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COMPARISON OF *AMARANTHUS CRUENTUS* AND *ZEA MAYS, L.* STACH CHARACTERISTICS

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Starch is a very important, naturally renewable and relatively inexpensive raw material. Since the current industrial production establishes demands pertaining starch quality, a greater attention has been paid to development and improvement of existing technological procedures for starch isolated from different botanical sources.

This paper describes the procedure for amaranth starch isolation. Starch was isolated from *Amaranthus cruentus* seeds by low alkaline steeping and protease treatments. The properties of isolated amaranth starch were analyzed and compared with those of normal and waxy maize starches.

Key words: Amaranth seeds, starch, alcaline isolation, protease, properties

INTRODUCTION

Amaranth is one of America's most ancient crops with some outstanding agronomic traits. For several reasons it became almost forgotten for many years (PEREZ *et al.*, 1993). In the United States, the role of amaranth as an underexploited

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plant with promising economic values has been recognized recently by the National Academy of Science. Today amaranth is considered as an alternative crop and researchers in many parts of the world have focused on improving agronomic features of the plant, the nutritional quality, and processing technology of the seed. Several papers covering the field of amatanth research has been published in our country (BODROŽA-SOLAROV and LAZIĆ, 1994; VUKOBRATOVIĆ *et al.*, 1996; ŠUMARINA *et al.*, 2000; RADOSAVLJEVIĆ, 2001; VUJAČIĆ 2005). The seed of *Amaranthus species* has a good raw material potential for breakfast foods, cereals, extruded and expanded products, bread and bakery goods because of its nutritional, processing and storing characteristics (BODROŽA-SOLAROV, *et al.*, 2000). For example, flour made of Amaranthus seed can be used for bakery goods production in the quantity of 5% to 15% in the mixture with wheat flour, and the product is of higher nutritive value (ŠARIĆ, 2000).

The major grain-producing species are *Amaranthus cruentus*, *Amaranthus hypochondricus* and *Amaranthus caudates*. All three of these species can be used as multi-purpose plants. Starch is the most abundant chemical component in amaranth seeds. Its content is reported to range from 48 to 69%, depending on the species. It also contains 12-18% protein that is reach in the amino acid lysine normally limiting in most cereal grains and 5-8% fat. Amaranth starch can be isolated by many different methods in the laboratory scale. Most of the methods use alkali steeping to remove the protein (YANEZ *et al.*, 1986, MYERS and FOX, 1994). High concentration of alkali damages starch quality, increases the production costs, and results in environmental pollution. Despite the substantial commercial interest in this starch, there is no effective method to isolate the starch from amaranth seeds because of its small granules and relatively high protein content. Therefore, there was a need to develop the methods that could improve processing and qualities of amaranth starch.

The objective of this paper is to present the importance of Amaranth seeds as raw material for high quality starch production.

ISOLATION OF AMARANTH STARCH

Whole *Amaranth cruentus* grain used for starch isolation contained 60 % starch and 15.9 % protein. Starch was isolated by low alkaline steeping combined with protease treatment. Amaranth seeds (100 g) of were steeped in 1 L of a 0.05% NaOH solution (pH 12.1) for 22 hr under propeller stirring. After steeping the steep solution was decanted and the seeds were washed with distilled water. Then the sample was blended for 6 min in the Osterizer blender at full speed. Different doses of the enzyme (Protease Type XIX: Fungal from *Aspergillus sojae*, 0.35 units/mg solid) were added to the ground slurry (pH 7.5). The slurry was mixed in the blender for 1 min at full speed and then incubated in a shaker water bath at 37°C and 50 rpm for 2 hr. After incubation, the slurry was filtered through a nylon screen (30mm) with additional distilled water for washing the fiber fraction. The fiber fraction was ground in the Osterizer blender at full speed for 3 min.

The starch was isolated by centrifuging at 6000 x *g* for 20 min (350 units-dose of protease). For a dosage of 175 units of protease, the starch-protein fraction was centrifuged at 700 x g for 20 min. The supernatant was discarded, and the top yellowish layer of protein was removed with a laboratory spatula. The starch layer was washed with distilled water two times and was then dried in a convection oven at 40°C for 48 hr.

Performance of each amaranth starch isolation method was evaluated on the basis of recovery (ratio of extracted starch to total starch in the grain), yield (ratio of extracted starch to amount of grain), and purity of starch. High starch recovery, high starch yield, and low protein content in starch are indicators of good wet milling.

