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Effect of Microwave on Pasting Properties of Heat-Moisture Treated Tapioca Flour And Corn Flour

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ABSTRACT

Tapioca and corn flour adjusted to 20% and 25% moisture (wet basis, w.b.) were heat-moisture treated in microwave oven at power 900 watts to determine the effect of microwave heating time at 15 sec, 30 sec, 45 sec, and 60 sec on pasting properties of the heated flours. It was found that pasting properties of tapioca and corn flour significantly changed after microwave heat treatment. At 20% moisture, tapioca flour heated in microwave oven showed increase heating time increased setback viscosity from 610 cP (non-treated flour) to 723 cP and pasting temperature from 72.0 ^{0}C (non-treated flour) to 73.8 ^{0}C after heating for 60 sec, while breakdown viscosity decreased from 1031 cP (non-treated flour) to 940 cP after heating for 60 sec. For 20% (w.b.) corn flour found that the pasting properties don't significantly change after heated in microwave at duration 0 -60 sec. At 25% tapioca flour heated in microwave oven showed increase heating time increased setback viscosity from 610 cP (non-treated flour) to 719 cP, pasting time from 4.4 min (non-treated flour) to 4.7 min and pasting temperature from 72.0 ^{0}C (non-treated flour) to 73.7 ^{0}C after heating for 60 sec, while breakdown viscosity decreased from 1031 cP (non-treated flour) to 910 cP after heating for 60 sec. For 25% (w.b.) corn flour heated in microwave oven showed increase heating time increased breakdown viscosity from 150 cP (non-treated flour) to 172 cP and setback viscosity from 138 cP (non-treated flour) to 176 cP after heating for 60 sec. The data obtained in this study indicate that moisture content and heating time in microwave had affect on pasting properties of tapioca flour and corn flour.

Key words: Microwave; Heat-moisture; Tapioca flour; Corn flour; Pasting properties

INTRODUCTION

Heat-moisture treatment (HMT), a physical modification technique for modified starch, was natural and safe when compared with chemical modification. This method involved treatment of flour or starch at temperature (80 – 120 ^{0}C) below the gelatinization temperature, at very restricted moisture content (20-30% moisture w/w), and during time (15 min – 16 hr) [4,7,18]. Under the above condition, HMT induced changes in structure and properties of flour and starch. The size of protrusion on the surface of HMT starch decreased when compared with native starch [9]. The pasting properties of starch treated with heat-moisture method changed when compared with native starch such as lower paste viscosity in HMT canna starch [18], and changes pasting profiles of rice starch and rice flour especially rice flour [15]. Flour is fine powder which obtained by grinding the raw materials such as seed, grain, root or tuber. The composition of flour consists of starch, non-starch polysaccharide, protein, lipid, and inorganic materials. Khamthong and Lumdubwong [10] found that HMT induced β-turn conformation of rice proteins which causes the properties of HMT rice flour differ from HMT rice starch.

Traditionally, the heating in HMT method for study the effect of heat-moisture treatment on the properties of starch used conventional air oven such as hot-air oven [1,12,9], or boiling [4]. Microwave oven is popular in the kitchens. In microwave processing, energy was supplied by electromagnetic field directly to food material and affect on various food materials differently from conventional cooking [17,3]. Under the condition of heat-moisture treatment, the microwave heating induced changes in structure and properties of HMT starches such as crystalline structure of potato starch changes from Type B to type A [14], increasing gelatinization temperature of wheat corn and waxy starch [13]. Fan *et al.* [5] studied the starch-water interaction during microwave heating. They found that vibration mechanisms of polar molecule accelerated the destruction of hydrogen bonds between starch and

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water molecule. A microwave energy application in the study of HMT of tuber and grain flour, which consists of protein and other materials beside of starch, has not been commonly studied. The objective of this study was to apply microwave heating to heat-moisture treated flour in order to evaluate the effect of microwave heat-moisture treatment on the pasting properties and microstructure of tapioca flour and corn flour.

