Kasetsart J. (Nat. Sci.) 29 : 515 - 520 (1995)

Microwave Effect on the Gelatinized Conditions on Tapioca and Glutinous Rice Starches

Woatthichai Narkrugsa[1]

ABSTRACT

Microwave effect on starch gelatinization was studied by using tapioca starch and glutinous rice starch as raw materials. Starch samples were heated in the microwave at 2450 MHz in various initial moisture content (13,15,20,25 and 27%) and heating times (0,3.5,5,8.5 and 10 min). Heating was done in the range of 78°-143°C for tapioca starch and 78°-146°C for glutinous rice starch. The retained moisture content of microwave heated starch were 6.90-19.76% for tapioca starch and 7.08-19.61% for glutinous rice starch.Regarding to the gelatinization of starch, it was found that the microwave affected starch to gelatinize. Expressing the gelatinization as degree of gelatinization (%DG), it was shown that the%DG of tapioca starch was 15.00-82.88 while the %DG of glutinous rice starch was 10.80-77.38. The %DG had correlation coefficient (r) to the heating time (X_1) and the initial moisture content (X_2) 0.7947 and-0.1620, respectively, for tapioca starch, and 0.8465 and -0.2554, respectively, for glutinous rice starch. The multiple regression of the %DG as a response (Y) due to factor X_1 and X_2 at the second order was also studied. For tapioca starch, $Y = -131.891609 + 26.263387X_1 + 7.370923X_2 + 0.628992X_1^2 - 0.0306X_2^2 - 1.275157X_1X_2$ (r^2=0.940 at P £ 0.05), and for glutinous rice starch, $Y = 17.221115 - 3.177827X_1 + 0.032624X_2 + 0.198334X_1^2 + 0.003831X_2^2 + 0.003256X_1X_2$ (r^2=0.965 at P £ 0.05), were resulted.

Key word: starch,gelatinized starch,glutinous rice,tapioca,microwave

INTRODUCTION

In prepared foods, gelatinized starch affects food texture by absorbing water, forming a gel or increasing viscosity of mixtures. The proportion of raw and gelatinized starch in ready to serve starchy products is the principal factor in determining acceptability. Foods, that their texture is depended on gelatinized starch, are breakfast cereals, beverages, noodles, pasta, dreied soup and crispy snacks. The quantitative of the starch gelatinization as the degree of gelatinization was an obvious choice as index of the cookking process (Birch and Priestley, 1973; Chinachot *et al.* 1990; Guraya and Toledo,1993).

Gelatinined starch are able to produce by using drum dryer and extruder (Narkrugsa and Berghofer,1992). Microwave can create the heat inside the material that contains of the polar molecues such as water (Decareau,1985). Narkrugsa (1993) found that Starch Citrate can be produced by using microwave heating technique to create the thermal energy for esterification.

In this experiment, tapioca starch and glutinous rice starch were gelatinized by using microwave to create heat at various levels of the

[1] Department of Agricultural Industry, Faculty of Agricultural Technology. King Mongkut's Institute of Technology Ladkrabang, KMITL Bangkok 10520, Thailand.

amount of water content as initial moisture content during heating.The degree of gelatinization of starches is the main objective of the experiment.

MATERIAL AND METHODS

Tapioca starch and glutinous rice starch which had the compositions showing in the Table 1, were used as raw materials for gelatinization by heating with microwave at 2450 MHz (Goldstar model 4160 D, Korea). Response surface method was used to design the experiment at various heating time (0, 3.5, 5, 8.5 and 10 min, X_1) and various initial moisture content (13, 15, 20, 25 and 27%, X_2) as shown in the Table 2 and 3. Designed initial moisture content of starches, sample of starches were added with the distilled water and should be conditioned at a room temperature 18 hours for a good moisture distribution in the samples before microwave heating.Then 500 grams of the sample was trasnfered into a tray ($27 \times 30\ cm^2$) with 10 mm height of the samples. Heating temperature was determined by using a couple of wire probes connected with temperature moniter (Digicon model DD-6,Japan) ;the measuring was done at five positions into the sample layer on a tray after heating and the averaged temperatures was reported.

The gelatinization of starches were expessed in the degree of gelatinization (%DG) that analysed by using the method of Guraya and Toledo (1993). The retained moisture content was also analysed by using AOAC (1995).

RESULTS AND DISCUSSION

Microwave heating was able to gelatinize starches by creating the thermal inside starches on the tray. The temperature of heated starches were shown in Table 4. From the results in Table 5 the heating temperature correlated to the heating time (X_1),X_1^2,X_1X_2 as a high positive for the two starches while the heating temperature correlated to the initial moisture content (X_2) and $(X_2)^2$ as a low positive. The response surface plots of the heating temperature of the two starches were shown in Figure 1. The models of the heating temperature

Table 1 Compositions of raw materials (dry basis).

Raw material	Moisture content %	Crude fat %	Ash %
Tapioca starch	12.19±0.079	0.93±0.020	0.29±0.018
Glutinous rice starch	11.37±0.085	1.32±0.028	0.25±0.015

Table 2 Response surface method experimental design of microwave heating time and initial moisture content of starches.

