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A Study on Preparation and Properties of Starch from Deep-purple Corn

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ABSTRACT

Starch was isolated from a variety of deep-purple corn (DPC) by wet-milling process. The use of suitable starch table could provide good protein-starch separation. The data on chemical and physical properties of the DPC starch was compared to those of Maizena, McGarett and Friendship, the three commercial starches. Chemical compositions and starch contents of the DPC starch and the others were quite similar. Protein, fat and crude fiber contents which indicate the starch quality were lower. The DPC starch granule size (7.65 - 22.95 micron) was a little wider range than those of the three commercial ones. Microscopic examinations, both light and scanning electron, of the starch granules were measured. The DPC starch had more white color, somewhat higher water and oil absorptions and higher solubility and swelling power than those of the commercial ones, but similar in gelatinization temperature range. It's degree of syneresis was lower than that of McGarett. Brabender viscosity patterns of the DPC starch and the commercial ones were quite similar. The DPC starch presented peak viscosity (660 B.U.), set-back (440 B.U.), consistency (630 B.U.) and breakdown (190 B.U.) upon continual cooking.

Key words : deep-purple corn, corn starch.

INTRODUCTION

Considering the wide variety of starch sources in the plant kingdom, corn is quite the prominent item, especially in USA. In Thailand, though corn is not the major source for starch production due to the more sophisticated technology involves in the process at industrial scale, the increasing volume of corn production keeps corn starch a promising one. Normal yellow corn varieties have been used for Thai corn starch production. Deep-purple corn, believed to originate in Peru, is a variety with white endosperm but densed deep- purple anthocyanin pigment at the kernel pericarp and the cob. It was brought to Thailand for the experimental breeding program, focusing on its pigment as another source of natural coloring agent for industrial use. Since the white endosperm, a good source of starch, may be automatically considered the left-over from the pigment extraction process. This is probably due to the contamination of the purple pigment which makes the starch color under the standard color for good quality corn starch.

This study was conducted to prepare white starch from this DPC by normal wet-milling process with slight modification. The resulting starch was then studied for chemical and physical properties in comparison with three commercial corn starches.

MATERIALS AND METHODS

A deep-purple corn variety was supplied by the National Corn and Sorghum Research Center, Nakhon Ratchasima province. Proximate composition and starch content of the corn were analysed by AOAC (1990) methods.

Three commercial corn starches were bought from the market to serve as the comparative materials for starch properties. These are Maizena (the American corn starch, repacked by the CPC/AJI Ltd., Thailand) McGarett (manufactured by the Peterish and company, Rotterdam city, Holland) and Friendship (Thai corn starch).

The DPC starch was prepared by wet-milling process (Figure 1). Protein and the purple pigment residue were separated from the starch by means of overnight setting of the protein-starch suspension in a steel container at 4°C, followed by using the inclined starch table. The resulting starch was dried at 60°C in an air-oven and ground into 100 mesh particle prior to being packed in a dried plastic bottle.

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Determination of starch properties

Both physical and chemical properties of the DPC starch and the three commercial ones were determined and the results were compared.

Chemical properties

The starches were analysed for proximate composition starch content (AOAC, 1990), pH value (TIS, 1986) and amylose content by simplified amylose procedure (Juliano *et al.*, 1981) modified by using 3 ml, instead of 5 ml, of the starch solution to mix with 1 ml 1 N acetic acid and 2 ml of iodine solution. Potato amylose and amylopectin (Sigma Chemical Co.) were used to prepare the standard curve of amylose.

Granule size measurement and microscopy of starches

The starches were studied microscopically by employing both light and scanning electron microscopes (SEM). For light microscopic examination, 0.5 % starch suspension in distilled water was prepared just prior to the measurement. A compound microscope with a calibrated ocular micrometer (2.55 micron) (calibrated against a stage micrometer) attached to an eyepiece lens was used for the measurement of the starch granule size at 200 magnification. The starch granules were studied for shape and size (diameter). The size measurement was performed on 15 representative starch granules in different fields. For scanning electron microscopic examination, the SEM (JEOL JSM-T220A Japan) at 2000 magnification was used.

Color was measured in terms of whiteness and tint values by using the Spectro-Sensor II, ACS Applied Color System USA, under the CIE standard illuminant D65.

