

COMPARATIVE STUDY OF MAIZE CULTIVARS 30 DAYS AFTER POLLINATION (30 DAP): CHARACTERIZATION OF STARCH

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SUMMARY

Characterization of starch was comparatively studied in five maize cultivars, i.e., Maya Normal, Nutrimaiz, two hybrids (L90 x L78, L90 x L41) and Supersweet (SRR "Duro"), 30 days after pollination (30 DAP). Amylose content was found to be higher in the Maya Normal starch (31.3^o/o) and lower (23 to 27^o/o) in the genetically-modified cultivars. The absolute density of the isolated starches did not show significant differences among cultivars. Solubility and swelling studies suggested the presence of more homogeneous forces maintaining the granular matrix on the starch from Maya Normal in relation to the other maize cultivars. The starch from the genetically-modified cultivars had a reduced solubility in dimethylsulfoxide and lower values for the gelatinization temperature range, in comparison to the Maya Normal. Information from the Brabender amylogram indicated greater resistance of the gelatinized maize starches to granule breakdown by mechanical stirring, in the new genotypes, resembling those starches modified by cross-linking.

INTRODUCTION

Due to its content of carbohydrates, mainly starch, and some other nutrients such as protein, oil and vitamins, maize is an important crop, both from the commercial and nutritional points of view. Maize is also of great importance in industry, as it appears in the market in the form of many industrialized products.

Brazil has reached the position of being the third world maize producer with a continuing increase in yield and planted area. The present

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cultivated area and production approach 12 billions hectares and 25 millions metric tons per year, respectively (1).

New maize cultivars have been developed at the Department of Genetics and Evolution of the State University of Campinas, Brazil, some of them exhibiting appreciable differences in composition (2, 3). Main changes have been observed in the carbohydrate fractions, particularly in the starch (4); however, no information is available as to the composition of said starch (amylose and amylopectin), as well as to possible changes in the technological and functional properties of starch in these genetically-modified cultivars. Changes in the lipid-soluble fraction for some of these cultivars (5) as well as for their proteins (6) have been published.

In the present paper, the starch chemical and functional properties of five maize cultivars, harvested 30 DAP, were comparatively studied.

MATERIAL AND METHODS

Cultivars — In the study herein described, the cultivars used were: Maya Normal, Nutrimaiz (suo2), L90 x L78 (suo2) and L90 x L41 (suo2), two híbrids obtained from isogenic lines selected from Nutrimaiz; and a Supersweet SRR “Duro” (Sh2). All of them were produced under identical conditions at the Genetics Department plot so as to avoid environmental influences as much as possible.

Isolation of starch — The ears were harvested 30 DAP, and after removing the husk were kept frozen (-20°C) for conservation purposes. Isolation of starch was done according to the procedure followed by Watson (7).

Chemical analysis of starch — Moisture, protein, ashes and lipid contents were determined following AACC methods 44-15, 46-11, 08-01 and 30-20, respectively (8). The fiber content was established by the acid detergent method of the AOAC (9). The amylose content was determined according to the iodine colorimetric technique of McCready and Hassid (10), using purified corn amylose as a reference standard.

Starch hydrolysis using 0.5N sulphuric acid solution and identification of the hydrolysis products by gas liquid chromatography were performed according to the procedure described by Reyes *et al.* (11).

Absolute density — Absolute density was investigated by the xylene displacement method of Schoch and Leach (12).

Gelatinization temperature range — The gelatinization temperature range of the starch slurries (0.2% o) was determined by microscopic observation under polarized light, according to MacMasters (13).

Swelling power and solubility — The method of Leach, McCowen and Schoch (14) was used to study the swelling and solubility of the starch samples.

Solubility in dimethylsulfoxide — A modification of the method of Leach and Schoch (15), introduced by Reyes *et al.* (11), was applied to determine the solubility of maize starches in DMSO.

Starch pasting properties — Pasting properties of maize starches were investigated utilizing the Brabender viscoamylograph. Concentration of the starch samples was 36.0 g of starch (dry basis) in 450 ml of distilled

water. Initial temperature of the starch slurry was 25°C, heated at 1.6°C/min in the amylograph bowl up to 95°C; it was kept at this temperature for 20 min, and then cooled to 35°C. The rotation value was maintained at 74.5 rpm.

