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Research article

Some Functional Properties of Starch Extracted from Improved Cassava (*Manihot esculenta Crantz*) Varieties

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Abstract

The roots of thirty new cassava varieties developed by the National Center of Agronomic Research (CNRA) of Ivory Coast have been studied according to some of their starch functional properties including Viscosity, Swelling and Clarity of the paste. The starch being a derived product of the cassava appreciated much in industry. So the required objective was to characterize the quality of the starch extracted from these new cassava varieties. The results of this study showed that: the paste of starch (40g /450 ml) of these cassava varieties had the viscosities, expressed in Brabender units, ranging between 470 UB and 730 UB and pasting indices ranging from15 to 87.5. The paste of starch (1% p/v) had clarities ranging from 44% Transmittance to 56, 11% Transmittance and swelling capacity ranging between 20.01 g /g and 40.89 g/g.

Keywords: cassava, starch, functional properties, viscosity, pasting indices, swelling, clarity

Introduction

The worldwide production of the cassava is estimated at 224 million tons in 2007 and was at the second rank after that of potato equal to 323.543 million tons). In Africa, the cassava ranked first, followed by yam, potato, sweet potato and aroids (taro and cocoyam) with respective productions of 114 million tons, 44.69 million tons, 17.68 million tons, 12.85 million tons and 8.86 million tons **[1].**. The cassava constituted an important source of starch **[2].** The work carried out on the starch by Cécil **[3],** Buléon *et al*. [4]. showed the many applications of the starch in food industry and nonfood

In the food industry the starch acted as a texture agent (thickener, stabilizer, pasting agent) in various commodities and non-food industry, it is used in the manufacture of textiles, glues, adhesives, paper, box and as a carrier or binder in the pharmaceutical industry **[5].**

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The National Center of Agronomic Research (CNRA) of Ivory Coast developed varieties of high-yielding cassava starch. The objective of our work was to study some functional properties of starch extracted from these cassava varieties including viscosity, pasting indices, swelling, and clarity of these improved cassava roots starch paste.

Material and Methods

Photo 1: Racine de manioc (B. C Ebah-Djedji)

The Vegetable material used in this study is composed of the roots of (30) cassava varieties (Manihot esculenta Crantz) as part of the varietal collection of the National Agronomic Research Center (NARC).
These are Yacé as a control and new varieties various: Bonoua2, Bounda1, Anango agba, Attiéké M'bossi2, Bonoua akpessé, KA19, Ay15, IM84, IM89, IM93, 88/263, TMS4 (2) 1425, TMS30572, CM52, CM (2), 9614A, 9620A, 9612A, 971A, 90/00039, 91/02322, I88/00159, I88/00158, 99 (27) 3 99 (14) 5, 99 (41) 1, 99 (10) 2 99 (27) 1 and 99 (28) 2. These tuberous roots of cassava were collected during the years 2006, 2007 and 2008 at different stages of the growth cycle (11, 13, 15 and 17 months after planting) in test plots of the National Agronomic Research Center to Adiopodoumé 17 km from Abidjan. They were then transported on the same day of harvest to the laboratory in Abidjan in jute bags and starch was studied.
The starch was extracted according to the method of Delpeuch *et al.* **[6].** Two kg of cassava tuberous roots, washed in tap water were peeled with a stainless steel knife. Pulps obtained were washed twice with distilled water and cut into small slices and then ground using a blender (at laboratory temperature (28 ° C ± 1 ° C). The ground material obtained was then passed through sieves of different mesh (710 microns, 150 microns, 100 microns). The starch slurry was allowed to settle. The supernatant was separated from the residue containing starch.
After several washings and decanting subsequent, the residue was dispersed and stirred in a solution of sodium chloride (4%, w / v). After a new series of washes followed by decanting, the residue was dried in a ventilated oven at 45 ° C for 48 h. The product thus obtained was finely ground using a mill and dry sieved through a sieve of mesh 100 microns.

