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Milled Rice Physical Properties after Various Radio Frequency Heat Treatments

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Introduction

The storage temperature, duration and relative humidity are storage factors and conditions which effect the physicochemical property such as stickiness, hardness, starch and protein properties that relate to rice quality (Marshall, et al., 1994; Sauer, 1992). Furthermore, during milled rice storage, the infestation of storage insect pest is the most serious problem in storage duration which cause weight loss, holing, contamination with insect fragments, frass, metabolite or disease organisms, fungal development and ultimate caking. The contaminated rice become unflavored taste and odor which made unpalatable taste for consumer. Various methods of insect control and eliminating such as trapping, pheromones and storage condition are practiced. The conventional method in the storage commercial scale is the use of chemical fumigation with methyl bromide or magnesium phosphide which are harmful to the consumer and pollute the environment (Hill, 1999). Beside, that there will be consequently cause the insect chemical resistance and mutation. The non-chemical and friendly to the environment ways are being investigated and evaluated. Radio Frequency Heat Treatment is one of the alternative method. It is a frequency or rate of oscillation within the range of about 3 Hz and 30 GHz, invisible and completely undetectable to humans. Electromagnetic waves of radio frequency can vibrate and heat up molecules and to kill pest insects (USDA, 2004). The taste or texture of the food affected by the treatment are few recorded. Wang et al.(2006) reported that Radio Frequency Heat Treatment would be an economical, environmentally friendly alternative to methyl bromides and other chemicals. Therefore, after using the Radio Frequency Heat Treatment in the milled rice in this experiment their influences to the physical property due to the various temperature used will be investigated.

Material and Methods

Sample preparation

500 g of milled rice cv. Khao Dawk Mali 105 were treated by Radio Frequency (RF) Heat Treatment at 27.12 MHz and the temperature used were 45, 60, 75 and 90 °C for the duration of three minutes in every treatment. The treated milled rice were sampled and investigated for their physical properties, cooking quality and processing quality.

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Sample determination

Colour of Grains

Rice samples were contained in the cuvette cell for measuring colour by Colorimeter (Color Quest XE, USA) in the value of L* : indicates lightness and b*: indicate color direction ; +b* is the yellow direction, - b* is the blue direction .

Cooking quality

In each treated rice with the RF Heat Treatment were cooked in the same condition. Afterward hardness: force required to bite through the sample with the molars and stickiness: degree to which the kernels adhere to each other were measured by using the texture analyzer (TA Xtplus, England) equipped with cylinder probe 35 mm. The texture analyzer setting are mode: measure force in compression, option: return to start, pre-test speed: 0.5 mm/s, test-speed: 0.5 mm/s, post-test speed:10 mm/s and strain: 90 %.

Viscosity analysis

Rice flour were measured viscosity by using a Rapid Visco Analyzer model RVA-4 (Newport Scientific, Australia). Rice flour (3 g each sample) was weighed directly into the aluminium RVA canister and 25 ml of distilled water were added and mixed with the rice flour. The RVA test profile was adopted from the method of Chen et al. (1999). The sample was held at 50 °C for 1 min, heated to 95 °C at a rate of 12 °C/min (i.e. in 3.75 min), held at 95 °C for 2.5 min, cooled to 50 °C at a rate of 12 °C/min and held at 50 °C for 2.5 min. The rotating speed of the paddle was kept at 160 rpm throughout the run except that the paddle speed was 960 rpm at the first 10 s.

Data analysis

The analysis of variance was selected and the least significant difference (LSD) was compared by using the SPSS program Version 6.0 (SPSS Inc.).

Results and Discussion

Rice grain colour

Colour of milled rice was shown in Table 1. It was found that L* and b* value significantly increased ($P<0.05$) when the temperature of RF Heat Treatment was higher than 60 °C. The untreated rice showed the low value of L* and b* which were 71.54 and 14.80 respectively. While milled rice treated with 90 °C had the high value of 75.03 and 14.91 respectively. These results can implied that high temperature effected on milled rice color which were changed from transparency white colour to opacity yellow. The similar study was reported by Dillahunty et al. (2000) which the temperature and treatment duration affect the yellowing of rice when it was treated with temperature over 50 °C more than 12 hr.

Grain moisture

The initial moisture content of milled rice was 12.74 % (Table1). After the RF Heat Treatment , there was no significantly difference in grain moisture ($P>0.05$). Normally, the moisture content of rice storage preferable to 12% and it can be decreased slightly because the movement of water from inside of the grain in to the air by evaporation when the temperature increased (Sauer, 1992).

Table 1 Color, moisture content, hardness and stickiness of milled rice cv. Khao Dawk Mali 105 after RF Heat Treatment with various temperatures.

RF temperature (°C)	L*	b*	Moisture content (%)	Hardness (N)	Stickiness (N)
control	71.54^{d}	14.80^{c}	12.74	142.30^{a}	-33.70^{bc}
45	71.03^{e}	14.88^{c}	12.09	137.20^{a}	-34.80^{cd}
60	71.64^{c}	14.92^{b}	11.94	116.80^{b}	-39.50^{d}
75	72.82^{b}	15.14^{a}	11.26	140.80^{a}	-26.90^{a}
90	75.03^{a}	14.91^{bc}	11.93	137.70^{a}	-29.30^{ab}
LSD (0.05)	0.02	0.04	NS	12.60	5.00
CV (%)	2.02	0.70	6.26	7.05	-11.63

NS indicate no significant difference at 95 % confidence.
Superscript in the different characteristic indicate significant difference at 95 % confidence.