RESULTS AND DISCUSSION

The chemical composition of the isolated starch from all five cultivars is shown in Table 1. Gas liquid chromatographic analysis of the trimethylsilyl derivatives of the maize starch hydrolysates revealed the presence of glucose only. No fiber was detected in any sample, and the protein, lipid and ash contents were very low. These results indicated starches with a high degree of purity. The amylose content of the genetically-modified cultivars was, in general, lower than that of Maya Normal, and the absolute density of the isolated starches did not show significant differences among cultivars.

The swelling and solubility properties of maize starches are illustrated in Figures 1 and 2. In general, the Nutrimaiz cultivars and the Hybrids L90 x L78 and L90 x L41 presented a similar swelling and solubility pattern. The Maya Normal cultivar had a starch with lower swelling and solubility at temperatures below 65°C, but presented a sharp increase in swelling and solubility with the increase of temperature. This suggests the presence of more homogenous forces maintaining the granular matrix on the starch from Maya Normal in relation to the other maize cultivars.

Solubilization rates of maize starches in DMSO are presented in Figure 3. Up to 25 hr of digestion, the starch from Maya Normal presented a higher rate of solubilization in DMSO, the Supersweet was intermediate, and Nutrimaiz, L90 x L78 and L90 x L41 were the lowest. The last three cultivars had a similar rate of solubilization in DMSO. These results may be attributed to a poor DMSO penetration in the starch of the genetically-modified cultivars in relation to the Maya Normal.

The values for the gelatinization temperature range of the starch from the different cultivars are presented in Table 1. As may be observed, in general, the starch from the modified cultivars had lower values than Maya Normal. Cultivars L90 x L78, L90 x L41 as well as the Supersweet, presented the lowest (66°C – 74°C) values, and Nutrimaiz, intermediate (72°C – 79°C) values for the gelatinization temperature range in relation to Maya Normal.

Pasting characteristics of maize starches are illustrated in Figure 4. All cultivars presented similar initial pasting temperature, with values ranging from 72°C for the cultivar Maya Normal to 76°C for the L90 x L78. Compared to the other cultivars, Maya Normal had a sharp increase in viscosity once the initial pasting temperature was reached, confirming the presence of homogeneous bonding forces that maintained the granular matrix on the starch of this cultivar. During

