Research article

Comparasion in Some Characteristics of Yam Tubers Starch (*Dioscoreaceae spp.*) from Thailand

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Abstract Yam Tubers were classified in the Family Dioscoreacea which is starch staple foods. This is the main source of starch supply in Africa. The original from Southeast Asia are *D.alata* and *D.esculenta*. Yam tubers were distributed to all region parts of Thailand. The aim of this research is to study some physical-chemical properties of starch obtained from three types of yam tubers from two species: water yam (mun jao diang: jd and mun lued: ld) and lesser yam (mun mue seu: ms) as alternative for food industry. Starch was extracted from fresh tubers by wet milling process and purification. Products were compared among three types of yam tubers. The yields of starch were about 17.01-41.73% for jd and ms, but ld was quite different in starch content at 95-99% (dry weight) estimated by enzymetric method. The chemical properties were not quite different, but the structural starch granule by image analysis and morphological approach by scanning electron microscope (SEM) showed that the shape of *D.alata* were trigonally rounded with average size of 20-26; also in *D.esculenta* the shape was polygonal with average size of 4.7. It was considered that some of starch granule could be destroyed by milling process. Viscosity and some functional properties were not remarkably different for all of yams starch.

Keywords yam tubers, *Dioscoreaceae spp.*, *Dioscorea alata*, *Dioscorea esculenta*, starch staple food, alternative

INTRODUCTION

Yam (*Family Dioscoraeceae*) is a food crop of economic value in countries in Africa and Asia, which produce tubers, bulbils or rhizomes as a starch staple food. That comprises at least 600 species distributed throughout the tropic lands. The plant is climbing vine with distinctively veined, cordate leaves and deep-lying tubers. Yam tubers of various size and shape contain high content of carbohydrate up to 77% (dry weight) (Onwueme, 1978 and Degras, 1993). Yams can be consumed by boiling, baking and frying as a cheap source of carbohydrate (Coursey, 1967).

Water yam or greater yam (*Dioscorae alata*) and lesser yam (*Dioscorae esculenta*) are the edible yams being most frequently cultivated in tropical areas. The original is from Southeast Asia (Ibrahim, 1994), and yam tubers were distributed to all regions of Thailand. But the main application of yams tubers in Thailand is only as home and local economic food, not for industry. Yams are also extraction starch on commercial scale when compared with other starch source (cassava, potato, maize, wheat and sweet potato), and little information is available for physico-chemical and functional properties of yam starch (Hoover, 2001).

The objective of the research was to perform a study on some physico-chemical characteristics and some functionalities of yam starch extraction from two species in wet milling for the new source of starch for industry.

METHODOLOGY

Raw Material

Two types of Yam *(Dioscoreaceae)* species *D.alata* (water yam: mun lued and mun jao dieng) and *D. esculenta* (lesser yam: mum mue sue) were obtained from a local market in Thailand**.**

Starch extraction

Starch was extracted as reported by Gebre-Mariam, T. et al. (1998). In the wet milling process, the flesh of yam after peeling was ground with distilled water, and starch slurry was filled through 120-mesh sieve screen. The collected substance was then repeatedly washed with 0.75% sodium metabisulfide solution for several times and finally washed with mix solvent: 10% toluene 80% ethanol 0.1% NaOH. Starch after being throughly washed with water was then collected using centrifuge at 2000 x g 10 min. 25°C and dried at 50°C until dried. The yield of starch extraction was also recorded.

Physico-chemical characterisation

Chemical composition

The content of moisture, protein, fiber, fat, ash and NFE [nitrogen free extract (100 - % protein - % fat - %fiber - % ash)] were determined by the standard method of AOAC (1990). The contents of starch were determined by enzymetric method according to the procedure of Dey and Harborne (1990).