Table 1. shows results obtained by a method using less NaOH (0.05% solution) for processing and in which the ground slurry was subjected to a protease treatment, RADOSAVLJEVIĆ *et al.*, 1998.

Table 1. - Comparison of Protein and Recovery of Amaranth Starch Isolated by Using 0.05 % NaOH and Different Dose of Protease for Steeping Amaranth Seeds

Protease (Units)	Protein Content (%)	Starch Recovery (%)	Starch Yield (%)
175	0.18±0.05	79.8±0.2	48.0±0.1
350	0.10±0.00	83.5±0.3	50.3±0.2

The yield of starch with this alkaline/protease method was better than those with alkali alone. Protein content of the isolated amaranth starch was very low (0.2%) pointing out to high purity of obtained starches. During the protease treatment the enzyme hydrolyzes the protein matrix surrounding the starch granules and facilitates the separation of starch by washing with water. The starch yields, starch recoveries, and starch purity were also good with low concentration protease (175 units) treatments.

CHARACTERIZATION OF AMARANTH STARCH

The amaranth starch granule size was about 1mm and had a polygonal shape similar to that of other amaranth cultivars. Amylose content determined by iodine potentiometric titration and gel permeation chromatography (GPS). GPC profiles of amaranth starch isolated by low alkaline/protease treatment is shown in Figures 1.

The chromatogram showed no amylose in the starch, indicating a waxy variety. Amaranth starch amylose contents determined by this two methods are in reasonably good agreement. This is consistent with published results that native *Amaranthus cruentus* starch contains up to 10 % amylose (PEREZ *et al.*, 1993).

Pasting properties of amaranth starches isolated by low alkaline/protease wet milling were determined by using a Brabender Viscoamylograph and compared with those of normal and waxy maize starches (Table 2).

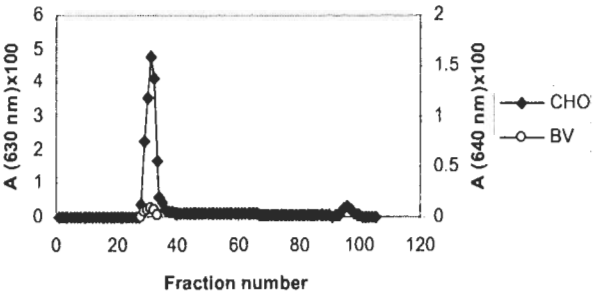

Fig. 1. - Gel permeation profile of amaranth starch

Table 2. - Pasting Properties of Starches

Starch	Pasting temperature (°C)	Peak temperature (°C)	Peak viscosity (BU)	Set-back viscosity (BU)
Amaranth starch	68.5±0.1	77.2±0.0	630±50	450±0
Normal maize starch	80.6±0.4	93.0±0.0	549±9	750±20
Waxy maize starch	67.6±04	74.2±03	1090±10	355±5

Pasting and peak temperatures of isolated amaranth starches is lower than that of normal maize starch, but higher than that of waxy maize starches.The data in Table 2. also show that the peak visvosity of amaranth starch is higher than that of normal maize starch and lower than that of wasy maize starch. Set-back viscosities of the starches is almost the same and similar with that of waxy maize starch.

Thermal properties of amaranth starch were determined by using a differential scanning calorimeter (DSC) and compared with those of normal and waxy maize starches. The ressults are shown in Table 3.

All the DSC thermal properties of amaranth starches isolated by low alkaline/protease treatment were very similar to those of normal and waxy maize starch.

Table 3. Thermal Properties of Starches[a]

Sample	T_o (°C)	T_p (°C)	T_c (°C)	ΔH (j/g)[b]
	Gelatinization			
Amaranth starch	65.5±0.9	69.2±0.9	77.7±1.1	14.4±0.7
Normal maize starch	64.7±0.4	70.8±0.4	78.6±0.2	12.4±0.2
Waxy maize starch	64.0±0.3	69.0±0.4	76.7±0.9	15.0±0.4
	Retrogradation [c]			
Amaranth starch	45.2±1.7	52.8±1.1	60.0±0.8	5.1±1.0
Normal maize starch	43.3±0.2	51.8±0.0	61.7±0.3	7.6±0.1
Waxy maize starch	45.0±1.2	53.7±0.3	62.5±0.5	9.8±0.2

[a] Starch samples (~2 mg, dry-starch basis) and distilled water (~6 mg) were used for analysis, Values are means±standard deviations,
T_o, T_p, and T_c = onset, peak, and complete temperature, respectively
[b] Δ H enthalpy change
[c] After storage at 4°C for 28 days.