Water and oil (soybean oil, density = 0.9250 g/ml) absorption capacities were determined by the centrifugal method (Sathe and Salunkhe, 1981). The results were expressed as millilitres of water or oil absorbed by one gram of dry starch.

Gelatinization temperature range (GTR) was determined with the Kolfler hot stage on a polarizing microscope (Schoch and Maywald, 1956). The temperatures (°C) at first, 50% and 90% losses of birefringence on duplicate slides for each starch were recorded and the average temperature at each loss was reported.

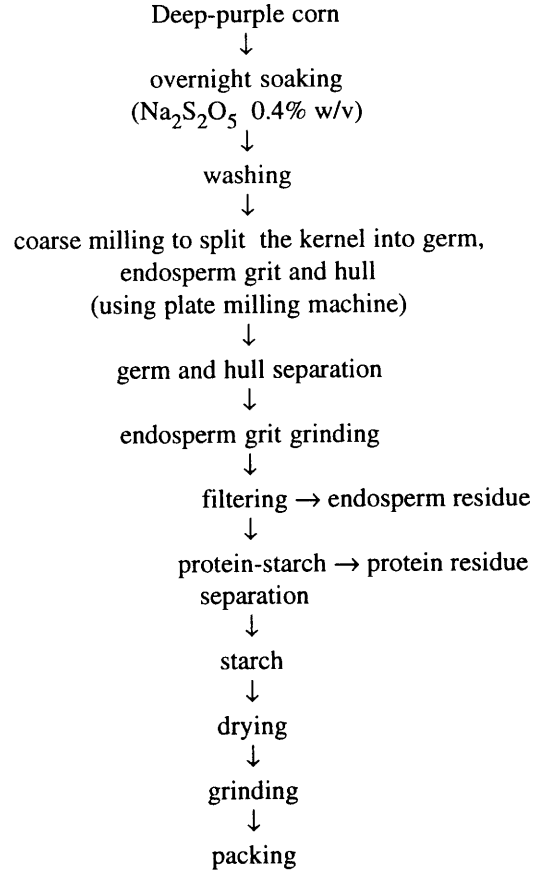


Figure 1 Wet milling process of DPC starch.

Table 1 Proximate compositions and starch contents of deep-purple corn and various corn starches.

Sample	Moisture	% Dry basis					
	(%)	Protein	Fat	CF[1]	Ash	CHO[2]	Starch
DPC	6.17	10.72	4.93	1.48	1.99	74.71	74.18
DPC starch	11.72	0.32	0.64	0.13	0.17	87.02	95.54
Maizena	13.52	0.46	0.66	0.25	0.12	84.99	95.61
McGarett	13.21	0.61	0.81	0.24	0.18	84.95	96.97
Friendship	11.66	0.43	0.85	0.19	0.19	86.68	95.03

1 Crude fiber
2 Carbohydrate by difference

Table 2 Amylose contents of various corn starches.

Sample	Amylose (%)
DPC Starch	22.80
Maizena	23.94
McGarett	22.53
Friendship	24.03

Swelling and solubility patterns of the starches at 60, 70, 80 and 90°C were determined in duplicate by the method of Leach *et al.*, (1959).

Gelations of the starches were determined following the method of Sathe and Salunkhe (1981) and the least gelation concentrations were reported. The degree of syneresis of the starch gel, prepared from starch concentrations at 7, 9, 11 and 13%, at 4°C was determined by the method of Yang *et al.* (1980). The volume of water separated from a definite volume of gel after being stored at 4°C for 24 hr. was designated as its degree of syneresis.

Pasting properties of the starch concentration at 8% w/v were determined by using Brabender Visco/Amylograph with 700 cmg cartridge. The viscosities at different temperatures were plotted against time and five successive points of significance on these curves were located. The figures of breakdown, set-back and consistency of these pastes were obtained by subtractions of the viscosity at 95°C after 30 minutes holding from peak viscosity, the peak viscosity from the viscosity at 50°C and the viscosity at 95°C after 30 minutes holding from the viscosity at 50°C, respectively.