Cooking quality

Hardness and stickiness were measured as cooking properties parameter. The result was shown in Table1. The hardness of the control untreated rice was 142.30 N whereas the one treated with 45 °C and 60 °C were decreased to 137.20 N and 116.80 N respectively but after treated with 75 °C and 90 °C the hardness showed significantly increase to 140.80 N and 137.70 N respectively. While, the stickiness of the control untreated rice was 33.70 N, and it were increased when treated with RF Heat Treatment at 45 °C and 60 °C. Contrarily, the stickiness property of milled rice treated at temperature 75 °C and 90 °C were decreased to 26.90 N and 29.30 N respectively. The result showed that the treated temperature influenced the texture of cooked milled rice which was related to the inner structural changes of the interior of cooked rice grain (Horigaine et al., 1999). Similarly, Aquerreta et al.(2007) stated that drying temperature at 60 °C give the best quality of rice.

Viscosity analysis

The qualities assessment results from processed rice were shown in Figure 1 and Table 2. The changing of peak viscosity of the radio frequency heat treated rice were significantly related to pasting temperature, trough, breakdown, final viscosity, set back and peak time. The peak viscosity, trough and final viscosity of heat treated rice with 45 °C, 60 °C and 90 °C were not significantly decreased compare to untreated rice. It could be explained that Radio Frequency Heat Treatment temperature at 45 °C, 60 °C and 90 °C were not influenced to the main processing qualities.

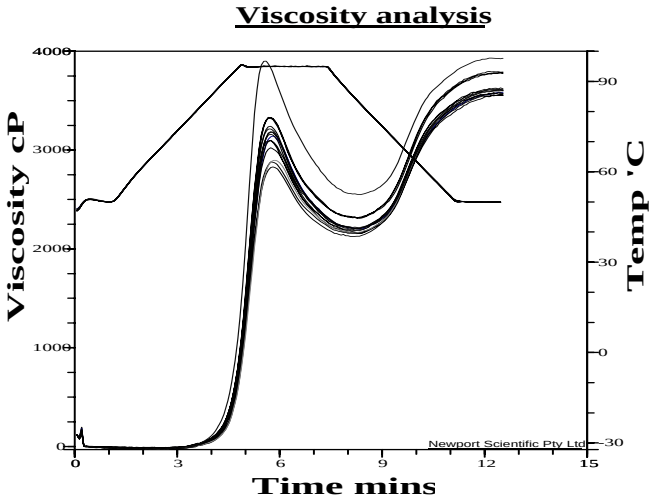

Figure 1 The RVA viscograms of the milled rice were treated by RF Heat Treatment.

RF Heat Treatment temperature at 75 °C showed different results from the others which showed the lowest value of all. Similar result was reported by Takahashi et al.(2005) who stated that rice flour treated with heat–dry showed more brittle and less pasty than untreated rice flour, which might due to the dehydration and decreasing in the damaged starch content which retarded starch granules swelling; the swelling power and solubility were suppressed, then the peak viscosity decreased with increasing temperature of heat-dry. By this experiment, unfortunately we did not have investigations on starch granule swelling, swelling power and solubility which should be done and confirm in the next study.

Table 2 The result of rapid viscosity analysis of milled rice treated by various RF Heat Treatment.

RF temperature (°C)	Pasting temperature (°C)	Peak1 (cP)	Trough1 (cP)	Breakdown (cP)	Final viscosity (cP)	Setback (cP)	Peak time (min)
control	87.0^{c}	3451.0^{a}	2319.7^{a}	1131.3^{a}	3714.3^{ab}	263.3^{c}	5.6^{b}
45	87.8^{b}	3169.3^{ab}	2203.0^{ab}	966.3^{b}	3586.7^{b}	417.3^{bc}	5.8^{ab}
60	87.8^{b}	3093.0^{ab}	2181.7^{ab}	911.3^{b}	3593.3^{b}	500.3^{b}	5.7^{ab}
75	88.5^{a}	2868.0^{b}	2145.7^{b}	722.3^{c}	3575.3^{b}	707.3^{a}	5.8^{a}
90	87.2^{bc}	3327.3^{a}	2311.7^{a}	1015.7^{ab}	3781.7^{a}	454.3^{b}	5.6^{b}
LSD (0.05)	0.7	322.6	162.3	162.2	155.4	169.9	0.09
CV (%)	0.4	5.6	4.0	9.3	2.3	19.9	0.8

Superscript in the different characteristic indicate significant difference at 95 % confidence.

Conclusions and Outlook

It can be concluded that application of RFHeat Treatment temperature lower than 60 °C was heat treatment temperature appropriate for milled rice heat treatment or unsignificantly affecting to the physical properties, cooking quality and processing quality. However, the sensory quality should be determined and investigated in the future research.

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