New Starches. VIII. Properties of the Small Granule-Starch from Colocasia esculenta[1]

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ABSTRACT

Examination of a number of dasheens has established the fact that there are two distinctly different size ranges of granules in different varieties. In general they have approximately one-half the amylose content of common cereal starches. Since the dasheen starches have a pasting temperature approximately 20° higher than the other small granule starches examined, small granule size cannot be the reason for the low pasting temperature of cow cockle, catchfly, and pigweed starch granules. In general, the dasheens show good granule stability and low setback. They are similar to other tuber starches in forming clear, stringy pastes somewhat resistant to enzyme action, but differ from them in solubility, swelling power, pasting temperature, and granule stability.

Our investigation of the small granule starch from *Saponaria vaccaria* (1), *Silene conoidea* (2), and *Amaranthus retroflexus* (3) has shown that all these small granule starches had a similar set of properties, namely, extreme granule stability, low pasting temperature, and lack of retrogradation on cooling, although they have a normal amylose content.

Since *Colocasia esculenta* (dasheen) was reported (4) to have 1 μ starch granules, it appeared desirable to examine the starch from a few varieties to compare small-granule tuber starch with the cereal types previously examined.

MATERIALS AND METHODS

Preparation of Starch

All the tubers used for a source except No. 12, which came from the University of Florida, were obtained from the Experiment Station at the University of Hawaii, and all were harvested from the same area at the same time.

The tubers were peeled, diced, and steeped in 0.2% metabisulfite for 24 hr. The steep water was decanted and the pieces were washed several times in warm water to remove the mucilaginous material. The pieces were then ground in a Waring Blendor and screened on a 48-mesh sieve. The residue was mixed with additional water and returned to the Blendor and screened a second time. The material passing through the 48-mesh sieve was screened on a 115- and finally a 400-mesh sieve. The starch was removed in a solid-bowl centrifuge, the dark layer at the top of the bowl removed with a spatula, and the starch resuspended in cold water and centrifuged a second time. The starch was dried in a warm air stream at 37°C.

The corn starch used for a control was supplied by CPC International through the courtesy of J. Keng.

The cow-cockle and pigweed starches were prepared by the procedures described previously (1,3).

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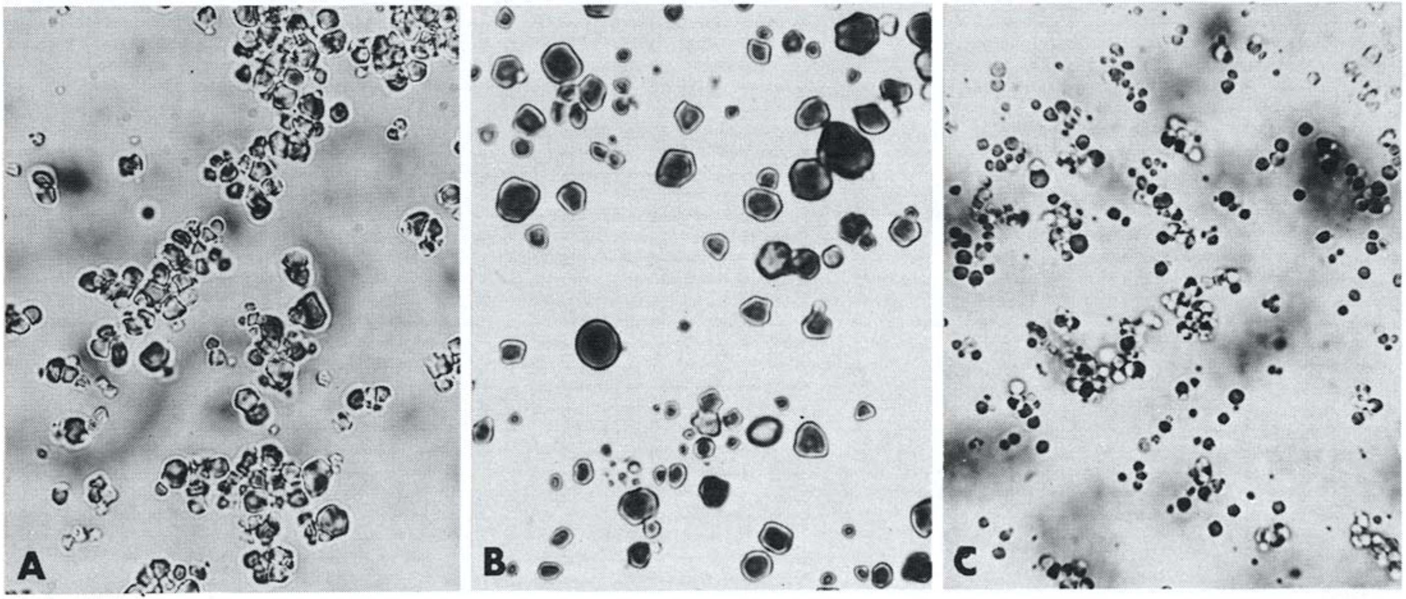

