Carbohydrate Polymers **20** (1993) 169–173

Variability in starch extracted from taro*

S.N. Moorthy, P.K. Thankamma Pillai & M. Unnikrishnan

Central Tuber Crops Research Institute, Sreekariyam, Trivandrum-695 017, India

(Received 5 May 1992; accepted 27 July 1992)

Starch was extracted from ten cultivars of taro and various physicochemical properties were determined. The granule size was found to vary considerably among the different accessions, C-9 starch having the largest average granule size (5·19 μm) while the lowest was recorded for C-46 (2·96 μm). The total amylose content varied between 14 and 19%, C-9 starch having the highest value. Soluble amylose content ranged from 4 to 11%. Although there was not much difference between varieties in the 2% viscosity determined using a Redwood viscometer, the Brabender viscosity patterns showed considerable variation, and C-9 starch had the highest peak viscosity, almost twice as much as the others. The swelling volumes ranged from 25·0 to 60·0 ml g^{-1} with C-266 starch having the highest swelling volume.

INTRODUCTION

Taro (*Colocasia esculenta* (L) Schott) belonging to the family Aracea is cultivated in large areas of Asia, Africa, the West Indies and South America. It is quantitatively the most important crop in the countries surrounding the Pacific (Plunknett, 1970). Taro starch, in view of its small granule size, has been considered to be easily digestible; hence it is widely used in baby foods and the diets of people allergic to cereals and children sensitive to milk (Wang, 1983). In addition to food use, taro has found some industrial applications. The very small size of taro starch granules makes them ideal in cosmetic formulations like face powder and in dusting preparations which use aerosol dispensing systems (Griffin & Wang, 1983). Higashihara *et al.* (1975) have found that taro starch is a suitable filler in biodegradable plastics.

In spite of the above uses, the large-scale extraction and utilization of this starch is not practised anywhere, probably due to the difficulty in extracting the starch from fresh tubers, which contain a lot of mucilagenous material. Recently, however, it was found that the yield of starch could be considerably enhanced by using 0·03 M ammonia solution for extraction (Moorthy, 1991).

Although a large amount of variability has been reported in the morphological and tuber characteristics of the crop, little information is available on the variation in taro starch properties in relation to varietal differences. Hence a study was undertaken to explore the variability of starch extracted from different accessions of the crop and the results are presented in this paper.

EXPERIMENTAL

Ten cultivars of *Colocasia* including two released varieties (C-149 and C-266) were grown at the CTCRI farm following standard practices and harvested at the 7th-month stage. The cormels were separated, washed and peeled. They were cut into small pieces and disintegrated in a blender at low speed using 0·03 M ammonia solution. The suspension was passed through 260 mesh screen twice and allowed to settle overnight. The supernatant was decanted off and the starch subjected to a second washing and settling. The starch cake formed was removed and powdered and dried at 45–50°C for 24 h. The resultant starch was used for various studies.

Granule size was determined using an ocular micrometer at a magnification of 15 × 40×. For each sample, five slides were prepared; 50 readings were randomly obtained from each slide and the average granule size was calculated.

The size of the starch granules was analysed with a Coulter Counter® Model TAII (Coulter Electronics

*CTCRI Publication No. 581.

Carbohydrate Polymers 0144-8617/93/$06.00

Ltd, Luton, UK) after dispersing the defatted starch granules into Isoton II® (filtered electrolyte solution, Coulter Electronics Ltd). The equipment was calibrated by PDVB Latex® (UK). Each sample was run five times and five replications for each sample were used for size determination.

The total and soluble amylose contents were determined by standard iodimetry (Sowbhagya & Bhattacharya, 1971; Shanthy *et al.*, 1980). The viscosity of 2% solution of the starch in water was determined using a Redwood viscometer (India). The paste viscosity pattern was monitored using a Brabender Viscograph (Germany), Model 80102 using a 350 mcg cartridge. The concentrations of starch used in viscosity studies were 5, 6 and 7% and the pasting temperatures were directly read out from the viscograms. The swelling volumes were determined using a standard procedure (Schoch, 1964). The clarity was obtained by comparing the absorbance of the 2% starch solution with that of water as '0' at 500 nm. The sol stability was the time taken for the starch gel to start settling. Phosphorus content was determined by the Vanado-molybdate method (Smith & Caruso, 1964).

