

# Changes in Some Physicochemical Properties of Tapioca and Glutinous Rice Starches after Microwave Heating

Wootthichai Narkrugsal<sup>1</sup>

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## ABSTRACT

Changes of some physicochemical properties of tapioca and glutinous rice starches were studied after heating with microwave at 2450 MHz at various times (0,3,5,5,8.5 and 10 min) and various initial moisture contents (13,15,20,25 and 27%) in a stainless steel tray (27 × 30 cm<sup>2</sup>) with 10 mm height of the samples. By comparison with their native starches, the shearing stability and the freeze-thaw stability of the microwaved starches were decreased with increasing heating time and decreasing initial moisture content. The water absorption index was increased with increased heating time and increasing initial moisture content.

**Key word :** starch, physicochemical, glutinous rice, tapioca, microwave, heating

## INTRODUCTION

During drying or heating processes of starches, such as hot air drying, solar drying, drum drying, spray drying and cooking extrusion, starches not only decrease in moisture content but also their physico-chemical properties are changed. In wet heat treatment, it is believed that the reorientation of polymer chains within the starch granules is occurred, inducing and modified physicochemical properties (Golachowski, 1985; Colonna *et al.*, 1987). Physicochemical properties such as shearing stability, freeze-thaw stability, water absorption index, and water solubility index are always changed after heat treatment (Schweizer and Reimann, 1986;

Fornal *et al.*, 1987; Narkrugsal and Berghofer, 1992).

Microwave is a useful process to reduce some water in foods at very short time. Microwave heating range between 915 and 2450 MHz were normally used in the food industries (Decareau, 1985). Regarding with the frozen foods and pastes, microwaves generate heat within the foods and paste to vapourise the moisture or to thaw ice. Compared with hot air drying, microwave drying prevented damage to the surface, improved the moisture transferring during the later stages of drying and eliminated case hardening, especially in the moist areas (Fellows, 1988).

The purpose of the present study was to examine changes in some physicochemical

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<sup>1</sup>Department of Agricultural Industry, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, KMITL, Bangkok 10520, Thailand.

properties of tapioca starch and glutinous rice starch after microwave heating at various times and initial moisture contents.

## MATERIALS AND METHODS

Tapioca starch and glutinous rice starch were bought from the local market in Ladkrabang district of Bangkok, Thailand. Moisture content, crude fat and ash were analyzed by using the AOAC (1995) method no 14.004, 7.004 and 14.006, respectively.

The experimental design was a response surface method with two factors, the heating time and the initial moisture content, in various levels (Table 1 and 2). Both raw materials were conditioned with distilled water to set initial moisture contents at 13, 15, 20, 25 and 27% at room temperature for 18 hrs to set a good moisture distribution before heating with a microwave oven (Goldstar model ER-461 OD, Korea) at 2450 MHz in a stainless steel tray ( $27 \times 30 \text{ cm}^2$ ) with the 10 mm height of the sample for 0, 3, 5, 8.5 and 10 min. Then the microwaved samples were packed in plastic bottles and stored at a room temperature for 24 hours. The samples were used to inspect some of the physico-chemical properties.

To inspect the shearing stability, the method of Klaushofer *et al.* (1975) was used. A 20 g starch (dry basis) was mixed with distilled water to a total weight 300 g in the stainless steel cups with rotor

mixer (Kika Laboratechnik Type RW20, German) at 240 rpm, 95°C for 30 min with blade no 1. Then paste viscosity ( $V_a$ ) was measured in centipoise (cp) with Brookfield Viscometer model RVF-100 by using spindle no 2. The paste was then sheared again at 2000 rpm, 95°C for 5 min with blade no 3 and paste viscosity ( $V_b$ ) again was measured. Shearing stability was calculated by using the following formula.

$$\% \text{ Shearing stability (SHS)} = (V_b / V_a) * 100$$

Freeze-thaw stability, a modified method based on Schoch (1968) and Narkrugsa (1990) was used. Starch, 7.5 g (dry basis) for the glutinous rice starch but 15 g (dry basis) for the tapioca starch, was mixed with 300 ml distilled water in the stainless steel cup at 95°C with rotor mixer speed 240 rpm for 20 min. Then the mixture or paste was poured into a plastic cup and frozen at -10°C in deep freezer (Sanyo model 600LA, Japan) for 7 days. The mixture was then thawed in a water bath at 30°C for 4 hrs. A 100 ml of the mixture was centrifuged (Jouan model GR4-11, France) at 8000 rpm for 30 min. The result was reported as the amount of separated water (FTS, %) from the mixture in the centrifuge tube.

