Characterization of amylose-free and high-amylose starch mutations in cassava

Sánchez T[1], Ceballos H[1], Dufour D[2], Pérez JC[1], Morante N[1]

[1] International Center for Tropical Agriculture (CIAT). Cassava Breeding Project. Mailing address 6713, Cali-Colombia. e-mail of contact person: h.ceballos@cgiar.org
[2] Centre de Coopération Internationale en Recherche Agronomique por le Développement, Montpellier, France.
[3] John Innes Center, Norwich Research Park, UK
[4] Universidad Nacional de Colombia, Palmira, Colombia

Introduction

Two important starch mutations have been recently identified in cassava. The first one is an amylose-free spontaneous mutation identified in the self-pollinated genotype AM 206-5[1]. The second mutation was identified in a mutagenized population irradiated with gamma rays[2]. Granules are smaller (5.8 µm compared with 15.0 µm in wild type cassava), their surface is rough and their shape irregular.

Materials and Methods

Normal and waxy starches from cassava and potato were included in this study as well as the small granule cassava starch mutant. Swelling power and solubility patterns were determined at 60, 75 and 90°C. Pastes were prepared in Rapid Visco Analyzer (RVA, increasing temperatures at 6°C min-1 rate. Stirring was at 960 rpm for the first minute and then maintained at 160 rpm during the entire analysis. The supernatant and sediment after centrifugation for 10 min at 6000g at 25 °C were collected and weighed (Wsu and Wse, respectively) then dried at 100 °C for 24h and 48h respectively and weighed (Dsu and Dse, respectively). Three parameters were calculated: concentration of soluble material in the supernatant (solubility), the swelling power and the volume fraction of the dispersed phase (Φ).

Solubility (%db) = 100 * Dsu /0.28
Swelling Power (g water/g Starch) = (Wse – Dse)/Dse
(Φ) = (27.91 – (Wsu – Dsu))/27.91

Results

Solubility in the small granule cassava mutation (SG) was considerably higher than in the normal and waxy cassava. Swelling index of waxy cassava increased rapidly with higher temperatures, compared with normal and SG cassava starch (Table 1). A similar trend was observed for volume fraction of the dispersed phase (Φ) (Table 2). SG has very low Φ and paste clarity values compared with normal and waxy cassava starches. These results highlight the differences in functional properties of the starches evaluated, therefore, increasing the competitiveness of cassava in the starch industry markets.

Table 1. Solubility and swelling index of different types of starch quantified at 60, 75 or 90°C.

Source of Starch	Solubility			Swelling Index		
	60 °C	75 °C	90 °C	60 °C	75 °C	90 °C
N Potato	2.5 (±0.66)	5.2 (±0.24)	6.0 (±0.21)	13.8 (±0.06)	35.8 (±1.72)	51.6 (±2.92)
W Potato	0.4 (±0.15)	1.9 (±0.06)		11.4 (±0.67)	86.6 (±3.67)	
N Cassava-1	2.3 (±0.12)	5.3 (±0.17)	7.6 (±0.07)	18.2 (±1.15)	37.2 (±2.87)	37.0 (±0.54)
N Cassava-2	2.4 (±0.09)	5.0 (±0.02)	6.9 (±0.08)	18.4 (±1.99)	30.2 (±0.41)	44.8 (±0.21)
N Cassava-3	2.8 (±0.20)	5.1 (±0.05)	7.2 (±0.16)	12.0 (±1.32)	30.2 (±0.05)	44.2 (±0.14)
W Cassava	0.6 (±0.07)	5.2 (±1.00)	8.7 (±0.35)	4.5 (±0.67)	48.2 (±1.59)	54.7 (±1.63)
SG -1	11.5 (±0.23)	17.8 (±0.20)	24.2 (±0.40)	10.3 (±0.64)	24.0 (±1.47)	34.0 (±1.48)
SG -2	11.5	16.2	23.9	11.6	22.0	32.7

N = normal; W= waxy; SG= small granule cassava mutations

Table 2. Amylose content (colorimetric quantification), paste clarity and volume fraction of the dispersed phase (Φ) quantified at 60, 75 or 90°C of different types of starch.

Source of Starch	Amylose content (%)	Paste Clarity (%)	(Φ) 60 °C	(Φ) 75 °C	(Φ) 90 °C
N Potato	27.7 (±0.5)	88 (±0.8)	0.16 (±0.02)	0.31 (±0.00)	0.47 (±0.01)
W Potato	7.7 (±0.8)	92 (±1.4)	0.14 (±0.04)	0.74 (±0.13)	1.00 (±0.00)
N Cassava-1	16.5 (±0.6)	47 (±0.8)	0.20 (±0.01)	0.33 (±0.01)	0.37 (±0.01)
N Cassava-2	19.5 (±0.6)	51 (±1.6)	0.20 (±0.01)	0.32 (±0.01)	0.43 (±0.00)
N Cassava-3	19.9 (±0.7)	51 (±0.5)	0.22 (±0.00)	0.32 (±0.00)	0.42 (±0.00)
W Cassava	0	61 (±0.7)	0.07 (±0.02)	0.46 (±0.02)	0.48 (±0.01)
SG -1	31.0 (±1.6)	17 (±0.5)	0.11 (±0.01)	0.15 (±0.00)	0.15 (±0.01)
SG -2	29.0 (±0.8)	17 (±0.5)	0.1	0.2	0.2

N = normal; W= waxy; SG= small granule cassava mutations

References

[1] Ceballos H, Sánchez T, Morante N, Fregene M, Dufour D, Smith AM, Denyer K, Pérez JC, Calle F, Mestres C. 2007. Discovery of an Amylose- free Starch mutant in cassava (*Manihot esculenta* Crantz). Journal of Agricultural and Food Chemistry 55(18): 7469-7476.

[2] Ceballos H, Sánchez T, Denyer K, Tofiño AP, Rosero EA, Dufour D, Smith A, Morante N, Pérez JC, Fahy B. 2008. Induction and identification of a small-granule, high-amylose mutant in cassava (*Manihot esculenta* Crantz). Journal of Agricultural and Food Chemistry 56(16): 7215-7222.

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
Consultative Group on International Agricultural Research