RESULTS AND DISCUSSION

The average granule size of starch from the ten cultivars of *Colocasia*, as determined microscopically, are given in Table 1. Unlike other tropical tuber crops which do not show any significant difference in size between varieties, *Colocasia* starch exhibited significant size differences. C-9 starch had the highest average granule size, i.e. 5·19 μm, followed by C-62 which possessed a granule size of 4·27 μm. The rest exhibited values ranging from 2·96 to 3·55 μm. Strauss and Griffin (1984) reported a value of 3·34 μm, while Griffin and Wang (1983) found the granule size to be 1–6 μm. The Coulter counter data on the distribution of granules in different size ranges also confirmed the difference in C-9 starch from three other cultivars (Fig. 1). The distribution pattern for C-9 starch showed a

Table 1. Average granule size and reducing values of *Colocasia* starch

	Granule size[a] (μm)	Reducing values (ferricyanide number)
C-9	5·19	1·2
C-46	2·96	1·2
C-62	4·27	1·5
C-149	3·06	1·1
C-189	3·30	1·2
C-216	3·51	1·3
C-218	3·39	1·0
C-220	3·55	1·4
C-266	3·16	1·3
C-304	3·20	1·1

[a]CD(1%) = 0·3011, where CD is the critical difference obtained by the analysis of data on measurement of starch granule size in a randomised block design. If CD(1%) is greater than 0·3011 then the accession will be significantly different.

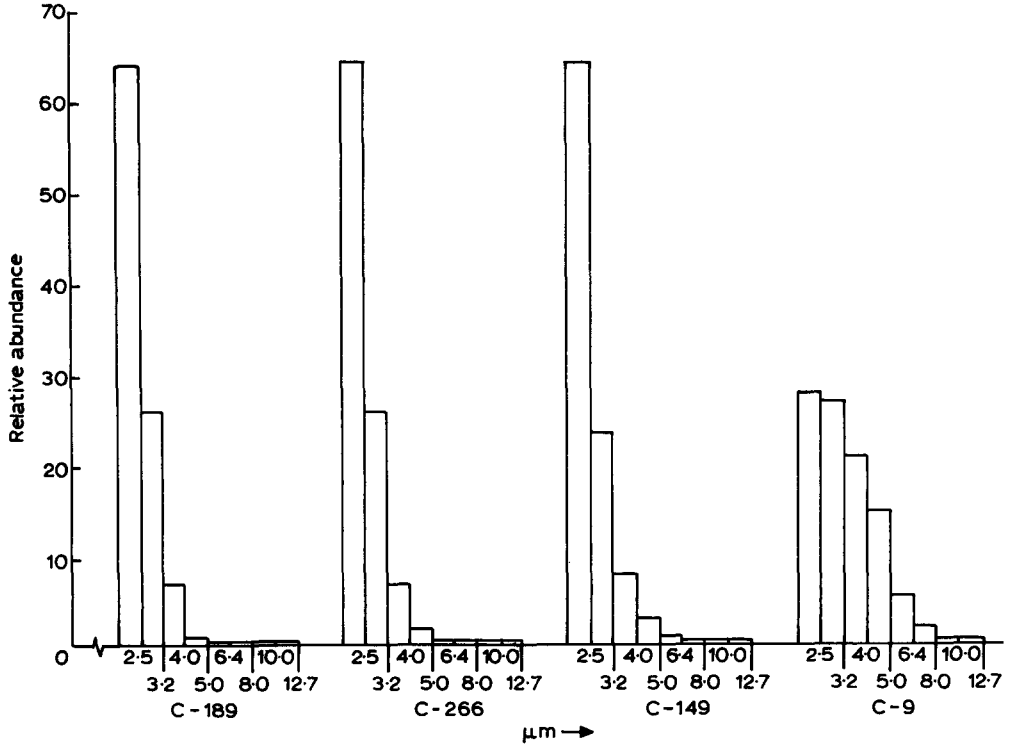

Fig. 1. Granule size distribution from four varieties of *Colocasia*.

smaller proportion of granules in the size range 1·6–2·5 μm (Fig. 1), unlike the starch of other cultivars which had over 60% of their granules in this range. The percentage of granules in the range 5–8 μm is much larger in C-9 compared to the others.

The reducing values of the starches from the different cultivars were almost in the same range (between 1·0 and 1·5), indicating that there is no noticeable difference in the molecular weights of the starch from the different varieties (Table 1).