Fig. 1. Photomicrographs of *Colocasia esculenta* compared to cow cockle: A, Uramata; B, Globulitera; C, cow cockle—all at the same magnification.

Determinations

The protein content was determined by a modified Kjeldahl method (5, p. 16) (conversion factor 6.25). The samples were ashed according to the usual procedure (5, p. 123). The total free fat was determined by ether extraction (5, p. 128).

Iodine affinity was determined by the procedure of Lansky et al. (6), using methanol for fat extraction; and by the technique of Banks et al. (7), using dimethyl sulfoxide (DMSO).

Brabender pasting-temperature range was determined by amylograms in the presence of CMC as described by Crossland and Favor (8) and modified by Sandstedt and Abbott (9).

Brabender viscosity curves were determined by the procedure of Mazurs et al. (10) except that maximum temperature was 92.5°C., as dictated by the altitude of our laboratory.

The effect of α-amylase on viscosity was determined by the procedure of Goering and Brelsford (1).

Solubility and swelling power were determined by the method of Leach et al. (11).

RESULTS AND DISCUSSION

Starch Granules

Photomicrographs of the starch granules obtained from two different varieties of *Colocasia esculenta* are compared to *Saponaria vaccaria* in Fig. 1.

The size of granules and a description of sample numbers are given in Table I.

It is interesting to note that all five Yen varieties, Uramata, and Iliuaua consist of small-granule starch with a general size range of 1.5 to 4.0 μ, which is substantially larger than the starch granules of *Saponaria vaccaria* (cow cockle). However, they still are significantly smaller than rice starch and therefore they can be classed as small-granule starches.

On the other hand, Poitere, Bun long, and Miyako appear to be similar and much larger than the first group, with a general size range of 2.0 to 6.6 μ. Since these samples were all grown at the Experiment Station at the University of Hawaii and harvested at the same time, environment cannot be a factor.

TABLE I. SIZE OF GRANULES FROM COLOCASIA ESCULENTA

Sample No.	Variety	Size, μ		
		Smallest	General range	Largest
1	Uramata	0.5	1.5–4.0	6.5
2	Yen No. 608	0.75	2.0–4.0	5.5
3	Yen No. 606	1.0	1.5–2.5	4.0
4	Yen No. 830	0.6	1.5–3.0	3.0
5	Miyako	1.5	2.5–6.5	7.5
6	Bun long	1.0	3.0–6.6	7.5
7	Yen No. 610	...	...	...
8	Yen No. 612	1.0	1.5–3.5	4.0
9	Poitere	1.5	2.0–5.0	6.0
10	Iliuaua	0.75	1.5–3.0	3.5
12	Globulitera	1.0	2.0–5.5	7.5
Cow cockle	...	0.5	0.75–2.0	2.5

TABLE II. CHEMICAL COMPOSITION

Dasheen	No. 1	No. 10	No. 12	CC[a]
% Protein	0.33	0.33	0.65	0.38
% Fat	0.25	0.42	0.37	0.20
% Ash	0.39	0.48	0.20	0.30
% Iodine affinity (1)[b]	2.5	2.2	2.5	3.7
(2)[c]	2.7	2.3	3.7	3.8

[a] CC = cow cockle.

[b] Procedure using 85% methanol for fat extraction.

[c] Using Banks' DMSO procedure (7).