Materials and Methods

1.1 Materials:

Tapioca and corn flour were obtained from Artchit International Pepper and spice Co., Ltd. (Nguan soon, Hand brand No.1) Thailand. Moisture content of flour, was adjusted to 20 and 25 %(wet basis) and stored in the aluminum containers at room temperature for further use.

1.2 Heat-moisture treatment in microwave oven:

Moisture-adjusted flour sample (12.0g) was placed in crucible (30 ml), covered the lid, and placed in an Electrolux Model EMS 2475 commercial microwave oven. The flour sample was heated at power 900 Watts for 0, 15, 30, 45 or 60 sec. Then, the heat-moisture treated flour sample in microwave was dried by using 50 ^{0}C $\pm$ 2 ^{0}C in hot air oven to about 13% moisture content. The flour sample was kept in aluminum bag at room temperature for 1 day.

2.3 Pasting properties:

A Rapid Visco-Analyzer (Newport Scientific model RVA-3D, Sydney, Australia) was used to evaluate the pasting properties of heat-treated flour samples. About 3.0 g of flour (13 % moisture content) was weighed and put into 25 g distilled water in aluminum RVA canister. The content was quickly stirred using a plastic paddle for 10 times before placed into Rapid Visco-Analyzer. The temperature profile consisted of equilibrating the flour suspension at 50 ^{0}C for 1 min, then heated to 95 ^{0}C at 12.2 ^{0}C/min, and held at 95 ^{0}C for 2 min 30 sec. It was subsequently cooled to 50 ^{0}C at 11.8 ^{0}C/min, and held at 50 ^{0}C for 2 min. The rotation speed was maintained at 160 rpm. The pasting characteristics: peak viscosity (PV), trough (T), breakdown (BD), final viscosity (FV), and setback from trough (SB) were determined from Newport Scientific's ThermoCline for Windows software. All measurements were done in triplicate.

1.3 Scanning Electron Microscope (SEM):

The samples of microwave heat-treated tapioca flour and corn flour were mounted on SEM stubs using double sided adhesive tape and were coated with gold. Scanning electron micrographs were taken using SEM (JEOL model JSM-6510 microscope, Tokyo, Japan) at the accelerating voltage of 5 kV and magnification of 3000 X and 10000 X.

1.4 Statistical analysis:

The experimental data were analyzed using one-way analysis of variance (ANOVA) and expressed as mean value $\pm$ standard deviations. The least significant difference (LSD) was conducted to examine significant difference among experimental mean values ($p \leq$ 0.05). The software used for analyses was GenStat 12.1.0.3338 software.

Results And Discussion

1.5 Pasting properties of heat-moisture treated tapioca flour and corn flour at 20 %(wet basis):

The RVA pasting properties of microwave heat-moisture treated tapioca flour and corn flour at 20% (w/w) were summarized in Table 1. At the condition of moisture content in flour samples 20% (w/w), it was found that pasting parameters of tapioca flour changed significantly ($p \leq$ 0.05) after microwave heat-treatment more than in corn flour, The pasting parameters of tapioca flour decreased with increasing heating time in microwave oven method, except setback viscosity and pasting temperature. Decrease of peak viscosity and increase in pasting temperature after microwave heat-moisture treatment were consistent with other starches treated with HMT which were reported for rice starch and rice flour by Puncha-arnon and Uttapap [15], canna starch by Watcharatewinkul et al. [18] or cocoyam starch by Lawal [11]. While, setback viscosity was commonly used to describe the viscosity of cooling pasted starch. Thus, the data obtained in this study indicated that microwave energy has affected on pasting temperature and the re-aggregation of tapioca flour was more than corn flour at this condition.

1.6 Pasting properties of heat-moisture treated tapioca flour and corn flour at 25 %(wet basis):

The RVA pasting properties of microwave heat-moisture treated tapioca flour and corn flour at 25% (w/w) were summarized in Table 2. At the condition of 25% (w/w) moisture content in flour samples. It was found that pasting parameters of tapioca flour and corn flour changed significantly ($p \leq$ 0.05) after microwave heat-treatment. The pasting parameters of both flours decreased with increased heating time in microwave oven, except setback viscosity and pasting temperature. These changes were more obvious at the heating time of 30 sec, the viscosity of the samples significantly deceased with increasing heating time. The viscosity of paste flours determined by using RVA, represented the behavior during cooking cycle (from 50 ^{0}C to 95 ^{0}C) reflected the capacity of flour to absorb water and swell as the paste was heated.