Water absorption index, a modified method based on Schoch (1968) was used. Approximately 2.5 g ( $W_0$ , dry basis) of the milled microwaved starch (the particle size <60 mesh or passed through the sieve of Fritsch type 08502 No.7813, German) was mixed with 30 ml distilled water in the bottle

**Table 1** Experimental design by response surface method for microwave heating of starches.

Factors	Code	Level				
		-1.414	-1	0	1	1.414
Heating time, min.	$X_1$	0	3.5	5	8.5	10
Initial moisture content	$X_2$	13	15	20	25	27

**Table 2** Level combinations coded and real for heating time ( $X_1$ ,min) and initial moisture content ( $X_2$ ,%) in experiment conditions.

Treatment	Level of $X_1$		Level of $X_2$	
	Coded	Real	Coded	Real
1	-1	3.5	-1	15
2	-1	3.5	1	25
3	1	8.5	-1	15
4	1	8.5	1	25
5	1.414	10	0	20
6	-1.414	0	0	20
7	0	5	1.414	27
8	0	5	-1.414	13
	9	0	5	0 20
10	0	5	0	20
11	0	5	0	20
12	0	5	0	20
13	0	5	0	20

and then was shaken in the water bath at 300C for 30 min. The mixture ( $W_1$ ,g) was centrifuged at 8000rpm for 10 min. The water was decanted out of the centrifuge tube and the mixture was weighed ( $W_2$ ,g) again. Water absorption index was calculated by using the following formula.

$$\text{Water absorption index (WAI)} = (W_1 - W_2) / W_0 * 100$$

## RESULTS AND DISCUSSION

Tapioca starch (12.19±0.079% moisture content, 0.93±0.020% crude fat and 0.29±0.018% ash) and glutinous starch (11.37±0.085% moisture content, 1.32±0.028% crude fat and 0.25±0.015% ash) were inspected the shearing stability, the freeze-thaw stability and the water absorption index after microwave heating at 2450MHz. ( Table 3.)

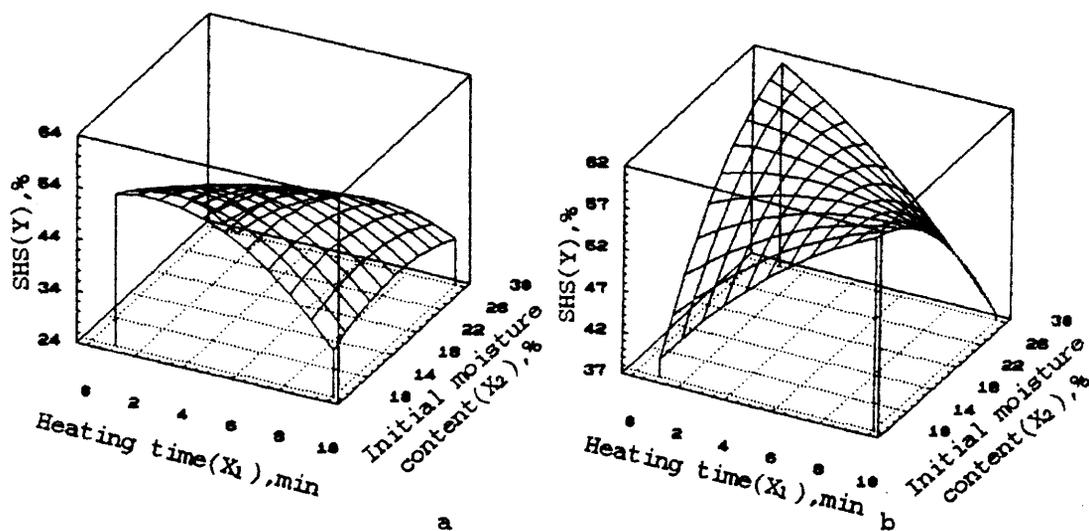
The results showed that the longer heating

time and lower initial moisture content decreased the shearing stability of starches comparing with native starches (13% moisture content and non microwave heated) ,as shown in Figure 1. The glutinous starch which had 15% initial moisture content and heating for 3.5 min had the maximum SHS (48%) of glutinous rice starch while the tapioca starch which had 25% initial moisture content and heating for 3.5 min had the maximum SHS (59%) of tapioca starch. From Table 4 the SHS correlated to the initial moisture content ( $X_2$ ),  $X_1^2$ ,  $X_2^2$  and  $X_1X_2$  as a medium negative for the glutinous rice starch while as a low negative for the tapioca starch. The models of the SHS as response (Y) of the two starches were  $Y = 8.364029 + 6.135353X_1 + 3.188349X_2 - 0.118183X_1^2 - 0.045735X_2^2 - 0.24869X_1X_2$  ( $r^2 = 0.66$  at  $P \leq 0.05$ ) for the tapioca starch and  $Y = 56.704267 + 0.312254X_1 - 0.1317X_2 - 0.377546X_1^2 - 0.037099X_2^2 + 0.160464X_1X_2$  ( $r^2$