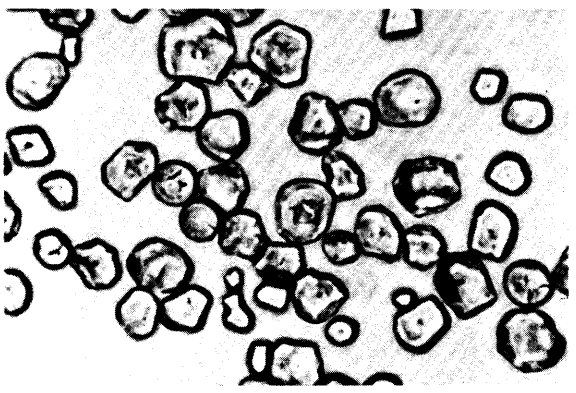


Figure 2 Polygonal type of corn starch granules under light microscope (x200).

Table 3 Starch granule size of various corn starches.

Sample	Granule Size (micron)
DPC starch	7.65 - 22.95
Maizena	10.20 - 20.40
McGarett	10.20 - 22.90
Friendship	10.20 - 23.00

RESULTS AND DISCUSSION

Chemical properties

Proximate compositions and starch contents of DPC, DPC starch, Maizena, McGarett and Friendship were shown in Table 1. Protein, fat and starch contents of the DPC are 10.72, 4.93 and 74.18% respectively. Chemical compositions of the DPC starch and the three commercial ones were quite similar. However, the DPC starch had even lower values of protein, fat and crude fiber contents than those of the three commercial ones. This indicated that the starch extraction method used in this study was quite suitable. The DPC starch had 95.54% starch content which was quite close to that of Maizena, slightly higher than that of Friendship and slightly lower than that of McGarett. Chemical compositions of the DPC starch, except fat content, were within the standard of corn starch (TIS, 1986).

Amylose contents of the DPC starch and the three commercial ones were shown in Table 2. The amylose contents of these starches ranged from 22.53% of McGarett to 24.03% of Friendship. The DPC starch

Table 4 CIE whiteness of various corn starches under the CIE standard illuminant D65.

Sample	CIE whiteness	
	Value[1]	Tint[2]
DPC Starch	86.61	- 0.52
Maizena	81.71	- 0.95
McGarett	84.54	- 0.60
Friendship	83.55	- 0.49

1 The more value, the more whiteness.
2 The sign indicates color shade :
- indicates reddish-blue tint (-0.51 to < - 5.5).
+ indicates greenish-blue tint (+0.5 to > + 5.5).
- 0.5 to + 0.49 indicates no tint.

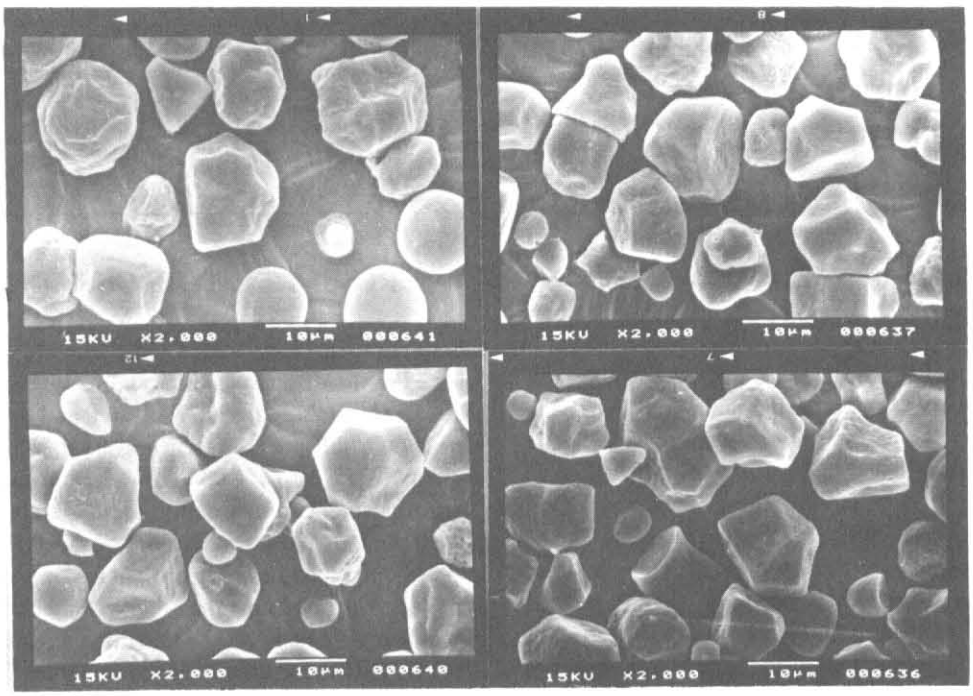


Figure 3 SEM views of various corn starches (x2000).
A = DPC starch B = Maizena
C = McGarett D = Friendship