Study of the starch properties

Grain morphology
Electron microscopy Scanning: Five mg of starch were collected and spread out on a pad primed with carbon double-sided adhesive. The distribution on the pad was made evenly. The surface of the pad was blown through a dryer to remove particles which were not well adhered to the adhesive carbon. After this operation, the pad was attached to the tray containing eight (8) blocks. The tray starch samples prepared was then mounted on the plate

the Chamber of a Scanning Electron Microscope (SEM) having varying voltages (0.1 Kv to 30 Kv). The morphology of the samples of grain starch cassava varieties was then observed with a voltage of 1 kV.
Determination of the grain size: The distribution of average grain diameter was determined on a total of 500 grains according to the method of Rasper **[7].**

Viscosity

The viscosity of the starch was measured with viscoamylograph Brabender according to the method of Mazur *et al*. **[8].** The aqueous suspension of starch (40 g / 450 ml) is introduced into the tank of Brabender viscoamylograph and is then heated. During the heating process the temperature is increased gradually from 1.5 ° C / min until to 95 ° C where it is maintained constant during 15 min. After which time of heating the temperature decreases gradually from 1.5 ° C / min until to 50 ° C. During the heating and the cooling, peak viscosity of the starch was registered.

Swelling

The swelling test was carried out according the method of Leach *et al.* [9]. Suspensions of 1% (w / v) of native starch were put in a water bath at different temperatures (50 ° C to 95 ° C) with stirring during 30 min maximum. The suspensions in the tubes were centrifuged at 5000 rev / min during 15 min. The pellet and the supernatant were collected in different containers. They were placed in an oven at 105 ° C for 24 hours to 48 h and the supernatant to the pellet. The supernatant was used to determine the solubility and the pellets, the swelling capacity. The swelling capacity was then determined from the following relation

$$G\ (g/g) = \frac{(M_{cu} - E_{cu})}{(E_{cu} - M_{co})}$$

With:
Mco: mass of empty crucible (g)
Mcu: mass of crucible + residue (g)
Ecu: mass of crucible + residue after drying (g)

Clarity

The clarity of the starch pastes was determined using the method of Craig *et al* **[10].** The pastes of 1% (w / w) dry matter were prepared. An amount of 0.2 g of starch was weighed and placed in a screw tube of quartz. This mass was diluted with 20 g of distilled water. The mixture of the tube well homogenized after closure was brought to a boiling water bath (100 ° C) for 30 min with agitation every 5 min maximum
The paste thus prepared was cooled on the bench for 10 min. The clarity or percentage of transmittance (% T) was determined with a spectrophotometer at 650 nm against a witness containing only distilled water.

Statistical Analysis

All measurements were carried out in triplicate. The statistical analysis of data were made with the software STATISTICA 7.0 (Statsoft Inc, Tulsa-USA Headquarters) et XLSTAT-Pro 7.5.2 (Addinsoft Sarl, Paris-France
The analysis of variance (ANOVA) was used to study the factors product and parameters and their variability. The homogeneity of the parameters studied was determined by the comparison of the averages according to the test of Duncan to the threshold of 5%.

Results

Grain Morphology

The forms of the native starch granules (Photo 2) extracted from the roots of improved cassava varieties were identical. The improved cassava varieties roots had shapes of starch granules predominantly spherical and ovoid.

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The average grain diameter of native starch extracted from cassava tuberous roots varied significantly at 5% one variety to another and from one group to another variety.

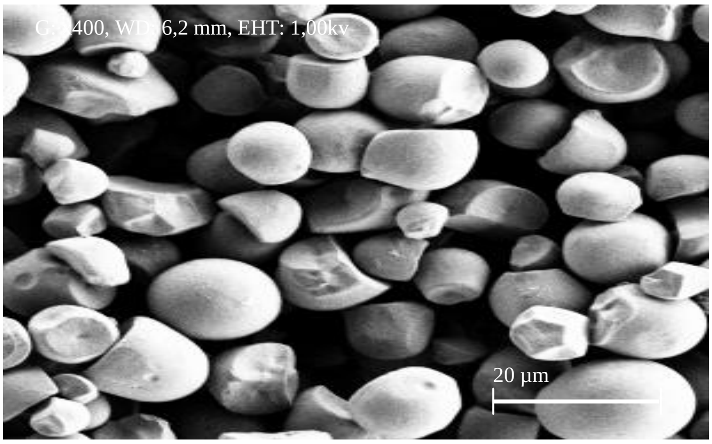

Photo 2: Granules of Cassava native starch (B. C Ebah-Djedji)