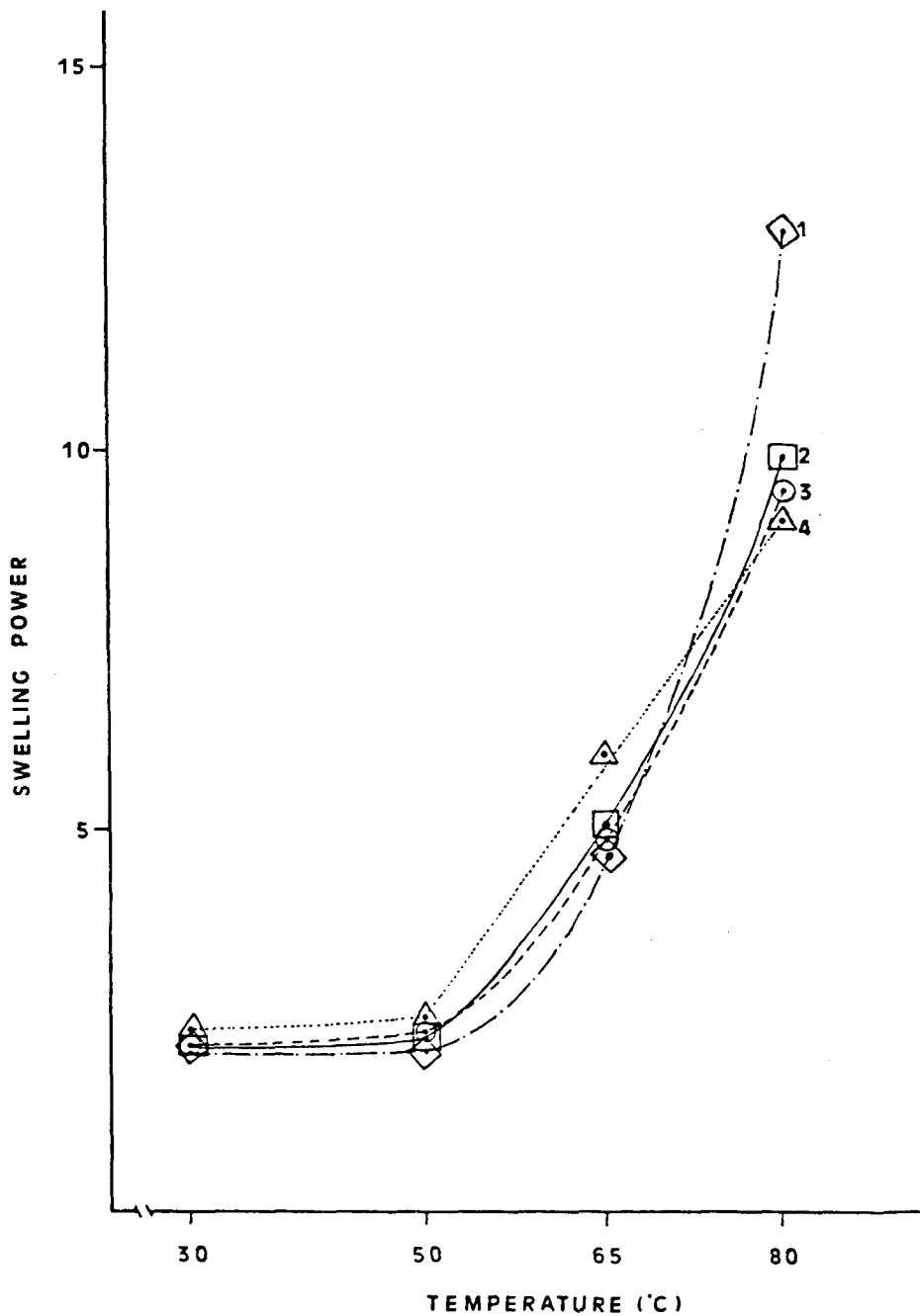


FIGURE 1

Swelling power, in water, of maize starches isolated from cultivars, with 30 days after pollination. 1 = Maya Normal. 2 = Hybrid L90 x L41. 3 = Hybrid L90 x L78, and 4 = Nutrimaiz