The total and soluble amylose contents in the starch of different varieties are presented in Table 2. Although a small variation in amylose content is usually observed among different varieties in cassava, the variation observed for the taro starches was much more striking. The values ranged from 14·0 to 19·4% and interestingly C-9 starch, which possessed the largest granule size had the highest amylose content, viz. 19·4%. C-220 starch had the next highest amylose content and the lowest was observed for C-189. Variation in amylose content in *Colocasia* has been found by Chowdhary and Hussain (1979) who obtained values between 12·2 and 17·0 for five cultivars. Rasper (1967) reported values of 14·5 and 15·0% for two varieties. Strauss and Griffin (1984) have obtained a range of 16–43% among Hawaiian cultivars. Though C-9 starch had the highest amylose content and granule size, the data for the other starches does not suggest a general relationship between starch content and granule size. This is in agreement with the observation of Strauss and Griffin (1984) who also failed to observe any correlation between granule size and amylose content.

To our knowledge, the soluble amylose contents in *Colocasia* have not previously been reported. The values obtained in this study showed that the content varied from 14·4% to 10·7% based on total starch content. The starch of C-189 had the lowest soluble amylose content, while it was highest for C-220. No conclusion could be drawn in terms of the relationship between soluble amylose content and total amylose or granule size.

Table 2. Total and soluble amylose contents and 2% viscosity of *Colocasia* starch

	Total amylose (%)	Soluble amylose (%)	2% viscosity (s)
C-9	19·4	8·8	38
C-46	16·1	9·3	36
C-62	14·5	6·6	37
C-149	15·1	8·8	36
C-189	14·0	4·4	32
C-216	14·5	6·5	35
C-218	15·7	8·3	37
C-220	17·6	10·7	34
C-266	15·7	9·8	35
C-304	16·1	7·5	36

The 2% viscosity of the starch of the different accessions showed only very minor differences. The values ranged from 32 to 38 s. Here also C-9 starch had the highest viscosity (Table 2). No relationship between granule size and viscosity could be observed from our study.

The Brabender viscosity data provide some more data on the rheology of the starch of the different cultivars (Table 3). Very prominent differences in the peak viscosity were noted among the cultivars. C-9 starch, which had the highest 2% viscosity, possessed the highest peak viscosities viz., 350, 600 and 880 BU at 5, 6 and 7% concentrations, respectively. C-189 starch had the next highest values (250, 440 and 620 BU at 5, 6 and 7% concentrations) while the lowest values were recorded for C-220 (120, 240 and 370 BU at 5, 6 and 7%). Although the viscosity is lower compared to cassava or *Dioscorea* starches, the values are generally higher than those of cereal starches. It is interesting to note that C-9 starch with relatively larger granules exhibits the highest peak viscosity. However, no direct relationship could be observed between the viscosity and granule size, since C-189 starch, which had the next highest viscosity, possessed only a small granule size. The breakdown in viscosity when the paste was held at 95°C for 30 min was quite small at 5% concentration. It was less than 100 BU for all the cultivars, and there was no breakdown when peak viscosities were less than 200 BU. When the concentration was raised to 6%, the breakdown was more pronounced, but still low, i.e. between 20 and 120 BU, and at 7% concentration, the breakdown varied from 40 to 120 BU for all varieties, except for C-9, whose viscosity breakdown was 240 BU. Even this value is quite small compared to cassava starch, which undergoes much higher breakdown at this concentration and viscosity (Moorthy, 1985). The relatively lower viscosity breakdown can be exploited in food uses, where a short non-cohesive texture may be required. The lower viscosity levels and the lesser breakdown can be attributed to the strong associative forces in starch granules of *Colocasia*. The pasting temperatures as observed from the viscosity curves were almost similar for all the accessions and fall within 3 or 4°C from each other. All of them had pasting temperatures between 80 and 86°C and exhibited only a single-stage gelatinization.

The swelling volumes also showed noticeable variation among the different accessions. The largest value was obtained for C-266 starch, viz. 60 ml g^{-1}, compared to starch of C-216, with the lowest swelling volume of 25 ml g^{-1}. The result indicates that swelling volumes and viscosity may not be directly dependent upon each other or upon the starch-granule size.