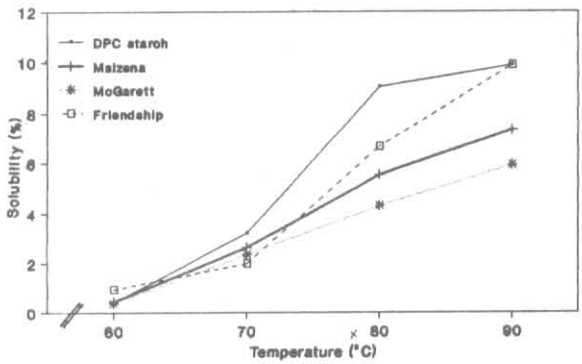
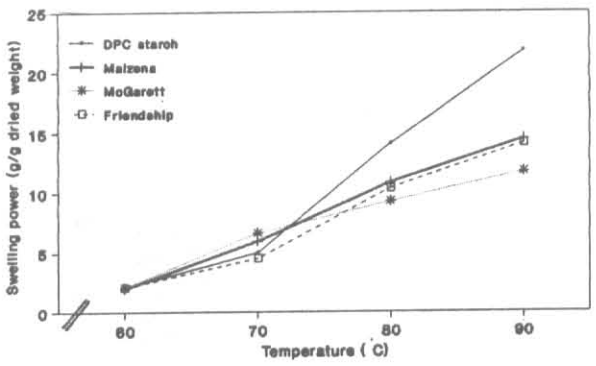


Figure 4 Solubility pattern of various corn starches at different temperatures.



Figrure 5 Swelling pattern of various corn starches at different temperature.

Table 5 Water and oil absorptions by various corn starches.

Sample	Water absorbed (ml/g)	Oil[1] absorbed (ml/g)
DPC Starch	0.60	0.60
Maizena	0.60	0.75
McGarett	0.60	0.93
Friendship	0.75	0.93

1 Soybean oil with density 0.9250 g/ml at room temperature

Table 6 Gelatinization temperature ranges (GTR) of various corn starches.

Sample	GTR (°C
DPC Starch	68.3 - 72.3 - 74.0
Maizena	67.3 - 72.3 - 74.8
McGarett	66.8 - 71.0 - 72.5
Friendship	68.3 - 72.3 - 74.5

had amylose content 22.80% which was quite close to 22.53% of McGarett, whereas Maizena and Friendship gave the very close values of 23.94% and 24.03% respectively. This indicated that these starches had the amylose content of normal corn starch.

pH value ranges of the three commercial starches were from 5.07 of Maizena 5.08 of McGarett to 6.39 of Friendship, while the DPC starch had the value of 6.18 which was in the range (pH 4.0 to 7.0) of normal corn starch (TIS, 1986).

Granule size and microscopic appearance

Microscopic appearances of the DPC starch, Maizena, McGarett and Friendship exhibited polygonal type of starch granule (Figure 2), the normal appearance of corn starch (Radley, 1976). Under the SEM, these starch granules showed basically smooth surface and polygonal structure (Figure 3). Granule sizes of the three commercial starches (Table 3) were within the normal range (10-25 micron) of corn starch (Radley, 1976). However, slightly differences due to different sources of corn starch could be observed. The DPC starch granule size (7.65 - 22.95 micron) was in the wider range than those of the three commercial ones.

Color property

Color appearance of the DPC starch was more white than those of the three commercial ones as observed under the naked-eyes. This was confirmed by the results of color measurement in term of CIE whiteness as interpreted by the values of whiteness and tint (Table 4). The DPC starch had the whiteness value (86.61 unit) higher than McGarett (84.54 unit), Friendship (83.55 unit) and Maizena (81.71 unit), respectively. The DPC starch, Maizena and McGarett showed slight reddish-blue tint (R1) as indicated by the tint values which fell into the same range of tint deviation (from -1.5 to -0.51). However, among these three starches, Maizena showed the highest value (0.95 unit) and the DPC starch showed the lowest (0.52 unit). On the other hand, Friendship showed whiteness with no tint at all, (tint deviation from -0.5 to +0.49). The color of the DPC starch pointed out that the starch preparation method used in this study was quite effective in discarding the deep-purple pigment from the resulting starch.