Factors	Code	Levels				
		-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 3 Level combinations coded and real for the heating time (X_1,min) and the 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

Table 4 Heating temperature, retained moisture content and degree of gelatinization of starches after microwave heating.[1]

Treatment	Heating temperature,°C		Retained moisture content,%		Degree of gelatinization,%	
	T-Starch[2]	G-Starch[3]	T-Starch	G-Starch	T-Starch	G-Starch
1	78	78	9.95	10.03	15.00	19.39
2	97	84	12.45	12.13	20.31	24.14
3	109	106	7.67	7.33	73.56	51.37
4	121	127	9.56	9.52	21.70	10.80
5	143	146	7.45	6.87	82.88	77.38
6	29	29	19.76	19.61	0	0
7	128	97	12.55	9.78	26.63	16.86
8	83	88	6.90	7.08	18.07	17.68
9	98	89	9.80	8.60	24.00	31.64
10	109	119	9.10	8.90	20.10	30.00
11	110	104	9.10	8.90	22.05	30.82
12	105	125	9.33	8.80	23.00	32.00
13	104	107	8.61	8.77	21.10	29.64

Note: 1 The results in the table were mean of duplicate.
2 T-Starch = Tapioca starch
3 G-Starch = Glutinous rice starch

Table 5 Correlation coefficient (r) of responses and variables.[1]

Variables	Responses					
	Heating temp.		Retained moisture content		Degree of gelatinization	
	T-Starch[2]	G-Starch[3]	T-Starch	G-Starch	T-Starch	G-Starch
Heating time,X_1	0.8690	0.9877	-0.8055	-0.7981	0.7947	0.8465
Initial moisture Content,X_2	0.2975	0.0677	0.4201	0.3315	-0.1620	-0.2554
X_1^2	0.7529	0.9369	-0.7063	-0.6719	0.8636	0.8638
X_2^2	0.2952	0.0646	0.4176	0.3273	-0.1638	-0.2673
X_1X_2	0.9129	0.9123	-0.6395	-0.6670	0.5921	0.6109

Note: 1 The sample size was 25 determinations.
2 T-Starch = Tapioca starch
3 G-Starch = Glutinous rice starch

as response (Y) of the two starches were $Y = -80.941259 + 24.663205X_1 + 7.509233X_2 - 0.97846X_1^2 - 0.093726X_2^2 - 0.251853X_1X^2$ (r^2 = 0.930 at $P \leq 0.05$) for tapioca starch and $Y = -115.102797 + 14.016676X_1 + 15.398134X_2 - 0.996538X_1^2 - 0.405353X_2^2 + 0.329876X_1X_2$ (r^2 = 0.899 at $P \leq 0.05$) for glutinous rice starch.

The retained moisture content of the two starches (Table 4 and 5) correlated to the heating time (X_1) as a high negative, to $(X_1)^2$ and X_1X^2 as a medium negative,and to the initial moisture content (X_2) and $(X_2)^2$ as a low positive.The response surface plots of the retained moisture content of the two starches were shown in Figure 2. The models of the retained moisture content as a response (Y) of the two starches were $Y = 16.552101 - 2.526319X_1 - 0.156103X_2 + 0.190947X_1^2 + 0.015083X_2^2 - 0.024812X_1X_2$ (r^2 = 0.968 at $P \leq 0.05$) for tapioca starch and $Y = 17.221115 - 3.177827X_1 + 0.032624X_2 + 0.198334X_1^2 + 0.003831X_2^2 + 0.003256X_1X_2$ (r^2 = 0.965 at $P \leq 0.05$) for glutinous rice starch.

Regarding with the degree of gelatinization of the two starches (Table 4 and 5),showed the correlation to the heating time (X_1) and $(X_1)^2$ as a high positive, to the initial moisture content (X_2) and $(X_2)^2$ as a low negative,and to X_1X_2 as a medium positive. The response surface plots of the degree of gelatinization of the two starches were shown in Figure 3. The models of the degree of gelatization as a response (Y) of the two starches were $Y = -131.891609 + 26.263387X_1 + 7.370923X_2 + 0.628992X_1^2 - 0.0306X_2^2 - 1.275157X_1X_2$ (r^2 = 0.940 at $P \leq 0.05$) for tapioca starch and $Y = -224.287968 + 24.394425X_1 + 18.568361X_2 + 0.054806X_1^2 - 0.354461X_2^2 - 0.967015X_1X_2$ (r^2 = 0.833 at $P \leq 0.05$) for glutinous rice starch.