For tapioca flour, Peak viscosity (PV) of flour treated with microwave heat-moisture at 25 % (w/w moisture) for 60 sec was 1587 cP which was lower than that of non-treated flour (1910 cP). This may be due to the hydrophilic properties of protein in flour. The microwave energy denatured protein and fiber in flour so that PV of treated flour was lower than that of non treated flour. Breakdown viscosity (BD) of tapioca flour treated with microwave heat-moisture had the trendency to decrease with increasing of microwave heating time, Decreasing of BD showed that flour was resistant to heat and shear. Modification of starch made the double helix of amylose and amylopectin looser until hydrogen of amylose and amylopectin moving close together and created to hydrogen bond in crystalline, which brought to resistant starch [8]. During the final of cooling (from 95 ^{0}C to 50 ^{0}C), the setback viscosity increased owing to the alignment of the amylose chains [6]. Setback viscosity (SB) of flours ranged from 610 cP to 719 cP, the lowest being for non-treated flour and it increased with increasing heating time by using microwave. This result indicated that microwave energy increased tendency of flour retrogradation. Peak time of tapioca flour treated with microwave heat-moisture for 60 sec was 4.70 min which was higher than that of non-treated flour (4.41 min). Pasting temperature (PT) for tapioca flour ranged from 72.01^{0}C to 73.70^{0}C, the lowest being for non-treated flour and the highest for flour treated with microwave heat-moisture at 25%(w/w moisture) for 60 sec. PT was the indicator of the minimum temperature required to cook flour.

For corn flour, PV of corn flour treated with microwave heat-moisture was lower than that of non-treated flour. This may be due to the hydrophilic properties of protein in flour because corn flour consisted of high protein (5-8%) [16]. The microwave energy destroyed protein in flour so that PV of treated flour was lower than that of non treated flour. SB of corn flour ranged from 138 cP to 176 cP, the lowest being for non-treated flour and it increased with increasing heating time by using microwave. PT for corn flour sample ranged from 86.46^{0}C to 88.07^{0}C, the lowest being for non-treated flour and the highest for corn flour treated with microwave heat-moisture at 25%(w/w moisture) for 60 sec.

The data obtained in this study was consistent with other starches which reported by previous researchers [15,18,11]. They claimed that there were rearrangements of the starch structure by HMT. The scanning electron microscope of microwave heat-moisture treatment of tapioca and corn flour samples showed in Fig. 1 and Fig.2. In this study, morphology of flour samples treated with microwave heat-moisture indicated that microwave energy had the effect on structure of corn flour more than tapioca flour. At 25% (w/w), the surface of corn flour changed from smooth to rough during microwave heat-moisture treatment more than tapioca flour (Fig. 1). The rough surface of corn flour may be due to the changing of protein in corn flour denature because corn flour had protein content between 5-8% [16] For tapioca flour, the microwave energy had the effect on the surface less than corn flour. It may be because the chemical composition of tapioca flour is different from corn flour especially protein content, which is only 1-3% in cassava flour [2]. At magnified x10000 (Fig.2), it found that there were the compaction of matter among the granules of corn flour so that the pasting properties of corn flour treated with microwave heat-moisture changed more than the samples from tapioca flour.