Water and oil absorptions

The results of water and oil absorptions of various corn starches were presented in Table 5. The same amount of water (0.60 ml/g) was absorbed by the DPC starch, Maizena and McGarett whereas Friendship showed slightly higher absorption (0.75 ml/g). This was probably due to a little lower moisture content (Table 1) and a greater amount of large granule starch of the Friendship.

The DPC starch had the lowest oil absorption (0.60 ml/g) whereas McGarett and Friendship ab-

Table 7 Pasting temperatures and viscosities at five significant points on the amylogram of various corn starches.

Sample	Initial pasting temp. (°C)	Viscosity (B.U.) A	B	C	D	E
DPC starch	73.3	660	590	470	1100	1200
Maizena	74.0	740	710	500	1180	1210
McGarett	71.0	700	700	583	1260	1180
Friendship	74.0	660	640	500	1190	1230

A = Peak viscosity
B = Viscosity at 95°
C = Viscosity at 95°C after 30 min. holding
D = Viscosity at 50°C
E = Viscosity at 50°C after 30 min. holding
B.U. = Brabender units

Table 8 Peak viscosity, breakdown, set-back and consistency of various corn starches.

Sample	Peak viscosity (B.U.)	Break-down[1] (B.U.)	Set-back[2] (B.U.)	Consistency[3] (B.U.)
DPC starch	660	190	440	630
Maizena	740	240	440	680
McGarett	700	117	560	677
Friendship	660	160	530	690

1, 2, 3 were calculated from the viscosity values in Table 7 as follows : 1 = A-C, 2 = D-A and 3 = D-C.

sorbed the identical highest amount (0.93 ml/g). Maizena, on the other hand, showed the oil absorption capacity (0.75 ml/g) in between the DPC starch and the group of McGarett and Friendship.

Gelatinization temperature range

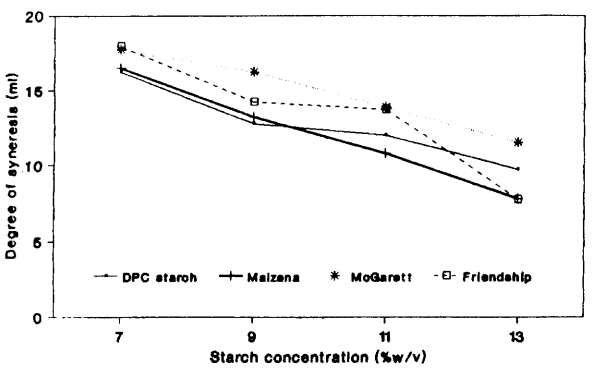
The gelatinization temperature ranges (GTR) of the DPC starch and the three commercial ones observed by the losses of birefringence were reported in Table 6. The figures indicated that all of these starches had quite similar GTR which was due to similar amount of amylose contents. However, slight differences due to different sources of corn starches could be observed. The DPC starch and Friendship had the highest identical initial temperature at 68.3°C and the midpoint temperature at 72.3°C but slightly different in the final temperature at 74.0 and 74.5°C, respectively. Among these starches, McGarett had the lowest GTR. Maizena had the initial temperature 67.3°C, a little higher than that of McGarett, the same midpoint temperature as the DPC starch and Friendship, and a little higher final temperature (74.8°C) than Friendship.

Solubility and swelling patterns

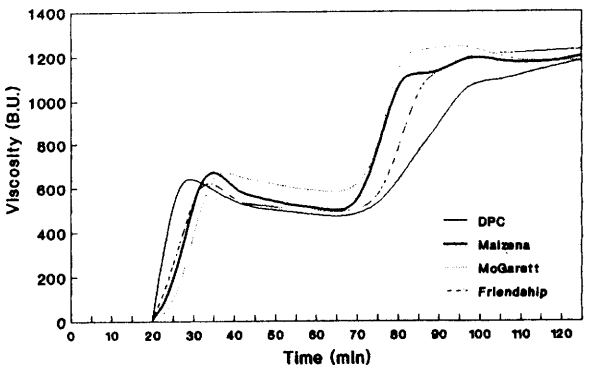
Solubility and swelling patterns of the DPC starch and the three commercial ones at 60, 70 80 and 90°C were presented in Figure 4 and Figure 5 respectively. At temperatures below their gelatinization temperatures (less than 70°C), all starches were less soluble. The solubility was increased rapidly between 70° and 90°C. After gelatinization temperature, the DPC starch had the highest solubility whereas McGarett had the lowest. Maizena showed higher solubility than Friendship between 70°C and 74°C, but thereafter the solubility of Friendship was higher. The swelling patterns of these starches were quite similar to that of the solubility characteristics. Prior to gelatinization, there was little increase in swelling capacity. Once the gelatinization set in, however, swelling increased rapidly with increasing temperatures. The increase was even more pronounce for the DPC starch whereas the three commercial ones had the lower swelling powers.