**Table 3** Some physicochemical properties of tapioca starch and glutinous rice starch after microwave heating.

Treatment	Tapioca starch			Glutinous rice starch		
	SHS	FTS	WAI	SHS	FTS	WAI
1	54.0	37.0	77.9	48.0	44.0	149.0
2	59.0	52.5	82.1	43.0	45.0	145.9
3	56.0	47.0	82.6	45.0	49.7	166.2
4	48.5	58.5	82.8	46.0	49.0	146.6
5	50.0	42.0	89.2	33.0	51.5	175.2
6	53.0	50.0	75.2	39.0	44.0	132.4
7	55.5	53.5	79.9	33.5	43.0	137.3
8	54.0	54.5	81.3	50.0	45.0	144.1
9	56.5	39.0	87.6	47.0	47.0	140.4
10	57.5	40.5	88.5	47.6	46.0	139.9
11	55.5	38.5	87.5	47.2	47.0	140.5
12	58.0	37.8	87.0	46.4	48.5	140.8
13	56.0	40.2	86.2	46.8	46.5	140.4

Note: The data in the table were mean from the two determinations.



**Figure 1** Response surface plot for the effect of the microwave heating time and the initial moisture content on the shearing stability of of glutinous rice starch(a) and tapioca starch(b).

**Table 4** Correlation coefficient(r) of responses and variables.1

Variables	Responses					
	SHS		FTS		WAI	
	T-Starch <sup>2</sup>	G-Starch <sup>3</sup>	T-Starch <sup>2</sup>	G-Starch <sup>3</sup>	T-Starch <sup>2</sup>	G-Starch <sup>3</sup>
Heating time, X <sub>1</sub>	-0.1159	-0.2463	0.0668	0.4455	0.2330	0.8515
Initial moisture content, X <sub>2</sub>	-0.0148	-0.5348	0.3642	-0.3864	0.2424	-0.0696
X <sub>1</sub> <sup>2</sup>	-0.2139	-0.4279	0.1391	0.4656	0.1076	0.9142
X <sub>2</sub> <sup>2</sup>	-0.0404	-0.5302	0.4391	-0.4416	0.1802	-0.0520
X <sub>1</sub> X <sub>2</sub>	-0.2008	-0.4077	0.2063	0.1829	0.3417	0.7658

1 The sample size was 25 determinations.

2 T-Starch= Tapioca starch

3 G-Starch= Glutinous rice starch

= 0.77 at  $P \leq 0.05$ ) for the glutinous rice starch.

Regarding with the freeze-thaw stability of the two starches, they were decreased with longer heating time and decreasing the initial moisture content (Figure 2). The glutinous rice starch, 27% initial moisture content and heating for 5 min gave the lowest of FTS-value (43%) while the tapioca starch, 15% initial moisture content and heating for 3.5 min gave the lowest of FTS-value (37%) (Table 3). The FTS of tapioca starch correlated to both variable as a low positive while the FTS of glutinous rice starch correlated to only the heating time ( $X_1$ ),  $X_1^2$  and  $X_1X_2$  as a very low and a low positive but correlated to the initial moisture content ( $X_2$ ) and  $X_2^2$  as a low negative (Table 4). The models of the FTS as response (Y) of the two starches were  $Y = 159.987922 - 3.741542X_1 - 11.854445X_2 + 0.345978X_1^2 + 0.31305X_2^2 + 0.004165X_1X_2$  ( $r^2 = 0.75$  at  $P \leq 0.05$ ) for tapioca starch and  $Y = -1.122787 + 4.16531X_1 + 3.82238X_2$

$+ 0.002641X_1^2 - 0.076761X_2^2 - 0.183826X_1X_2$  ( $r^2 = 0.88$  at  $P \leq 0.05$ ) for glutinous rice starch.

The water absorption index or WAI of the two starches were increased with longer heating time and increasing initial moisture content (Figure 3). The maximum WAI of glutinous rice starch (175.2%) and tapioca starch (89.2%) were found from starches that had 20% initial moisture content and heated for 10 min (Table 3). The correlation between WAI and both variables for tapioca starch were low positive while for glutinous rice starch only the heating time ( $X_1$ ),  $X_1^2$  and  $X_1X_2$  were high positive (Table 4). The models of WAI as response (Y) were  $Y = 11.595585 + 0.11484X_1 + 7.122494X_2 - 0.303245X_1^2 - 0.19549X_2^2 + 0.186908X_1X_2$  ( $r^2 = 0.71$  at  $P \leq 0.05$ ) for tapioca starch and  $Y = 227.757108 - 7.496759X_1 - 7.420976X_2 + 0.581475X_1^2 + 0.138236X_2^2 + 0.299105X_1X_2$  ( $r^2 = 0.89$  at  $P \leq 0.05$ ) for glutinous rice starch.

