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EFFECTS OF MICROWAVE ROASTING TIME ON PHYSICO-CHEMICAL PROPERTIES AND SENSORY EVALUATION OF GERMINATED RED BROWN RICE MILK

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ABSTRACT

The study was aimed to investigate the effects of different microwave heating times (1, 2, and 3 min at output microwave of 800 W) in comparison with the traditional heating (3 min, 110°C) on some physico-chemical properties and sensory evaluation. The consumer survey for the final product use was also conducted to determine whether there is a significant difference in general liking of the product with gender. The results indicated that the product with the shorter microwave heating time contained higher protein and reducing sugar compared to traditional heating. The microwave heating time significantly affected the viscosity of milk, whereas insignificantly influenced color, pH, and TSS values of milk. Among samples, microwave roasted at 3 min provided the comparable total acceptance score in sensory evaluation of the traditional heating. The milk contains protein (0.18g/100ml), total lipid (0.87g/100ml), and carbohydrate (7.56g/100ml). No significant association between gender and opinion was found expressing the liking of the product in which there were 61.35% females and 45.58% males liking the product. This study revealed that microwave heating could be used for roasting step to replace the traditional roasting in terms of product quality and nutrient retention. The study also provided a basic formula of the main components of the rice milk and demonstrated that the using the germinated red-brown rice to produce the rice milk could provide the product, ensuring all main compositions of rice such as protein, lipid, and carbohydrate.

Keywords: Microwave heating time, germinated brown rice milk, rice physico-chemical property, market survey, sensory evaluation

INTRODUCTION

Dairy-free milk alternatives are gaining their popularity such as oat, coconut, almond, soy milk, and rice milk. In Asia, the traditional soy milk has been used for many decades (**Zhang *et al*., 2005; Sethi *et al*., 2016**). The evolution of plant milk is really bringing many advantages for industrial beverage. In recent years, the traditional soy milk has reached the market saturation point while the rice milk alternatives have proliferated, especially in the Asian market (**Sethi *et al.*, 2016**).
Rice milk is processed from the rice grains, normally the polished rice. The color of the rice milk is white as resulted from the polished rice and non-dairy creamer. The sweet taste of the rice milk could be created by the addition of sugar, or amylase enzymes to hydrolyze the starch (**Nguyen *et al*., 2015; Bui *et al*., 2016**). Moreover, the whole taste of milk can be greasy together with roasted smell of light-burnt rice or other added flavors.
Health-related claims become a common sign to offer brands a needed selling point to target consumers (**Valencia-Flores *et al.*, 2013**). The purple, red and black-brown rice in Asian market are popular rice in daily used-life. As well-known that those brown rice varieties contain more nutrient values than white rice due to its bran layer which contains most of protein, fiber, mineral and vitamin of the cereal (**Abdel-Aal el-SM *et al.*, 2006; Das *et al.*, 2012**). The rice protein is hypoallergenic and contains good quality of lysine (**Das *et al*., 2012**). Although rice milk is low in fats, the rice milk product contains much energy from sugars and other carbohydrates (**Sethi *et al.*, 2016**). In addition, the process of germination also brings more nutritions to the brown rice (**Charoenthaikij *et al.*, 2009**). In recent year, the germinated brown rice preferred than brown rice by its nutrition values, soft texture, and easy-taste. The germinated process is conducted by soaking, and incubated in the appropriate condition of temperature and humidity; Its nutritional values might up to many folds compared to white polished rice (**Saikusa *et al.*, 1994; Tian *et al.*, 2004; Komatsuzaki *et al*.,2005; Charoenthaikij *et al.*, 2009; Banchuen *et al.*, 2009; Moongngarm and Saetung, 2010; Karladee and Suriyong, 2012**). Therefore, using the germinated red-brown rice to produce the rice milk is steps of value addition. The germinated red-brown rice milk produced by the germinated red-brown rice with rock sugar, non-dairy cream, and other ingredients (peanut and stabilizers) could fulfil demands of consumers such as the lactose intolerant/allergy sufferers and its nutrition values (**Valencia-Flores *et al.*, 2013**).
During germinated rice milk production, the maintaining of nutritional contents and essential substances from raw materials to the finished product is a challenging work. The visible common problem is that after the brown rice germinated, its structure is soft and porous, which is difficult to control the uniformity of roasting temperature. Thus, the grains are easily burnt and cracked as roasted by traditional method so that nutritional values are also reduced followed by. Deriving from such a problem, several studies used microwave technology replacing for the traditional method and the results obtained with higher nutrients, compared with traditional methods (**Cross and Fung, 1982; Uherová *et al.*, 1993; López-Berenguer *et al.*, 2007; Tiansawang *et al.*, 2014**). Furthermore, with the unique heating mechanism of microwave technology, the aroma of roasted rice increases, the sour odor decreased and physical surface did not burn as the traditional method. No research has provided such information and any basic formula of main components as well as the whole process of the germinated red brown rice milk production so far.
The objective of this study is to investigate the effects of microwave roasting time on physico-chemical properties and sensory evaluation of rice milk producing from germinated red brown rice, namely Huyết Rồng. Furthermore, market survey of liking product was taken place to prospect the potential market. Roasting step in the process was replaced by microwave technology with the hypothesis of nutritional value retention and comparable quality.