CONCLUSION

The microwave heating process of the tapioca and glutinous rice starches showed that the heating time was the principal effect to the heating temperature, the retained moisture content and the

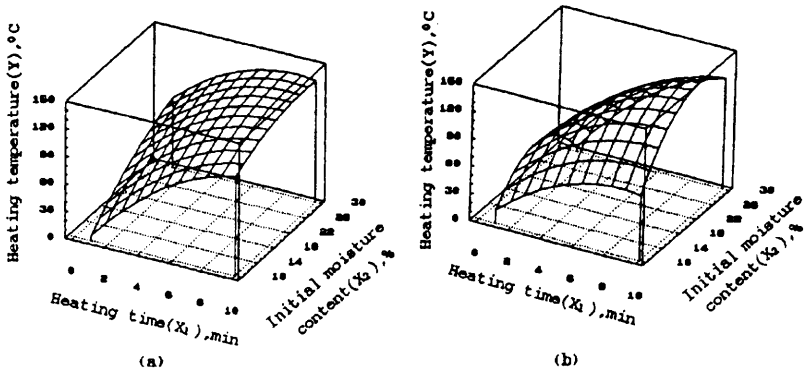


Figure 1 Response surface plot for the heating temperature.
(a : tapioca starch, b : glutinous rice starch)

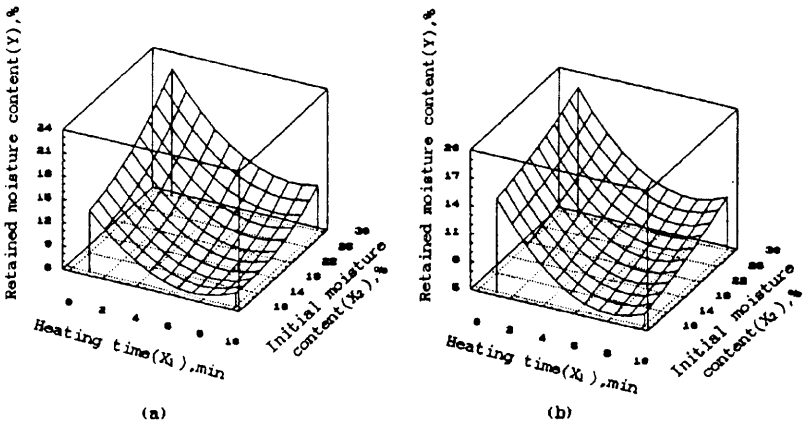


Figure 2 Response surface plot for the retained moisture content.
(a : tapioca starch, b : glutinous rice starch)

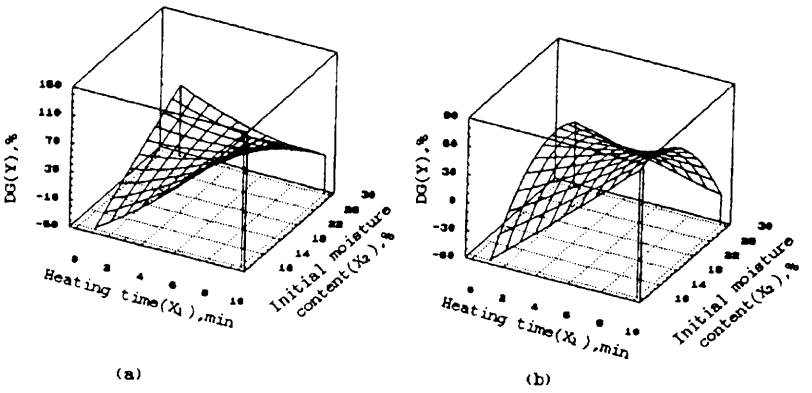


Figure 3 Response surface plot for the degree of gelatinization.
(a : tapioca starch, b : glutinous rice starch)

degree of gelatinization of the two starches as a high positve, a high negative and a high positive, respectively. The initial moisture content of the starch before the microwave heating process was the minor effect for both responses. The interaction of the heating time and the initial moisture content was also the principal effect to the heating temperature as a high positive,and was a medium effect to the retained moisture content as a medium negative and the degree of gelatinization as a medium positive. The highest of the degree of starch gelatinization (82.88% for tapioca starch and 77.38% for glutinous rice starch),the sample was heated at frequency 2450 MHz for 10 min and at the initial moisture content 20%.

LITERATURE CITIED

AOAC. 1995. Official Method of Analysis, 16th ed. Association of Official Analytical Chemists. Washington, DC.

Birch, G.G. and R.J. Priestley. 1973. Degree of gelatinization of cooked rice. Die Starke 25:98-100.

Chinachoti, P., M.P. Steinberg, and R. Villota. 1990. A model for guantitating energy and degree of gelatinization base on water, sugar and salt contents. Journal of Food Science 55:543-546.

Decareau, R.V. 1985. Microwave in the Food Processing Industry. Academic Press, Inc. Orlando, Florida. 236p.

Guraya, H.S. and R.T. Toledo. 1993. Determining gelatinized starch in a dry starchy product. Journal of Food Science 58:888-889,898.

Narkrugsa, W. and Berghofer, E. 1992. Physicochemical properties of modified cassava flour and starch for corrugated board Adhesive. Kasetsart J. (Nat.Sci.) 26:314-323.

Narkrugsa, W.1993. Study on the feasibility of starch citrate production by microwave technique, pp. 277-280. *In* Proceeding of the 31st Kasetsart University Annual Conference Febuary 3-6,1993,Kasetsart University Bangkok.