Table 1: Rapid Visco Analyser pasting properties of microwave heat-treated tapioca and corn flour 20% (wet basis)

Kind of flour	Heating time(sec)	Viscosity (cP)					Peak time	Pasting temp.
		PV	Trough	BD	FV	SB	(min)	(^{0}C)
Tapioca	0	1910 ± 31^a	879 ± 27^a	1031 ± 58^a	1489 ± 44	610 ± 35^b	4.41 ± 0.06	72.01 ± 0.05^b
	15	1803 ± 40^b	798 ± 39^b	989 ± 48^{ab}	1489 ± 53	668 ± 29^{ab}	4.40 ± 0.10	72.00 ± 0.42^{ab}
	30	1826 ± 52^b	809 ± 20^b	957 ± 42^{ab}	1463 ± 48	654 ± 37^b	4.45 ± 0.05	72.85 ± 0.15^a
	45	1709 ± 38^c	769 ± 21^{bc}	969 ± 61^{ab}	1443 ± 37	674 ± 44^{ab}	4.41 ± 0.12	72.75 ± 0.12^a
	60	1698 ± 41^c	758 ± 23^c	940 ± 30^b	1481± 43	723 ± 32^a	4.41 ± 0.09	73.80 ± 0.38^a
Corn	0	999 ± 43	849 ± 39	150 ± 27	978 ± 21	138 ± 16	5.60± 0.04	86.46± 0.15
	15	1007 ± 51	845± 41	162± 33	972± 35	127± 30	5.63± 0.09	86.73± 0.33
	30	998 ± 37	841± 28	157± 21	971 ± 21	130± 27	5.61± 0.05	86.42± 0.47
	45	990 ± 41	829± 31	161± 37	959 ± 28	130± 33	5.63± 0.14	86.51± 0.14
	60	982± 53	830± 47	152± 33	952 ± 41	122± 47	5.63± 0.13	86.65± 0.17

PV = peak viscosity, BD = breakdown, FV = final viscosity, SB = setback, Pasting temp = pasting temperature.

Table 2: Rapid Visco Analyser pasting properties of microwave heat-treated tapioca and corn flour 25% (wet basis)

Kind of flour	Heating time(sec)	Viscosity (cP)					Peak time	Pasting temp.
		PV	Trough	BD	FV	SB	(min)	(^{0}C)
Tapioca	0	1910 ± 31^{a}	879 ± 27^{a}	1031 ± 58	1489 ± 44^{a}	610 ± 35^{b}	4.41 ± 0.06^{b}	72.01 ± 0.05^{b}
	15	1831 ± 49^{ab}	842± 43^{a}	989± 37	1517± 42^{a}	675± 31^{ab}	4.47 + 0.04^{b}	73.11 + 0.11^{ab}
	30	1807± 31^{b}	850± 30^{a}	957± 23	1506± 40^{a}	656± 24^{ab}	4.53 + 0.05^{a}	73.77 + 0.14^{a}
	45	1713± 50^{c}	774± 37^{b}	939± 41	1448± 53^{b}	674± 36^{ab}	4.61 + 0.10^{a}	73.57 + 0.10^{a}
	60	1587± 47^{d}	677± 43^{c}	910 ± 37	1396± 31^{b}	719± 18^{a}	4.70 + 0.07^{a}	73.70 + 0.09^{a}
Corn	0	999 ± 43^{a}	849 ± 39^{a}	150 ± 27	978 ± 21^{a}	138 ± 16^{c}	5.60± 0.04	86.46± 0.15^{b}
	15	1005± 27^{a}	836± 36^{a}	169± 18	977± 29^{a}	141± 27^{bc}	5.63± 0.11	86.73± 0.08^{b}
	30	921± 33^{b}	751± 47^{b}	170± 23	905± 34^{b}	154± 37^{bc}	5.65± 0.07	87.41± 0.47^{a}
	45	807± 37^{c}	641± 24^{c}	166± 21	804± 23^{c}	163± 22^{b}	5.60± 0.10	87.84± 0.60^{a}
	60	720± 57^{d}	548± 33^{d}	172± 30	724± 26^{d}	176± 37^{a}	5.67± 0.05	88.07± 0.63^{a}

PV = peak viscosity, BD = breakdown, FV = final viscosity, SB = setback, Pasting temp = pasting temperature.