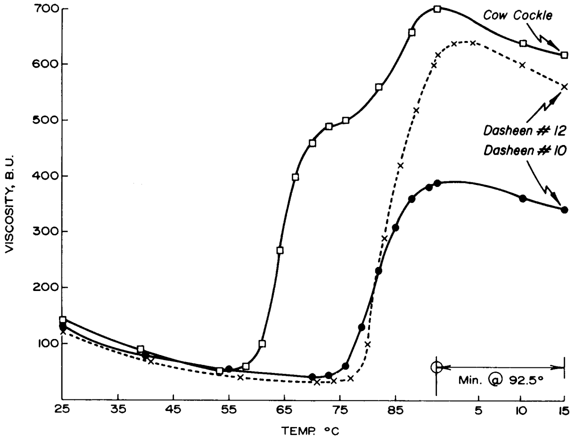

Fig. 2. Pasting of starch from two varieties of dasheen; comparison of curves with that from cow-cockle starch; 5.5% starch + 0.9% CMC.

Dasheen No. 12, Globulitera, was obtained from the University of Florida and appears to resemble the group with larger granules.

Adequate amounts of tubers were available for Uramata, Iliuaua, and Globulitera. The others did not furnish sufficient starch to run all the tests. By mixing all the Yen samples together we have made some physical measurements which must be considered as an average property of these selections.

Chemical Composition

The chemical composition of the starches is given in Table II.

It is apparent that most of the dasheen starches have approximately 50% of the amylose content observed in cereal-grain starches, and in this respect differ from cow-cockle and the other small-granule starches we have investigated. The reason for the high value obtained on dasheen No. 12 by the DMSO procedure is interesting and suggests that perhaps it contains lipid material not removed by the methanol extraction.

Pasting Characteristics

The pasting characteristics of dasheen starches are shown in Fig. 2.

Due to the limited amount of starch available, only two varieties were examined. It is interesting to observe that both have a pasting temperature approximately 20° higher than cow-cockle. The low amylose content and the fact that these were tuber starches made these results completely unexpected. Present concepts, namely that tuber starches have low pasting temperatures because they are formed under conditions of high moisture content and that the pasting temperatures increase with increasing amylose content due to additional hydrogen bonding, would have indicated lower pasting temperatures for the dasheens. It is apparent that small granule size was not responsible for the low pasting temperature we have observed in our previous work on small-granule cereal-type starches.

Paste Viscosity

Paste-viscosity curves are shown in Fig. 3.

These curves again confirm the higher pasting temperature of the dasheen starches as compared to small-granule pigweed starch. Dasheens 1, 10, and the combined 2, 3, and 4 all have similar cooking curves showing a slight pasting peak, extreme granule stability, and a low setback. Dasheen No. 12 has a higher viscosity and less granule stability than the other selections. This might be due in part to its somewhat larger granules, or more likely to the difference in amylose. Perhaps the amylose is larger, more like that in potatoes.

The high paste viscosity of No. 12 does not correlate with its swelling power. When this discrepancy was observed, both swelling power and Brabender viscosity were repeated, with the same results. This suggests that some other factor, perhaps adhesiveness due to impurities, rather than just swelling, is responsible for the viscosity observed in the Brabender. The differences observed in the solvents used in fat extraction for iodine-affinity measurements would reinforce this argument. All the dasheen peaks show a slight peak viscosity which may be a direct result of the higher percentage of amylopectin. Otherwise, one must conclude that the cooking curves differ little from those of the other small-granule starches we have investigated. The dasheen pastes are much more transparent than cereal-starch pastes and are extremely stringy. In this respect they resemble potato starch.

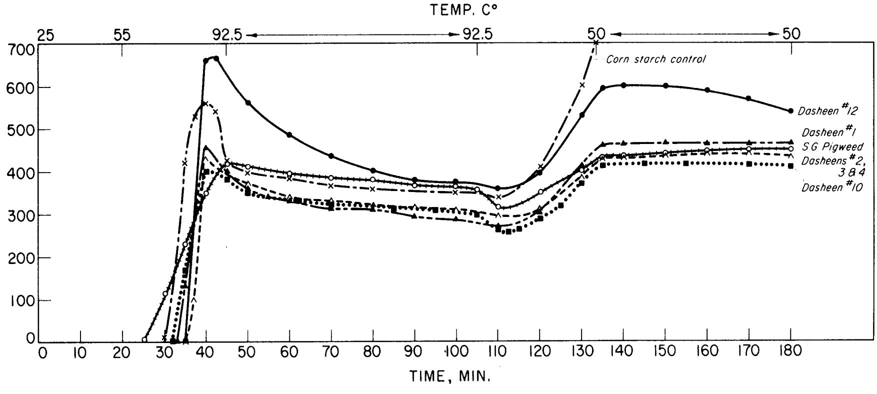

Fig. 3. Brabender amylograms on dasheen starch with corn starch and pigweed starch as controls; 8% starch.