Gelation and degree of syneresis

The least gelation concentrations of the DPC starch and the three commercial ones were at 5% w/v starch concentration. The degree of syneresis decreased as the concentration of the starch gel increased (Figure 6). The degree of syneresis of McGarett was higher than those of Maizena and the DPC starch at every starch concentration. This might be due to the lower amylose content of McGarett that caused less



Figrure 6 Degree of syneresis of various corn starches at different temperature.



Figrure 7 Barbender viscogram of various corn starches.

retrogradation during the gel formation and it resulted in the weaker gel structure. This reason also applied to the higher degree of syneresis of the DPC starch as compared to that of Maizena at the starch concentrations higher than 9.5%. However, the degree of syneresis of Friendship, though, decreased as the concentration of the starch gel increased, did not agree with amylose content.

Pasting properties

The results of Brabender viscosity patterns were presented in Figure 7, Table 7 and Table 8. The viscosity curves of the DPC starch and the three commercial ones showed typical behavior of paste viscosity for normal corn starch. The viscosity increased as the temperature increased until the curve reached moderate peak viscosity, continued with a little break-down during cooking which indicated consequent stability of its swollen granules, and a very high set-back on cooling due to retrogradation of its linear fraction. Though, little variation of the curves due to different sources of corn starch could be observed.

The results of initial pasting temperatures and viscosities at five significant points on the viscosity curves of these corn starches were shown in Table 7. Initial pasting temperatures of Maizena and Friendship were at 74.0°C which was a little higher than the DPC starch (73.3°C) and McGarett (71.0°C). Maizena possessed the highest peak viscosity (740 B.U.) whereas the DPC starch showed the lowest at 660 B.U. equal to Friendship. Among these starches, Maizena was the most difficult to cook whereas the DPC starch was the easiest as indicated by the viscosities at 95°C which were 710 and 590 B.U., respectively. The stability of these starches after continual cooking for 30 min. as indicated by breakdown viscosity (Table 8) showed that McGarett was the most stable and Maizena was the least stable among them. Upon cooling, McGarett had the highest set-back (560 B.U.) with consistency 677 B.U. whereas the DPC starch and Maizena had the same lowest set-back value (440 B.U.) with consistency of 630 and 680 B.U, respectively.

LITERATURE CITED

A.O.A.C. 1990. Official method of analysis (15th ed.). The Association of Official Analytical Chemists. Washington, D.C. 1298 p.

Juliano, B.O., C.M. Perez, A.B. Blakeny, T. Castillo, N. Kongseree, B. Laignelet, E. T. Lapis, V.V.S. Murty, C.M. Paule and B.D. Webb. 1981. International cooperative testing on the amylose content of milled rice. Starch 33(5) : 157-162.

Leach, H.W., L.D. McCowen and T.J. Schoch. 1959. Structure of the starch granule. I. Swelling and solubility patterns of various starches. Cereal Chem. 36 : 534-544.

Radley, J.A. 1976. Examination and analysis of starch and starch products. p. 13. Applied Science Publishers Ltd., London.

Schoch, T.J. and Eileen C. Maywald. 1956. Microscopic examination of modified starches. Anal. Chem. 28 : 382-387.

Sathe, S.K. and D.K. Salunkhe. 1981. Isolation, partial characterization and modification of the great Northern bean (*Phaseolus vulgaris* L.) starch. J. Food Sci. 46(2) : 617-621.

Thailand Industrial Standard Institute. 1986. Standard for Corn Starch TIS 637-2529. Ministry of Industry. Bangkok.13 p.

Yang, Chi-Chuen., Shuh-Ming Chang and Cheng-yi Lii. 1980. Studies of the starches in Taiwan, 4. Kidney bean. Bull. of the Institute of Chemistry Academia Sinica. No. 27. pp. 23-32.