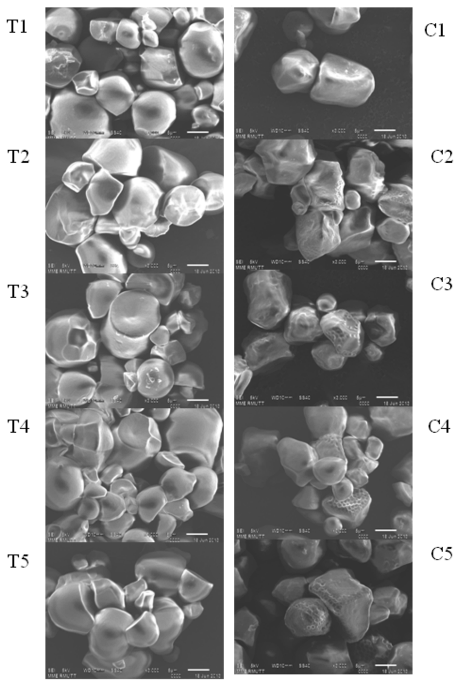

Fig. 1: Scanning electron micrographs of microwave heat-treared flour samples (25%w/w) at difference time:
(T1) tapioca at 0 sec
(T2) tapioca at 15 sec
(T3) tapioca at 30 sec
(T4) tapioca at 45 sec
(T5) tapioca at 60 sec
(C1) corn at 0 sec
(C2) corn at 15 sec
(C3) corn at 30 sec
(C4) corn at 45 sec
(C5) corn at 60 sec

T1 C1 T2 C2

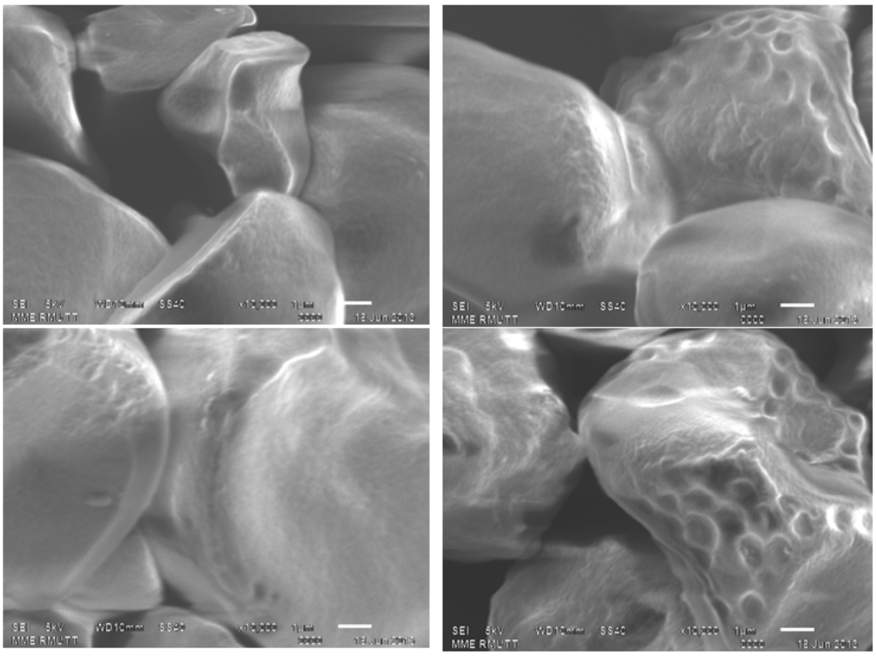

Fig. 2: Scanning electron micrographs of microwave heat-treared flour samples (25%w/w) at 45 sec (T1) microwave heat-treated tapioca flour (25%w/w) at sec (T2), microwave heat-treated corn flour (25%w/w) at 45 sec (C1), and microwave heat-treated corn flour (25%w/w) at 60 sec (C2) with maginfication of 10000 X.

Conclusion:

The pasting properties of flour samples, which were modified by using microwave heat-moisture at the moisture content of 25 % (w/w), had significantly affected on microwave heating time i.e. peak viscosity, final viscosity, setback viscosity, and pasting temperature. The morphological structure of tapioca flour treated with microwave heat-moisture changed at heating time up to 30sec, which was slower than that of corn flour (15 sec). It is interesting that microwave heat-moisture of tapioca flour resulted in a modified product that displayed much higher peak time and pasting temperature, while product from microwave heat-moisture of corn flour increased pasting temperature.