Starch granule morphology

Scanning electron Microscope (SEM) of starch was accomplished by sprinkling the starch on double-backed adhesive tape attached to a circular specimen stub and coated with gold using a Baltzers SDC 004 sputter coater. The samples were then viewed under a JOEL scanning electron microscope (JSM-5310, England) at 15 kV accelerated method according to the procedure of Walker (1976) and Gebre-Mariam T. et al. (1998).

Size distribution of starch granules were observed in 80% sucrose solution under a light microscope (Meiji Techno, Japan) at 10X and 40X magnification. Images were captured with Meiji CK3800 color video camera. The size of starch granule was further evaluated using the image analysis (Image Pro Plus 3.0, Media Cybernetic, LP. USA.), according to Sahai et al. (1998).

Functional properties

Solubility and swelling power of yam starch was carried out at 60-95°C following the procedure described by Schoch (1964). Pasting profiles of yam starch were investigated in Rapid Visco Unit (RVU) using a Rapid Visco Analyzer (RVA 4, Newport Scientific, Australia) with the same weight of 3.00 g (14% moisture content) in 25 ml distillated water, according to Newport scientific Pty, Ltd. (1995) and Farhat I.A et al. (1999). Gelatinization properties of extracted starch was determined using a Perkin Elmer Differential Scanning Calorimeter (DSC 7 Norwalk, CT, USA.) as described by Sriroth et al. (1998).

RESULTS AND DISCUSSION

Peeled yam tuber contain approximately 19-28% dry solid of which starch was the major content; accounting up to 61, 65 and 73% of starch are mun jao dieng (*D.alata*), mun lued (*D.alata*) and mun mue seu (*D.esculenta*), respectively. Yam starch could be extracted from tuber by wet milling using water as the extracting solvent, both starches were very pure; the data in Table 1 show starch content of 97-98.53% (dry basis) when estimated by enzymatic method (Lee and Whelan, 1966). Other component fibers content was about 0.01-0.21, protein 0.23-0.6, fat 0.02-0.14 and ash 0.29-0.6. NFE content was 98.51-99.18 with non-significantly different ($p>0.05$). The yield for starch extract from yam tubers were about 26.61-41.73% significantly ($p<0.05$) different mun mue seu (*D.esculenta*) and mun lued (*D.alata*) have less yield than mun jao dieng (*D.alata*) from these process. Numerical data are shown in mean standard deviation.

Table 1 Chemical composition of yam starch (% drybasis) yield (% dry weight of tubers) and starch content (% drybasis)

	MC	Fiber	Ash	Fat	Pro	NFE	Starch	Yield	average size (µm)
Mun jao dieng (***D.alata***)	8.12 (0.1)	0.12 (0)	0.6 (0.03)	0.02 (0)	0.6 (0.06)	98.51 ns (0.08)	97.00ns (0.36)	41.73a (0)	20.88
Mun lead (***D.alata***)	14.54 (0.1)	0.01 (0)	0.29 (0.01)	0.07 (0)	0.42 (0.08)	99.18 ns (0.08)	98.53ns (0.16)	26.61c (0)	26.68
Mun mue seu (***D.esculenta***)	9.27 (0.1)	0.21 (0.03)	0.34 (0.02)	0.14 (0)	0.23 (0.06)	99.08 ns (0.02)	97.11ns (0.02)	34.92b (0)	4.75

a,b,c : values on the same column with different superscript are significantly (p< 0.05)different.
ns: non significantly different (p >0.05).

The appearances of yam starches extracted from tubers by wet milling were examined closer by Scanning Electron Microscopy (Fig. 1). The shape of starch granule on 2 types of *D.alata* are the same in trigonally rounded and large size but *D.esculenta* have small size and polygonally shape; however, there were some exhibited starch granules with more irregular surface and not clear in some of granule, probably being damaged due to vigorous mechanical treatment. Heat generated during dry milling may also promote the interaction of protein to granule surface. Observed under the bright-fielded microscope shape of starch are same. The granular size of yam starch shown in Table 1 has average size of 4.75, 26.68 and 20.88 (µm) for mun mue seu (*D.esculenta*), mun lued (*D.alata*) and mun jao dieng (*D.alata*) respectively. The morphological starch granule shape and size are similar to Rasper and Coursey (1967) experiment.