CONCLUSION

The described procedure of the alkali extraction of starch is a significant contribution to the improvement of the existing technology for starch production and can be used for different plant raw materials as the alternative to a conventional procedure. These studies show that it is possible to isolate starch with a low percentage of proteins (0.2%) from *Amaranthus* seeds by the alkali extraction method. The efficiency of the procedure, i.e. starch recovery is 80%.

The analysis of produced starch shows that its granule sizes range from 1 to 2 microns, as well as, that they are composed only of amylopectin molecules (97.9%). Very small granules provide exceptionally beneficial properties of this biopolymer for the application in food and paper industry.

REFERENCES

BODROŽA-SOLAROV M., O. ŠUMARINA, S. BOJAT, R. VUKOBRATOVIĆ (2000): Amaranthus sp. Seed in Food Industry, International Congress, XIV Cereal Bread, Novi Sad, June 2000, Proceedings, 242-244.

BODROŽA-SOLAROV, M. AND B. LAZIĆ (1994): Prilog proučavanja *Amaranthus*-a sp. kao povrtarske kulture. Savrem. poljopr. 42 (vanredni broj):132-136.

MYERS, D. J., and S. R. FOX (1994): Alkali wet-milling characteristics of pearled and unpearled amaranth seed. Cereal Chem. 71:96.

PEREZ, E., Y. A. BAHNASSEY, and W. M. BREENE (1993): A simple laboratory scale method for isolation of amaranth starch. Starch/Stärke 45:211.

RADOSAVLJEVIĆ M. (2001): Unapređenje tehnološkog postupka za dobijanje skroba, PTEP-Časopis za procesnu tehniku i energetiku u poljoprivredi, 5,3:70-74.

RADOSAVLJEVIĆ M., J. JANE, L. A. JOHNSON (1998): Isolation of Amaranth Starch by Diluted Alkaline-Protease Treatment, Cereal Chem., 75(2): 212-216, 1998.

ŠARIĆ M. (2000): Vrednovanje kvaliteta žita i proizvoda od žita prema nameni u poređenju sa međunarodnim modelom kvaliteta po ISO standardima, Tehnološki fakultet; Novi Sad.

ŠUMARINA O., VUKOBRATOVIĆ R., BOJAT S., BODROŽA-SOLAROV M (2000): Amaranthus sp. Seed in the Production of Special Kinds of Bakery Goods, International Congress, XIV Cereal Bread, Novi Sad, June 2000, Proceedings, 182-184.

VUJAČIĆ V. (2005/2): Hijerarhijska klaster analiza introdukovanih vrsta iz roda Amaranthus, Arh. Poljopr. Nauke, 66, 234:53-59.

VUKOBRATOVIĆ R.,O. GAJIĆ, M. BODROŽA-SOLAROV, M. NIKOLIĆ (1996): Amaranthus Seed in Bakery Production, IX Jugoslovenski kongres o hrani, Kotor.

YANEZ, G. A., J. K. MESSINGER, C. E. WALKER, and J. H. RUPNOW (1986): *Amaranthus hypochondriacus*: Starch isolation and partial characterization. Cereal Chem. 63:273.

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UPOREDNO ISPITIVANJE SKROBA I IZOLOVANJE IZ *AMARANTHUS CRUENTUS* I KUKURUZA (*ZEA MAYS L.*)

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I z v o d

Skrob je veoma važan prirodno obnovljiv i relativno jevtin sirovinski materijal. Pošto moderna industrija postavlja određene zahteve u pogledu njegovog kvaliteta, razvoju novih i unapređenju postojećih tehnoloških postupaka za dobijanje skroba različitog botaničkog porekla pridaje se sve veći značaj.

U ovom radu opisan je postupk za dobijanje skroba alkalnom ekstrakcijom. Skrob je izolovan iz semena vrste *Amaranthus cruentus* primenom alkalnog močenja i enzimskog tretmana. Osobine izolovanog skroba ispitivane su različitim metodama i poređene sa osobinama normalnog i voštanog kukuruznog skroba.

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