The average diameters of native starch grains of improved cassava varieties *90/00 039, CM52, Attiéké M'bossi 2, 99 (27)3* and *99 (14)5* differed significantly at 5%, with respective values of 9.74 ± 3.01 microns, 13.50 ± 3.99 microns, 12.87 ± 3.96 microns, 13.96 ± 4.62 microns and 10.16 ± 3.99 microns.
The first group is composed of varieties *Bonoua akpessé, I88/00158, CM2, Bonoua 2, 9614A, KA19, IM93 and 99 (10) 2,* with mean diameters ranging from 10.55 ± 3.29 microns and 10 88 ± 3.16 microns
The second group included varieties *Bounda1, IM84, 971A, 9612A* and *Anango Agba* with average diameters ranged between 11.34 ± 3.56 microns to 11.72 ± 3.04 microns.
Yacé variety had an average diameter which did not differ significantly at 5% of the 2 groups of varieties mentioned above.
The third group included varieties *TMS30572, I88/00159, TMS4 (2) 1425, 99 (41) 1 91/02 322* and *AY15* with average diameters ranged between 11.88 ± 3.94 microns and 12.20 ± 3.94 microns.
The fourth group is composed of cassava varieties *99(28) 2, IM89, 99 (27) 1 88/263 and 9620*, with average diameters ranged between 12.46 ± 2.79 microns and 12.82 ± 3.95 microns.
The cassava variety *99 (28) 2* having an average diameter of 12.35 ± 3.50 microns did not differ significantly at 5% with the third and fourth group of cassava varieties.
Within these four groups of cassava defined, it did not appear significant differences at 5%. These groups of varieties to be significantly different at 5% level according to Duncan's test.

Viscosity

The viscosity values of starches extracted from cassava varieties Expressed in Brabender Units ranged from 470 BU (*99 (10*) 2) to 730 BU (*Ay15)* (Table 1).
The analysis of variance showed a significant difference only at the threshold of 5% between the values of the viscosity of the starch cassava varieties *Anango agba 90/00039, 90 (10) 2, 99 (27) 3 470 and CM52 UB (99 (10) 2)* to *730 BU (Ay15)* (Table 1). But it does not present significant differences at the 5% level between the values of the viscosity of the starch cassava varieties in different groups.
The starch of the cassava variety 99 (10) 2 is set to the lower viscosity of the variety and Ay15 had the Highest viscosity value. The starches indices of pasting ((viscosity at 50 ° c - 95 ° c Viscosity end) / viscosity at 50 ° c) Improved cassava varieties of Studied Were ranged Between 15 *(99 (27) 1)* to 87.5 (Yacé). The ANOVA showed only a significant difference between the 5% threshold indices starch pasting of cassava varieties *Ka 19; Attiéké M'bossi 2; Bonoua akpessé, 88/263, 99 (14) 5, 9614A, 99 (41) 1 99 (27) 1* and those of starch cassava varieties *IM89, Yacé, 971A* (Table 1). The average value of the pasting indices is equal to 39.95

Swelling

The swelling capacity of starch cassava varieties was ranged between 1.20 g / g (*99 (14) 5)* and 40.89 g / g (*88/263*) (Table 1). The analysis of variance (ANOVA) showed a significant difference at the 5% level between the swelling capacity of starch from cassava varieties *Bonoua 2 Anango agba, TMS30572, 88/263, 99 (41) 1* and cassava varieties *I88 / 00159, 99 (27) 3 99 (14) 5, 9614A, 9612A.* It did not show significant differences at 5% level between cassava varieties in different groups.