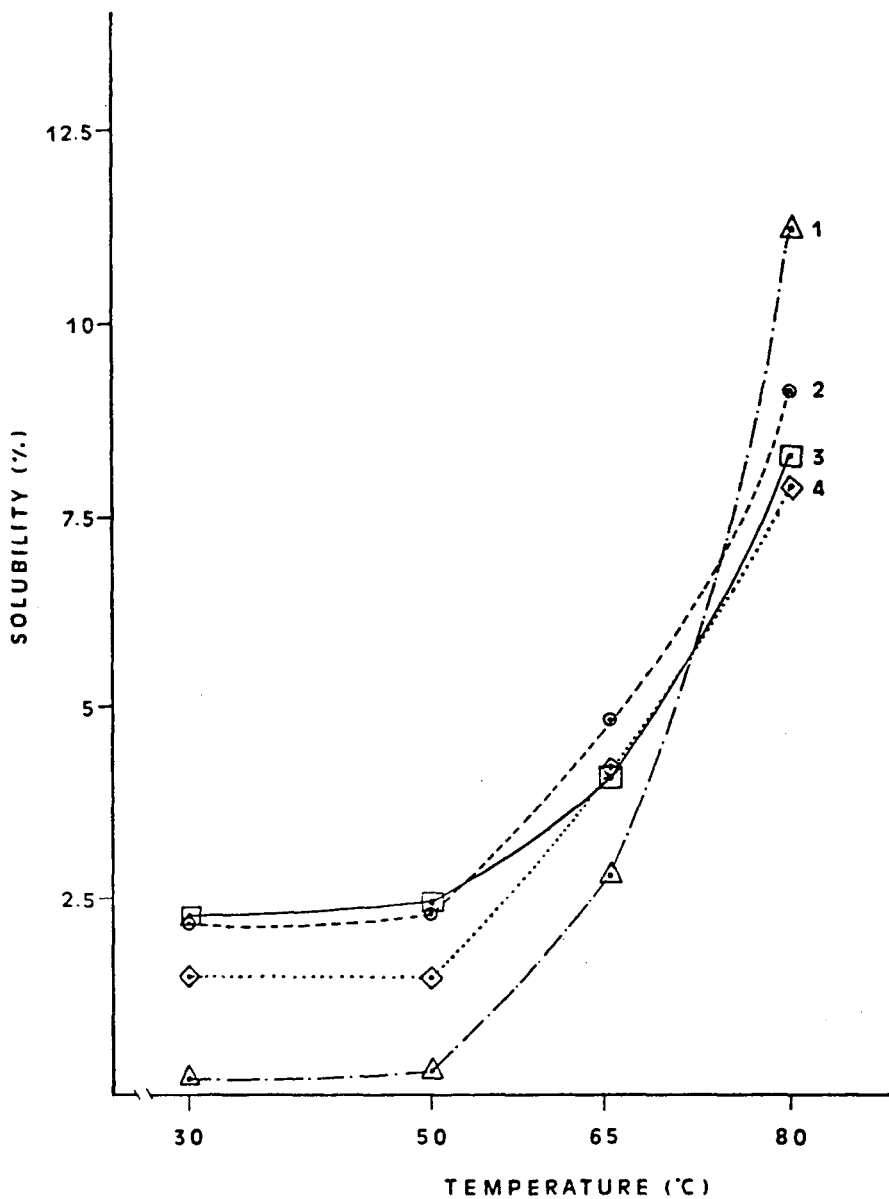


FIGURE 2

Solubility, in water, of maize starches isolated from cultivars, with 30 days after pollination. 1 = Maya Normal. 2 = Hybrid L90 x L41. 3 = Hybrid L90 x L78, and 4 = Nutrimaiz

the isothermal holding period at 95°C, all the starches had a constant viscosity, or even a small increase in viscosity, as shown by Supersweet, which is indicative of the high resistance of the gelatinized maize starches to granule breakdown by mechanical stirring in the Brabender amylograph bowl. The starch resistance of the genetically-modified maize harvested 30 DAP, to mechanical shear upon gelatinization, resembles those starches modified by cross-linking.

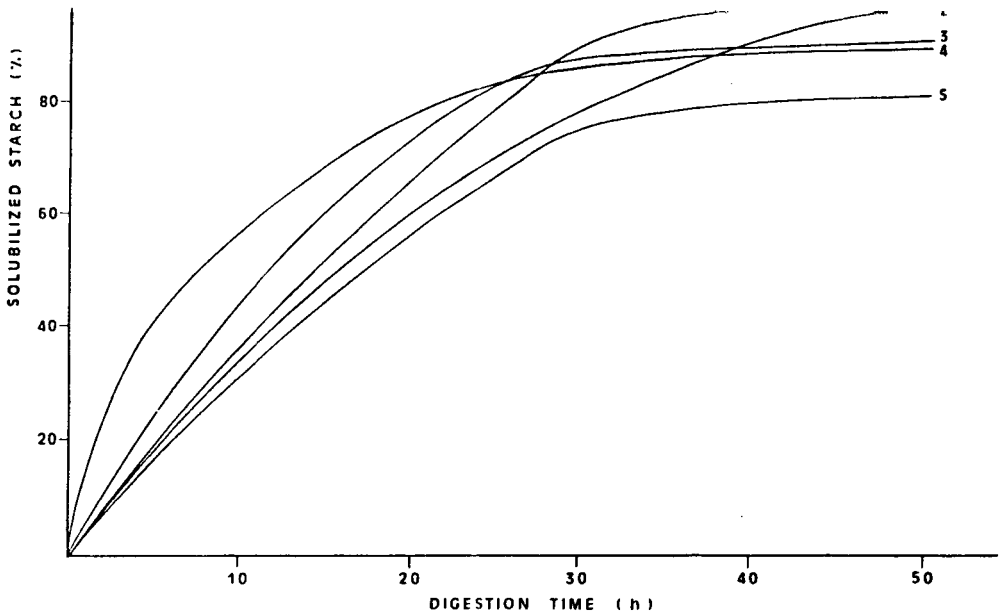


FIGURE 3

Solubility in dimethylsulfoxide of maize starches isolated from cultivars with 30 days after pollination. 1 = Nutrimaiz. 2 = Hybrid L90 x L48. 3 = Supersweet, SSR "Duro" (sh2). 4 = Maya Normal, and 5 = Hybrid L90 x L41

