obtained indicate that the effect of the drying method on the quality parameters of cassava flours was more significant than that of the cassava variety used. This shows that the use of hot air drying as an alternate drying method to enhance the drying process of cassava starch in order to obtain high quality products should be done at low temperatures.

Table 1: Effect of Drying Method and Variety on Some Physical and Functional Properties of Cassava Starch

Drying method	Varieties	Moisture content (%)	Yield (g)	Starch content (%)
Sun	TMS 01/1235	10.28b*	461.9d	84.30b
	TMS 01/1181	10.48a	540.4b	83.59cd
	TME 1	10.19c	550.9b	83.78c
	TMS 30572	10.26b	687.2a	85.68a
Oven	TMS 01/1235	9.77d	458.5d	84.45ab
	TMS 01/1181	9.6d	526.1c	83.72c
	TME 1	9.24e	519.1c	83.52cd
	TMS 30572	9.89cd	681a	85.24a

* Values are means of two determinations

Values with same letters in the same column are not significantly different ($P < 0.05$)

Table 2: Effect of Drying Method and Variety on Pasting Properties of Cassava Starch

Drying method	Varieties	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback value (RVU)	Peak time (mins)	Pasting temperature (^oC)
Sun dried	TMS 01/1235	496.04b	184.87b	346.67c	239.13ab	65.05b	3.79	73.41a
	TMS 01/1181	464.6c	156.62c	312.5d	225.01bc	60.51c	3.61	72.41b
	TME 1	435.01c	154.61c	308.39d	204.95c	54.2de	3.51	70.40c
	TMS 30572	335.76e	135.67d	199.38f	196.01cd	50.82e	3.23	70.05c
Oven dried	TMS 01/1235	619.885a	192.35a	433.99a	257.72a	77.05a	3.91a	72.95ab
	TMS 01/1181	602.406a	185.81b	410.74b	242.32ab	68.87b	3.85	71.15bc
	TME 1	505.23b	159.29c	281.2e	226.26bc	66.63b	3.68	69.25cd
	TMS 30572	411.38d	137.43d	271.91e	214.64c	56.44d	3.51	68.92d

Values are means of two determinations

Values with same letters in the same column are not significantly different ($P < 0.05$)

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