Clarity

The starches pastes clarity of the cassava varieties ranged from 16.44% Transmittance (*IM93*) and 56.11% Transmittance (*I88/00159*) (Table 1), The analysis of variance (ANOVA) showed a significant difference between the clarity of starch pastes obtained from cassava varieties *Bonoua2, Anango agba, IM89, TMS30572, Attiéké M'bossi2, Bonoua akpessé, 88/263, Bounda1, 99 (28) 2, 9614A, 99 (41) 1, 99 (27) 1, Yacé* and cassava varieties *IM84, 91/02322, CM (52) 90/00 039, 99 (10) 2, AY15, 99 (27) 3, 9620A , 99 (14) 5, 971A, I88/000158, 9612A.* The analysis of variance (ANOVA) also showed a significant difference between the clarities starch pastes cassava varieties *Bonoua2, Anango agba, IM89, TMS30572, Attiéké M'bossi2, Bonoua akpessé, 88/263, Bounda1, 99 (28) 2, 9614A, 99 (41) 1, 99 (27) 1, Yacé* and cassava varieties *TMS4* (2) 1425, KA19, I88/00159, IM93, CM (2) The starches clarity of the cassava varieties IM93 and CM (2) differed significantly at 5% of that of the starches cassava varieties TMS4 (2) 1425, KA19 and I88/00159.

Discussion

Morphology

The starches grains forms of different cassava varieties are similar. They look like the forms of cassava starches grains studied by Szylit *et al*. **[11]** and by Zoumenou **[12].** Which were spherical and ovoid.
Unlike forms, the average size of starch grains differed significantly at 5% of one variety to another and from one group to another variety.
The average diameters of native starch grains extracted from the roots of cassava varieties studied were consistent with those of cassava starches grains examined by Zoumenou **[1 2]** ranging from 2.6 microns to 39 microns, Duprat *et al.* **[13]** ranging from 1µm to 35 microns and by Sidibé *et al.* **[13**] varying from 1µm and 27µm.

Viscosity

There was a similarity between the viscosities of starches extracted improved cassava varieties, except the significant difference at 5% between viscosities of starch improved cassava varieties Anango agba, 90/00 039, 90 (10) 2 , 99 (27) 3 , CM52 and those of cassava varieties Yacé, TMS30572, KA19 and Ay15.
The capacity of starch extracted from improved cassava varieties to form paste at very low concentrations would justify their use in medicinal preparations as a thickener (Anonym, **[14].** 1998, Whistler **[15]**
According to the work of Whistler **[15]** such starch may be used in formulations at low or moderate temperatures (T <85 ° C) and cold.

The pasting indices of the starches extracted from improved cassava varieties *Bonoua2, Anango agba, KA19, IM84, Attiéké M'bossi2, Bonoua akpéssé 90/00039, 88/263, 99 (28) 2 99 (27) 3, 9620A, 99 (14) 5, CM (2), 9614A, 99(41)1 and 99(27)1 ranged* from 41.23 to 87.50. These pasting indices were higher than those reported by Chuzel **[16]** that varied between 21 and 38.
Improved varieties cassava *IM84, TMS4 (2) 1425, TMS30572, 91/02 322, CM52, I88/00159, 99 (10) 2, AY15, Bounda1, IM93, 971A, I88/00158* and cassava variety *control Yacé* had starches pasting indices of 15 to 38.96

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similar to those found by Chuzel **[16].** According to him when the indices of pasting and the viscosity drop were low the final consistency of paste after cooling had the best thickening and pasting properties. So the starches of improved varieties cassava were preparing better for such applications.

Swelling

Improved varieties cassava have swelling capacity similar, excepted the differences significant at 5% observed between the swelling capacity of the starch extracted from improved cassava varieties Bonoua *2 Anango agba, TMS30572, 88/263 and 99 (41) 1* and those of starch extracted from improved cassava varieties I88/00159, 99 (27) 3 99 (14) 5, 9614A, 9612A.
The similarity or the difference of starches water absorption capacity was due to presence of strong strength and homogeneous maintaining of the matrix grain according to Reys *et al.* **[17].**
The starches of improved cassava varieties had a swelling capacity higher than that of ginger starch equal to 18 g water / g starch (Amani *et al*, **[18].** The starch of the improved cassava variety *88/263* had a swelling capacity similar to that of cocoyam starch 40 g / g (Amani *et al* **[18].**
The improved cassava varieties IM93 and AY15 had swelling capacity similar to that reported by Dadié *et al.* **[19]** on the starch of potato yellow variety and equaled 32 g / g.