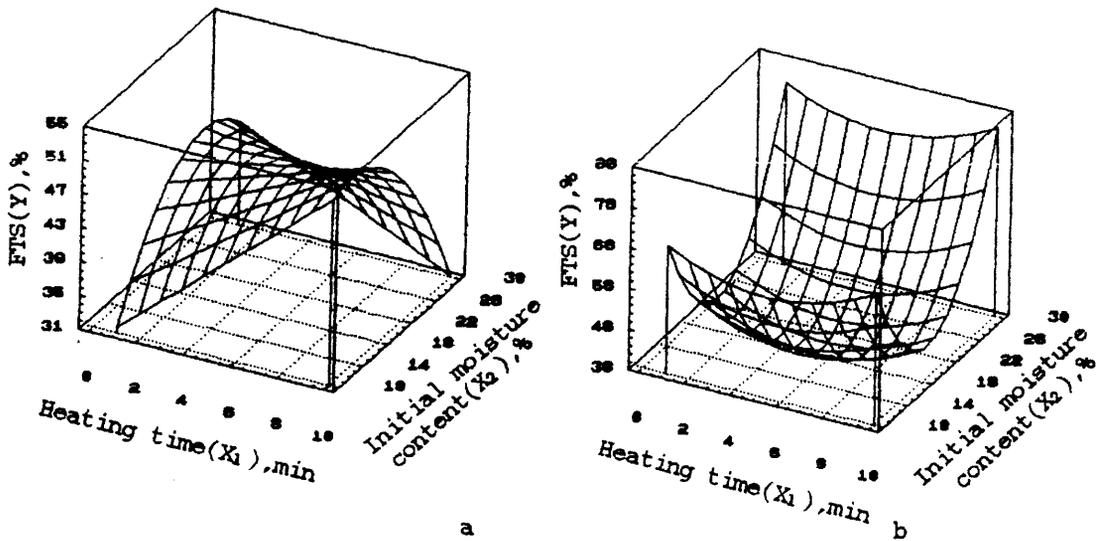


Figure 2 Response surface plot for the effect of the microwave heating time and the initial moisture content on the freeze-thaw stability of glutinous rice starch(a) and tapioca starch(b).

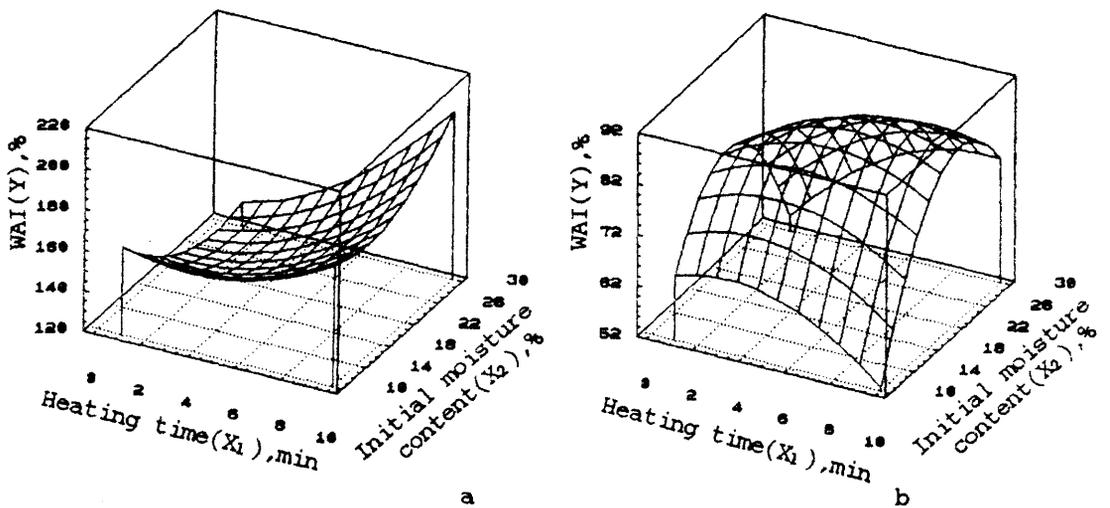


Figure 3 Response surface plot for the effect of the microwave heating time and the initial moisture content on the water absorption index of glutinous rice starch(a) and tapioca starch(b).

## CONCLUSION

Effects of microwave heating on some physicochemical properties of glutinous rice starch and tapioca starch were studied by heating starches with microwaves at 2450 MHz at various times and various initial moisture contents. Compared with their physicochemical properties of the two native starches, the results showed that shearing stability and freeze-thaw stability were decreased with increasing heating time and decreasing initial moisture content of starches, whereas water absorption index was increased with increasing heating time and increasing initial moisture content.

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