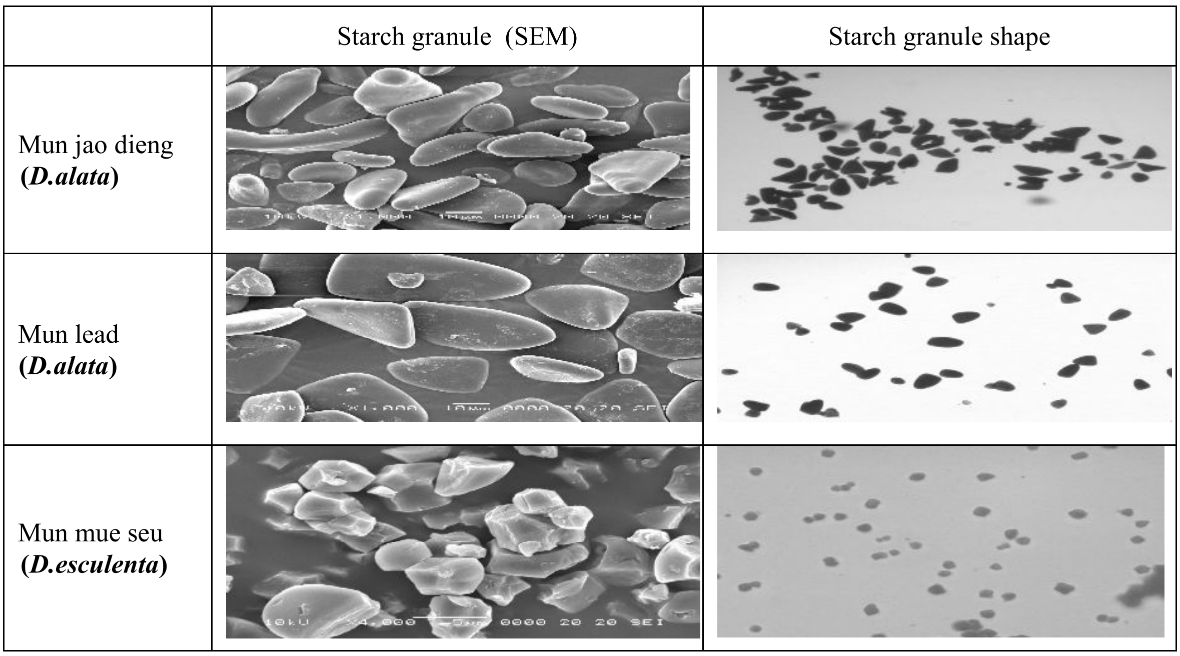

Fig. 1 Scanning electron micrograph (at 1000X and 4000X) and starch granule shape (10X and 40X) of yam (*D.alata* and *D.esculenta*) starch

The water uptake ability measured as swelling power of yam starch increased with increasing temperature data shown in Table 2, but the water uptake capability of yam starch was not quite different in types of variety. Swelling contents of starch from two *D.alata* are less than in *D.esculenta* and solubility is not quite different.

Table 2 Swelling power and % solubility at 60-95°C yam (*D.alata* and *D.esculenta*) starch