References

1. Adebowale, K.O., T.A. Afolabi and B.I. Olu-Owolabi, 2005. Hydrothermal treatment of finger millet (Eleusine coracana) starch. Food Hydrocolloids, 19: 974-983.
2. Aryee, F.N.A., I. Oduro, W.O. Ellis and J.J. Afuakwa, 2006. The physicochemical properties of flour samples from the roots of 31 varieties of cassava. Food Control, 17: 916-922.
3. Chandrasekaran, S., S. Ramanathan and T. Basak, 2013. Microwave food processing – A review. Food Research International, 52: 243-261.
4. Collado, L.S. and H. Corke, 1999. Heat-moisture treatment effects on sweet potato starches differing in amylase content. Food Chemistry, 65: 339-346.
5. Fan, D., S. Ma, L. Wang, H. Zhao, J. Zhao, Z. Hao and W. Chen, 2013. ^{1}H NMR studies of starch–water interactions during microwave heating. Carbohydrate Polymers, 97: 406-412.
6. Flores-Farias, R., F. Martinez-Bustos, Y. Salinas-Moreno, Y.K. Chang, J.S. Hernandez, and E. Rios, 2000. Physicochemical and rheological characteristics of commercial nixtamalised Mexican cornflours for tortillas. Journal of the Science of Food and Agricultures, 80: 657-664.
7. Gunaratne, A. and R. Hoover. 2002. Effect of heat-moisture treatment on the structure and physicochemical properties of tuber and root starches. Carbohydrate Polymers, 49: 425-437.
8. Jacob, H. and J.A. Delcour, 1998. Hydrothermal modifications of granular starch with retention of the granule structure, a review. Journal of Agricutural and Food Chemistry, 46: 2895-2905.
9. Jiranuntakul, W., S. Sugiyama, K. Tsukamoto, C. Puttanlek, V. Rungsardthong, S. Puncha-arnon and D. Uttapap, 2013. Nano-structure of heat-moisture treated waxy and normal starches. Carbohydrate Polymers, 97: 1-8.
10. Khamthong, P. and N. Lumdubwong, 2012. Effects of heat-moisture treatment on normal and waxy rice flours and production of thermoplastic flour materials. Carbohydrate Polymers, 90: 340-347.
11. Lawal, O.S., 2005. Studies on the hydrothermal modifications of new cocoyam (Xanthosoma

sagittifolium) starch. International journal of Biological Macromolecules, 37: 268-277.
12. Lee, C.J., Y. Kim, S.J. Choi and T.W. Moon, 2012. Slowly digestible starch from heat-moisture treated waxy potato starch: Preparation, structural characteristics, and glucose response in mice. Food Chemistry, 133: 1222-1229.
13. Lewandowicz, G., J. Fornal, A. Walkowski, M. Maczynski, G. Urbaniak and G. Szymanska, 2000. Starch esters obtained by microwave radiation-structure and functionality. Industrial Crops and Products, 11: 249-257.
14. Lewandowicz, G., J. Fornal and A. Walkowski, 1997. Effect of microwave radiation on potato and tapioca starches. Carbohydrate Polymers, 34: 213-220.
15. Puncha-arnon, S. and D. Uttapap, 2013. Rice starch vs. rice flour: Differences in their properties when modified by heat-moisture treatment. Carbohydrate Polymers, 91: 85-91.
16. Sandhu, K.S., N. Singh and N.S. Malhi, 2007. Some properties of corn grains and their flours I: Physicochemical, functional and chapatti-making properties of flours. Food Chemistry, 101: 938-946.
17. Thostenson, E.T. and T.-W. Chou, 1999. Microwave processing: fundamentals and application. Composites: Part A, 30: 1055-1071.
18. Watcharatewinkul, Y., C. Puttanlek, V. Rungsardthong, and D. Uttapap, 2009. Pasting properties of a heat-moisture treated canna starch in relation to its structure characteristics. Carbohydrate Polymers, 75: 505-511.