Clarity

The low clarity starch pastes of the improved cassava varieties *99 (41) 1, 9614A, CM (2), 99 (28) 2, IM93, 88/263, Bonoua akpessé, Attiéké M'bossi2, TMS30572, IM89, Anango agba and the control cassava variety Yacé* would be a consequence of slow and less solubilization of granular material (amylose, intermediate material) obtained by heating of the starch solution to 100 ° C for 30 min **[20].**
After pasting the starch dispersions were less transparent and they reflect the maximum amount of light used in the environment **[21]; [22]; [23].** The clarities higher starch pastes observed on the starches improved varieties cassava TMS4 (2) 1425, IM84, 91/02322, CM (52), I88/00159 90/00039, 99 (10) 2, AY15, 99 (27) 3, 9620A, 99 (14) 5, 971A, and 9612A I88/00158, would explain an important solubilization.
The clarity of the paste was a complex functional property depending on many factors, including morphology of starches grains. According to the work of Craig *et al* **[10],** opacity of paste was due to the refraction of light beams on the "ghosts" of starch granules, which were in other words the starch granules which have resisted to pasting in the paste.

Table 1: Functional properties of starch of new cassava varieties (Manihot esculenta Crantz)

Varieties	Viscosity (UB)	Pasting index	Swelling g/g	Clarty (%T)
Bonoua 2	570,00 ± 49,50^{abcdef}	50,91 ± 7,18^{ij}	33,65 ± 4,31^{fghi}	27,63 ± 3,30^{bc}
Anango agba	480,00 ± 25,46^{ab}	44,35 ± 6,18^{fghi}	27,25 ± 3,15^{abcdefgh}	20,30 ± 3,11^{abc}
IM 89	590,00 ±35,36^{abcdef}	26,06 ± 4,12^{abc}	35,01 ± 4,31^{ghi}	20,46 ± 2,63^{abc}
TMS 4[2]1425	550,00 ± 35,35^{abcde}	32,78 ± 5,18^{bcdef}	30,00 ± 2,61^{abcdefgh}	39,36 ± 4,31^{d}
Yacé [Temoin]	680,00 ± 35,24^{def}	15,00 ± 1,73^{a}	31,64 ± 4,31^{bcdefghi}	18,67 ± 3,21^{ab}
TMS 30572	650,00± 34,23^{cdef}	26,83 ± 2,90^{abcde}	34,76 ± 4,61^{fghi}	20,54 ± 1,97^{abc}
Ka 19	650,00 ± 36,45^{cdef}	51,61 ± 7,17^{hi}	27,25 ± 2,73^{abcdefgh}	27,94 ± 3,25^{c}
IM84	600,00 ± 35,55^{abcdef}	42,55 ± 7,18^{defghi}	28,95 ± 2,98^{abcdefgh}	48,28 ± 4,31^{ef}
Attiéké M'bossi 2	580,00 ± 35,25^{abcdef}	45,00 ± 7,18^{fghi}	26,48± 3,30^{abcdefgh}	21,19 ± 2,04^{abc}
91/02322	520,00 ± 35,26^{abcd}	29,53 ± 2,33^{abcdef}	24,81 ± 2,87^{abcdefg}	49,09 ± 4,31^{fg}