The paste clarity and sol stability did not vary much (Table 4). The clarity was much lower compared to cassava or *Dioscorea* starches. The sol stability was also relatively poorer compared to cassava starch paste. All

Table 3. Brabender viscosity properties of *Colocasia* starch

Starch	Conc. (%)	V_p[a] (BU)	V_{97}[b] (BU)	V_H[c] (BU)	Pasting temperature (°C)
C-9	5	350	340	280	81-83
C-9	6	600	640	480	81-83
C-9	7	880	720	640	80-84
C-46	5	160	160	160	85-86
C-46	6	230	230	210	83-84
C-46	7	320	300	280	82-84
C-62	5	220	210	200	81-83
C-62	6	380	360	300	81-83
C-62	7	530	500	460	81-83
C-149	5	130	130	130	83-84
C-149	6	220	200	170	83-84
C-149	7	340	310	270	82-84
C-189	5	250	240	280	82-83
C-189	6	440	390	330	81-83
C-189	7	620	540	500	80-83
C-216	5	280	260	220	83-84
C-216	6	460	410	360	82-83
C-216	7	560	500	490	81-83
C-218	5	170	170	170	83-85
C-218	6	320	310	290	82-83
C-218	7	420	400	380	82-83
C-220	5	120	120	110	84-86
C-220	6	240	230	190	84-86
C-220	7	370	340	280	83-85
C-266	5	180	180	180	81-83
C-266	6	320	310	290	81-83
C-266	7	500	430	380	81-82
C-304	5	140	140	140	84-85
C-304	6	300	290	280	83-84
C-304	7	390	370	320	82-84

[a] V_p — peak viscosity.
[b] V_{97} — viscosity at 97°C.
[c] V_H — viscosity after holding at 97°C for 30 min.

these point to a closer and stronger associative network in the starch granules.

Phosphate ester linkages in starches have been known to modify starch properties (Osman, 1967). The high viscosity observed for potato starch is attributed to the polyelectrolytic characteristic caused by the ester-bonded phosphate groups. However, no correlation between viscosity and phosphorus content could be observed in the accessions studied (Table 4).

Thus the study reveals considerable variability in the starch property of different cultivars of taro, which could be exploited by breeding for desirable characteristics.

Table 4. Swelling volume, phosphorus content, clarity and sol stability of *Colocasia* starch

	Swelling volume (ml g^{-1})	Clarity (OD)[a]	Sol stability (h)	P content (ppm)
C-9	26·5	0·50	48	100
C-46	47·5	0·45	72	115
C-62	34·5	0·50	48	122
C-149	40·0	0·55	48	100
C-189	45·0	0·60	72	132
C-216	25·0	0·45	72	105
C-218	27·5	0·65	48	55
C-220	42·5	0·5	72	120
C-266	60·0	0·45	48	75
C-304	35·0	0·65	72	130

[a] OD — optical density.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the help and encouragement provided by Dr G.G. Nayar, Former Director, CTCRI, Trivandrum and Dr C. Balagopalan, Head, PHT Division, CTCRI, Trivandrum. Thanks are also due to Prof. J.M.V. Blanshard and Mr M.C. Chapman, Department of Applied Biochemist and Food Science, University of Nottingham, UK for help with the Coulter counter measurements.

REFERENCES

Chowdhari, B. & Hussain, M. (1979). *Indian J. Agr. Sci.*, **49,** 110.

Griffin, G.J.L. & Wang, J.K. (1983). In *Taro,* ed. J.K. Wang, University of Hawaii Press, Honolulu, 400 pp.

Higashihara, M., Umeki, M. & Yamamoto, T. (1975). *J. Japan Soc. Starch Sci.*, **22,** 61.

Moorthy, S.N. (1985). *J. Agric. Food Chem.*, **33,** 1227.

Moorthy, S.N. (1991). *Carbohydr. Polym.*, **16,** 391.

Osman, E.M. (1967). In *Starch: Chemistry and Technology,* Vol. 2, ed. R.L. Whistler & E.F. Paschall, Academic Press, New York, USA, p. 163.

Plucknett, D.L. (1970). *Proc. 2nd Int. Symp. on Tropical Root and Tuber Crops,* **1,** 127

Rasper, V. (1967). *Proc. 1st Int. Symp. Tropical Root Crops.*, **2,** 48.

Schoch, T.J. (1964). *Methods in carbohydrate chemistry,* Vol. 4, Academic Press, New York, USA.

Shanthy, A.P., Bhattacharya, K.R. & Sowbhagya, C.M. (1980). *Staerke,* **32,** 409.

Smith, R.J. & Caruso, J.L. (1964). *Methods in Carbohydrate Chemistry,* Vol. 4, Academic Press, New York, USA.

Sowbhagya, C.M. & Bhattacharya, K.R. (1971). *Staerke,* **23,** 53.

Strauss, M.S. & Griffin, G.J.L. (1984). *Proc. 6th Symp. Int. Soc. Tropical Root Crops,* 165.

Wang, J.K. (1983). In *Taro,* ed. J.K. Wang, University of Hawaii Press, Honolulu, p. 4.