

MODIFYING NATIVE STARCH OF *XANTHOSOMA VIOLACEUM* BY CROSS-LINKING

F. Pereira and G. Nieto

Abstract

In a previous work, the native starch of the tannia *Xanthosoma violaceum* Schott was characterized, acetylated, hydrolysed, and oxidized. In this study, we modified it by cross-linking, performing a 2³ factorial experiment; the factors were two levels of reaction time, according to pH and PCIO₃ concentration. The response in viscosity was measured at a pH of 6 and of 3 to show the strength of the starch granule. Viscosity of the cross-linked starches showed the reinforcement effect of the cross-linking method in the starch granule. Basically, all samples showed higher viscosity than did the native starch, demonstrating that a chemical change occurred in the native starch. Differences in viscosity could not, however, be demonstrated statistically, probably because of the narrowness of the levels chosen for the independent variables.

Introduction

The main starch used by the Mexican food industry is that of maize but, because national production is insufficient to meet demand, this commodity is imported. However, Mexico could exploit other sources of starch, such the tannia *Xanthosoma violaceum* Schott. Studies involving starch extraction, acetylation, acid hydrolysis, and oxidation of this type of starch have been carried out at the Universidad Autónoma de Yucatán. In this study, we tested modification by cross-linking.

Materials and Methods

Sample. *Xanthosoma violaceum* tubercles—harvested in Yucatán and known locally as *malanga*—were sampled at random, and native starch obtained.

Chemical analyses. Characterization of the modified starch was carried out according to the methods of AOAC (1975), Gilbert and Spragg (1964), McMasters (1964), Radley (1976), Schoch (1964), Smith (1964), and Watson (1964).

Experimental design. For the cross-linking method, a 2³ factorial experiment was performed (Table 1). Two levels of reaction time were used, according to pH and PCIO₃ concentration. The response in viscosity was measured at a pH of 6 and of 3 to show reinforcement of the granules. Results were processed by a computational program (FACT2A3), according to López (1988).

Methodology. The methodology for modifying by cross-linking was based on the method described by E. Cañizares (1991, personal communication). Native *malanga* starch (30 g, dry basis) was weighed in 70 mL distilled water at 30 °C in a 200-mL beaker. The slurry was then placed under constant mechanical agitation, using a magnetic stirrer. The pH values selected in the experimental design were adjusted by adding 3% (w/v) sodium hydroxide solution; then the PCIO₃ was added. At the end of the reaction time (30 min), the pH was adjusted to 5.0-5.5 with 2N HCl. The slurry was filtered through a Buchner funnel holding Whatman No. 4 filter paper; the filter cake was washed with distilled water and oven dried (Felisa, model 291) for 6 h at 60 °C. The cross-linked starch was kept in a plastic bag in a desiccator for subsequent analyses.

Results and Discussion

Viscosities measured at pH 6. The viscosity of the cross-linked starches (measured at a pH of 6) showed the strength effect of the cross-linking method in the starch granule (Table 2). Basically, all samples showed higher viscosity than the native starch, demonstrating that a chemical change occurred in the native starch granule. Statistical analyses showed that none of the independent variables was significant. Differences in viscosity could not be demonstrated statistically, probably because of the narrowness of the levels chosen for the independent variables.

Viscosities measured at pH 3. Solubility and swelling power did not reflect the effect of the cross-linking modification. The gelatinization temperature was slightly lower than that of the native starch in almost all samples.

This type of modification has been carried out successfully with maize starch (E. Cañizares, 1991, personal communication); but, with the *malanga* starch, the effect of cross-linking was not demonstrated under the conditions studied. Normally, cross-linking reactions are run under neutral to fairly alkaline conditions, but to produce cross-linked starches with PClO_3 , alkaline conditions are recommended (Wurzburg 1986). The best response in viscosity was obtained with treatment 4 (Table 2), where pH 7 was used (Table 1). As can be seen in Table 2, treatment 4 gave higher viscosity than treatment 2, in which the only difference was reaction time. A wide range of cross-linked starches has been produced, depending on the level of treatment and conditions (Wurzburg 1986); therefore reaction time should probably be modified for this type of starch. However, at pH 8, this behaviour was not observed.