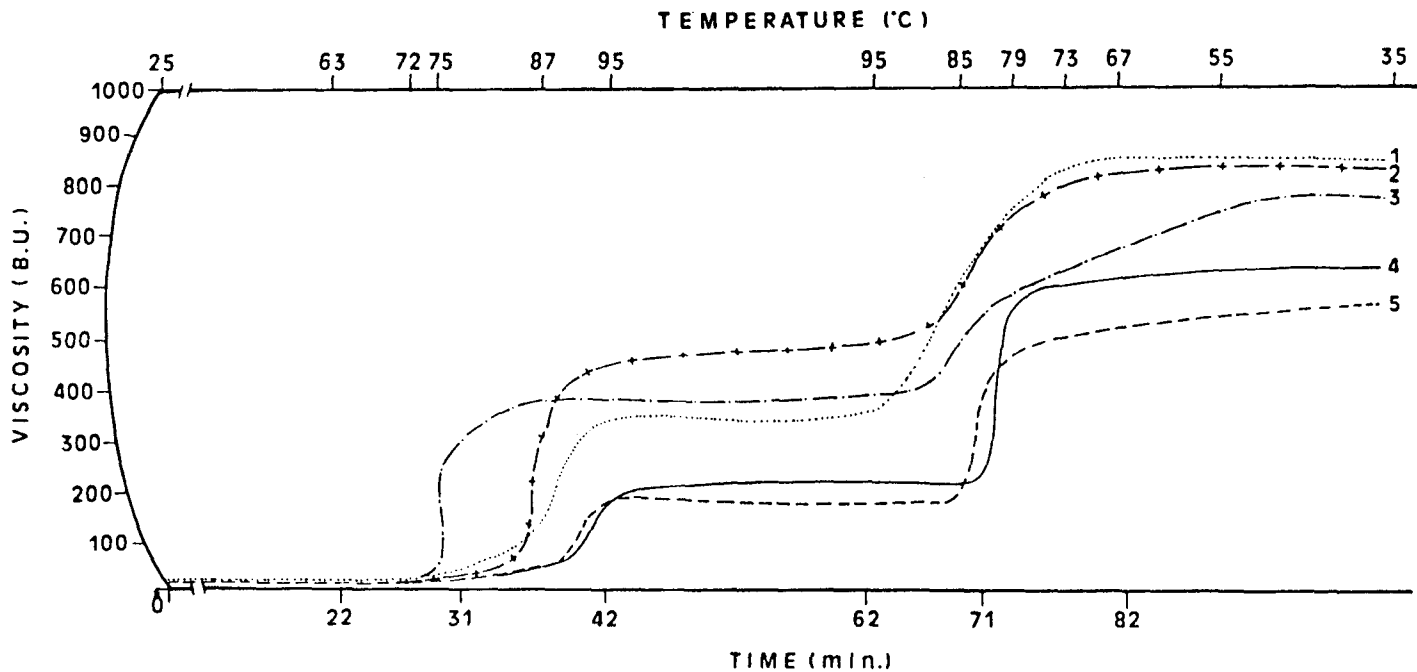


FIGURE 4

Brabender amylogram of maize starches, at 8% (W/V), isolated from cultivars with 30 days after pollination.
 1 = Nutrimaiz. 2 = Supersweet, SRR "Duro" (sh2). 3 = Maya Normal. 4 = Hybrid L90 x L41, and 5 = Hybrid L90 x L78

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RESUMEN

ESTUDIO COMPARATIVO DE CULTIVARES DE MAIZ 30 DIAS DESPUES DE LA POLINIZACION (30 DAP): CARACTERIZACION DEL ALMIDON

La caracterización del almidón fue estudiada comparativamente en cinco cultivares de maíz, a saber: Maya Normal, Nutrimaíz, dos híbridos (L90 x L78, L90 x L41) y Superdulce (SRR "Duro"), 30 días después de la polinización (30 DAP). Se encontró que el contenido de amilosa era más elevado en el almidón del Maya Normal (31.30/o) y más bajo (23 a 27/o) en los cultivares genéticamente modificados. La densidad absoluta de los almidones no difirió significativamente entre todos los cultivares. Los estudios de solubilidad y de capacidad de hinchamiento sugirieron la existencia de fuerzas más homogéneas en la manutención de la matriz granular del almidón del Maya Normal, en comparación con los otros cultivares. Con relación al Maya Normal, el almidón de los cultivares genéticamente modificados acusó menor solubilidad en dimetilsulfóxido y temperaturas de gelatinización más bajas. Los amilogramas de los almidones de los cultivares genéticamente modificados, indicaron mayor resistencia de los almidones gelatinizados de maíz a la ruptura de los gránulos por agitación mecánica, a semejanza de los almidones químicamente modificados por enlaces cruzados.

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