CM52	558 ± 33,34 abcde	35,67 ± 3,97 cdefgh	23,00 ± 1,73 abcde	45,16 ± 4,31 def
I 88/00159	600,00 ± 28,55 abcdef	37,45 ± 5,90 cdefghi	21,94 ± 2,96 ab	56,11 ± 4,13 g
Bonoua akpéssé	598,00 ± 29,25 abcdef	46,30 ± 6,42 ghi	31,24 ± 3,56 bcdefghi	17,73 ± 2,62 ab
90/00039	480,00 ± 35,56 ab	42,78 ± 6,41 defghi	27,53 ± 3,57 abcdefgh	44,68± 4,31 def
99[10]2	470,00 ± 35,36 a	29,29 ± 3,54 abcdef	30,22 ± 5,24 abcdefgh	40,16± 2,90 ef
88/263	590,00± 35,35 abcdef	53,36 ± 7,98 i	40,89 ± 6,33 i	17,68± 3,77 ab
AY15	730,00 ± 34,26 f	26,45 ± 4,89 abcd	32,41 ± 3,97 cdefghi	45,40± 4,10 def
Bounda 1	565,00 ± 33,52 abcde	37,86 ± 6,66 cdefghi	27,40 ± 3,25 abcdefgh	26,19± 1,90 bc
IM 93	630,00 ± 32,25 abcdef	29,54 ± 3,56 abcdef	32,67 ± 4,31 defghi	16,44± 2,00 a
99 [28] 2	530,00± 34,64 abcd	41,23 ± 6,85 cdefghi	29,64 ± 3,52 abcdefgh	19,65± 2,56 abc
99[27]3	700,00 ± 36,23 ef	42,85 ± 6,82 efghi	22,24 ± 4,47 abc	46,16± 4,31 def
96 20A	585,00 ± 31,25 abcdef	43,52 ± 6,52 fghi	24,60 ± 3,64 abcdef	44,92± 4,31 def
99 [14] 5	650,00 ± 33,26 cdef	51,36 ± 6,52 hi	20,01 ± 2,42 a	46,12± 4,31 def
97 1A	610,00 ± 35,26 abcdef	18,98 ± 3,80 ab	33,13 ± 4,31 efghi	46,66± 3,60 def
CM [2]	575,00 ± 31,26 ef	41,65 ± 4,31 cdefghi	28,56 ± 3,20 abcdefgh	16,83± 2,46 a
I 88/ 00158	490,00 ± 33,32 abc	38,96 ± 4,31 cdefghi	25,67 ± 2,93 abcdefgh	42,46± 4,31 def
96 14 A	510,00± 33,45 abcdef	52,45 ± 4,31 i	22,78 ± 3,22 abcd	20,72± 2,50 abc
99 [41] 1	635,00 ± 32,66 bcdef	47,89 ± 4,31 ghi	35,15 ± 4,31 hi	18,34± 2,05 ab
96 12A	620,00 ± 38,41 abcdef	28,83 ± 2,52 abcdef	21,91 ± 4,17 a	46,52± 4,31 def
99 [27] 1	558,00 ± 31,26 abcde	87,50 ± 4,31 j	31,36 ± 4,53 bcdefghi	25,78 ± 4,48 bc

Mean ± SD, n = 3

In each column, means affected by a common letter are significantly different from each other at 5% level according to Duncan's test. In bold, minimum and maximum values

Conclusion

Starches tuberous roots of cassava varieties have kernels heterogeneous forms do not differ from one variety to another. The grain size of these starches varies significantly at the 5% one variety to another and a lot of variety to another. They have swelling similar except for the differences significant at the 5% observed between the swelling of the starch granules of cassava varieties Bonoua 2 Anango agba, TMS30572, 88/263 and 99 (41) 1 and those of starches cassava varieties I88/00159, 99 (27) 3 99 (14) 5, 9614A and 9612A.The clarities were starch pastes variables. they have similar viscosities, except the difference between the viscosity revealed pastes cassava varieties Anango agba 90/00 039 90 (10) 2 99 (27) 3 and the CM52 and cassava varieties Yacé, TMS30572, KA19 and Ay15.The study of pasting index shows only difference between the indices of cassava varieties Ka 19 Attiéké M'bossi 2 Bonoua akpessi, 88/263, 99 (14) 5, 9614A, 99 (41) 1 and 99 (27) 1 and those of cassava varieties IM89, Yacé and 971A.

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