Wurzburg (1986) reported that, in addition to reacting with starch hydroxyls, a portion of the cross-linked reagent could be hydrolysed by water to form phosphoric acid or its salts. These would be present at very low concentrations because the level of reagents used in the cross-linking experiment is generally very low. The amount of starch and, therefore, the quantity of reagent were probably inadequate to promote the cross-linking reaction; time may also be important at certain pH levels.

Under the conditions studied, the degree of modification was apparently not enough to change significantly the physico-chemical properties of native *malanga* starch.

Conclusions

Although some changes occurred in the viscosity values of the cross-linked starches, no significant differences among treatments existed, probably because of the narrowness of levels chosen for the independent variables. More studies on this type of modification are recommended.

Acknowledgements

The financial support of the International Foundation for Science (IFS), Sweden, is gratefully acknowledged.

References

AOAC (Association of Official Analytical Chemists, Inc.). 1975. Official methods of analysis. 12th ed.

Proceedings of the Tenth Symposium of the International Society for Tropical Root Crops,
held in Salvador, Bahia, Brazil, October 23-29, 1994

Washington, DC.

- Gilbert GA; Spragg SP. 1964. Iodimetric determination of amylose; iodine sorption: "Blue Value". In: Whistler RL; Smith RJ; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- López PR. 1988. *Diseño estadístico de experimentos*. Científico-Técnica, Cuba.
- McMasters MM. 1964. Microscopic techniques for determining starch granule properties. In: Whistler RL; Smith RJ; BeMiller JN; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- Radley JA. 1976. Physical methods of characterising starch. In: *Examination and analysis of starch*. Applied Science Publications.
- Schoch TJ. 1964. Swelling power and solubility of granular starches. In: Whistler RL; Smith RJ; BeMiller JN; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- Smith RJ. 1964. Viscosity of starch pastes. In: Whistler RL; Smith RJ; BeMiller JN; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- Watson. 1964. In: Whistler RL; Smith RJ; BeMiller JN; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- Whistler RL; Smith RJ; BeMiller JN; Wolfrom ML, eds. *Methods in carbohydrate chemistry*, vol. IV. Starch. Academic Press.
- Wurzburg OB. 1986. Cross-linked starches. In: *Modified starches: properties and uses*. CRC Press.

Table 1. Experimental design used to modify, by cross-linking,
native starch extracted from tannia (*Xanthosoma violaceum*).

Treatment	PClO ₃ (%)	Time (min)	pH
1	0.05	30	7
1a	0.05	30	7
1b	0.05	30	7
2	0.10	30	7
3	0.05	60	7
4	0.10	60	7
5	0.05	30	8
6	0.10	30	8
7	0.05	60	8
8	0.10	60	8
8a	0.10	60	8
8b	0.10	60	8

Table 2. Physico-chemical characteristics of cross-linked starches extracted from tannia (*Xanthosoma violaceum*).

Treat.	Moisture	Alkaline fluidity ^a	Visc. at pH 6 ^b	Visc. at pH 3 ^c	Solubility ^d (%)	Swelling power
1	7.60	57.5	113	86.8	6.35	9.3
1a	8.73	57.0	123	88.4	4.72	7.8
1b	7.83	56.5	115	97.6	5.38	9.5
2	7.32	56.5	115	103.0	6.40	10.3
3	10.36	58.5	121	85.6	5.86	8.6
4	11.17	57.0	126	112.0	7.70	9.4
5	10.27	57.5	118	97.2	4.92	9.7
6	8.26	59.0	120	98.4	6.18	9.5
7	8.75	57.0	117	88.0	5.48	9.1
8	7.89	55.0	117	98.4	5.62	7.7
8a	10.10	55.5	117	89.2	4.10	6.6
8b	8.52	54.5	114	88.2	4.84	7.6
Native starch	9.40	61.0	105	86.1	4.14	9.0

a. Amount (mL) of alkaline starch suspension (2% w/v) that flows in 70 s.

b. Brookfield, spindle #2; starch suspension (2.5% w/v).

c. Brookfield, spindle #2; acid starch suspension (in acetic acid).

d. Measured at 75 °C.