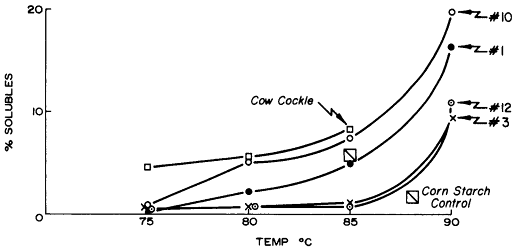

Fig. 4. Solubility of dasheen starch as compared to cow-cockle and corn starches.

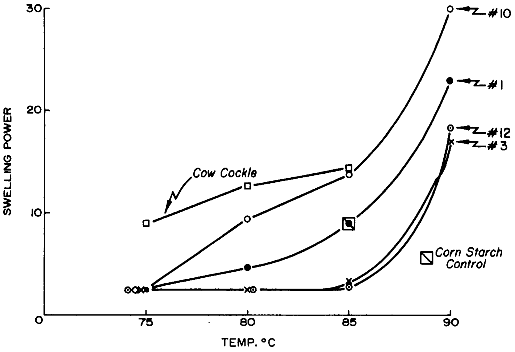

Fig. 5. Swelling power of dasheen starch as compared to cow-cockle and corn starches.

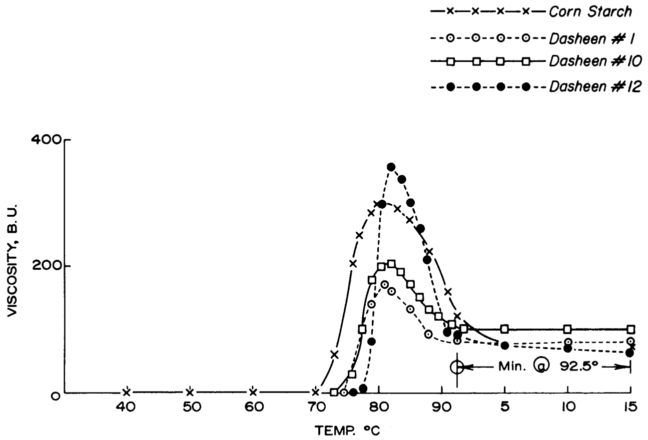

Fig. 6. Starch liquefaction: A comparison of the effect of α-amylase on starch from dasheens, with corn starch as a control; 7.6% starch and 0.006% HT-1000.

Solubility and Swelling Power

The percent solubles at various temperatures is shown in Fig. 4.

Although cow-cockle starch shows a slightly higher solubility at all temperatures, other small-granule starches (2,3) have values above and below the dasheens but not significantly different. The swelling power is given in Fig. 5.

It is observed that dasheens 3 and 12 show low solubility and restricted swelling power. Only the dasheen with the smallest granule size is similar to cow cockle in solubility and swelling power. In this respect the dasheens differ widely from other tuber and root starches, which show high solubility and swelling power.

Viscosity Reduction with α-Amylase

The susceptibility of dasheens to the action of α-amylase is shown in Fig. 6.

The dasheens show some resistance to amylase action, and in this respect are similar to other tuber starches and quite different from cow cockle. Since feeding experiments confirmed the ease of digestion of cow-cockle starch[2], it would be interesting to see if similar tests would confirm resistance to digestion.

Since granule size does not appear to be the reason for the low pasting temperature observed for cow-cockle starch, what is the reason for its anomolous behavior? Efforts to fractionate this starch in our laboratory result in obtaining an amylopectin with an extremely high iodine affinity. Perhaps this unusual amylopectin is responsible for low pasting temperature and low setback, since the amount of amylose present may be substantially less than the amount calculated on the basis of total iodine affinity.

Currently, we are investigating the structure of the starch fractions of cow cockle in an attempt to resolve this problem.

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[2] C. W. Newman, Animal Science Department, Montana State University.

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