Temp (°C)	Mun mue seu		Mun lued		Mun jao dieng	
	swelling	solubility	swelling	solubility	swelling	solubility
60	5.17 (0.29)	2.45 (0.11)	7.44 (0.27)	0.95 (0.04)	6.74 (0.57)	1.48 (0.08)
70	13.36 (0.28)	7.47 (0.06)	11.72 (0.39)	1.26 (0.05)	5.22 (0.11)	2.56 (0.25)
80	39.20 (1.04)	12.32 (0.27)	14.48 (0.75)	9.19 (0.49)	15.18 (0.53)	12.41 (0.65)
85	48.44 (1.65)	29.27 (0.21)	29.49 (1.24)	13.75 (0.51)	22.34 (0.33)	15.65 (0.52)
90	54.48 (0.63)	20.52 (1.26)	28.53 (1.34)	13.95 (0.77)	27.56 (1.23)	16.81 (0.24)
95	52.54 (1.39)	20.37 (1.17)	27.72 (1.44)	14.81 (0.28)	27.26 (0.17)	17.29 (0.22)

Change in paste viscosity of yam starch during heating using by Rapid Visco Analyser had the results as shown in Table 3. The pasting temperature of two varieties of yam starch are different - *D.alata* more than *D.esculenta*. In case of peak viscosity, *D.esculenta* has more than two types of *D.alata*. During heating, processed swollen granules can be broken due to the high shear and mechanical force, resulting in a decrease of paste viscosity.

Table 3 Pasting properties of yam (D.alata and D.esculenta) starch

	Pasting temp (°C)	Peak time	Pasting properties (RVU.)				
			Peak viscosity	Trough	Breakdown	Cold paste viscosity	Set back
Mun jao dieng	82.48	5.33	248	206	41	316	110
(*D.alata*)	(0.04)	(0)	(11)	(7)	(3)	(1.0)	(2)
Mun lead	83.22	4.91	279	218	62	334	116
(*D.alata*)	(0.37)	(0.1)	(0)	(2)	(3)	(1)	(3)
Mun mue seu	68.53	5.00	357	215	143	300	86
(*D.esculenta*)	(1.36)	(0.07)	(3)	(4)	(6)	(1)	(4)

On starch gelatinization process, starch suspension with continuous heating becomes swelling irreversibly and changes into paste ultimately. This occurence seem to be lost of ordered structure of starch granule. Thermal analysis of starch by Differential Scanning Calorimetry is used to accurately provide on this relationship of ordered structure and gelatinization process of starch granules. Data are shown in Table 4. Gelatinization occurred with not quite different in temperature. Comparatively, two varieties of yam starch, and the energy consumption at an equivalent sample weight for complete gelatinization were not quite different.

Table 4 Thermal analysis, as determined by Differential Scanning Calorimetry, of yam (*D.alata* and *D.esculenta*) starch

		Onset temperature (To, ^{0}C)	Peak temperature (Tp, ^{0}C)	Conclusion temperature (Tc, ^{0}C)	Gelatinization enthalpy (J/s)
Mun jao dieng	gelatinization	75.74 (0.12)	79.73 (0.59)	88.24 (0.62)	11.6 (1.62)
(*D.alata*)	retrogradation	48.69 (0)	65.74 (0)	87.87 (0)	9.23 (0)
Mun lead	gelatinization	77.57 (0.14)	80.46 (0.22)	88.44 (1.75)	16.9 (0.31)
(*D.alata*)	retrogradation	51.32 (0)	66.36 (0)	83.00 (0)	8.01 (0)
Mun mue seu	gelatinization	69.39 (0.42)	72.93 (0.30)	82.11 (1.48)	11.6 (0.72)
(*D.esculenta*)	retrogradation	50.22 (0.98)	61.40 (2.85)	74.20 (0.38)	6.46 (0.75)

CONCLUSION

Two species of yam tubers in Thailand could produce starch with different functional properties. Starch content when estimated by enzymatic method and NFE contents were non-significantly different ($p>0.05$). Wet milling can produce starch with higher purity, hydration property and more yields. The yield for starch extract from yam tubers were about 26.61-41.73% significantly ($p<0.05$) different mun mue seu (*D.esculenta*) and mun lued (*D.alata*), and have less yield than mun jao dieng (*D.alata*) from this process. To increase starch properties and utilization of this crop depends on the product quality needed.

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