MATERIAL AND METHODS

Material preparation

Red brown rice with 20.60% amylose content, namely “Huyết Rồng“ purchased at An Nhơn market, no. 276/1/17 Ward 17, Go Vap District, HCMC, Vietnam. Saccharose (Rock sugar) was bought from Anh Dang Ltd, Co., HCMC, Vietnam. Non-dairy creamer was bought at MINA Ltd, Co.,HCMC, Vietnam. Microwave Oven (Sharp, model IEC 60705, Japan) with 800W output was used to roast rice samples. The roasting process by microwave is described in the following flowchart (Figure 1) compared with the traditional roasting by saucepan.

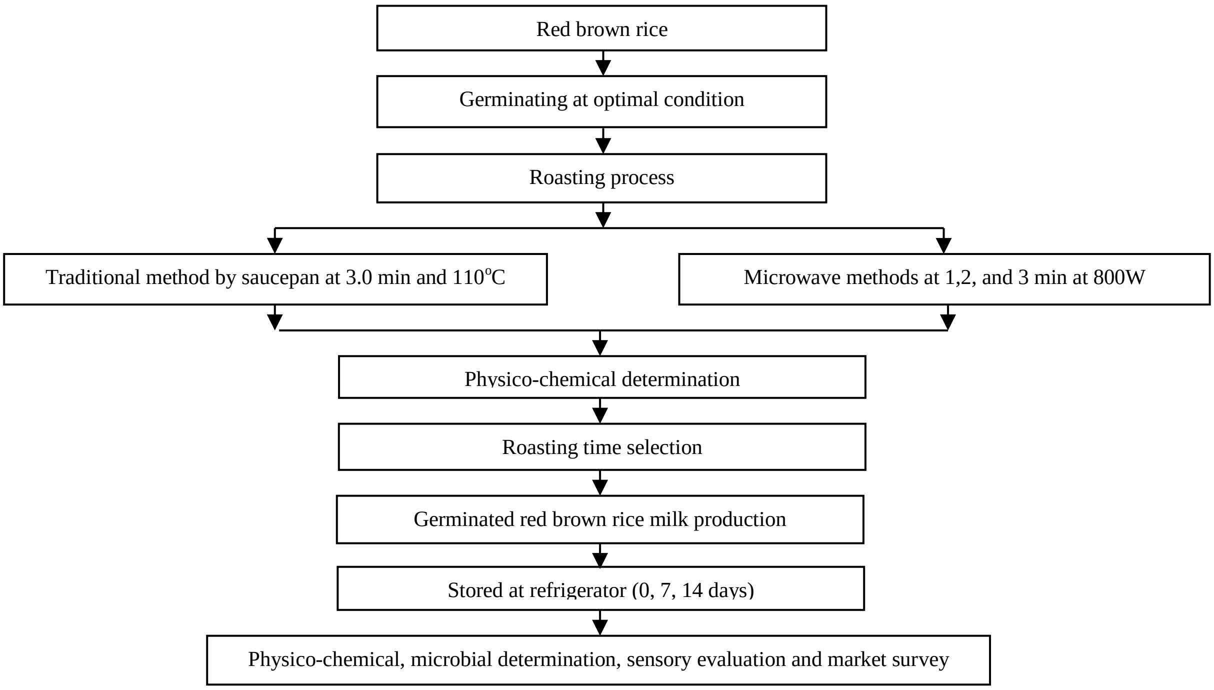

Figure 1 Germinated brown rice milk processing flowchart

The germinated brown rice production

Three varieties of color brown rice were conducted in the germination process. Three local color brown rice was purchased and conducted in this study, namely Huyết Rồng (red), Nếp Than (black), Tím Than (purple). The germinated brown rice was carried out by the following steps: (1) the brown rice was soaked for 8 hrs (1:5 = rice:water) at 40^{o}C and incubated for 48 hrs at 35 ± 2 ^{o}C to germinate (**modified from Komatsuzaki *et al.*, 2005**); (2) The germinated brown rice was washed several times to remove dirts and sour smell produced during soaking and incubated processes; (3) The rice was then dried at 40^{o}C in hot air oven to attend the moisture content demand, less than 13% (wet basis); The content of Gamma Amino Butyric Acid (GABA) was determined by HPLC-Le systems Pico-tag pour l’ analyzer des acids amines en provenance d’hydrolysats de proteins CASE.SK.0083 (LC/MS/MS) method (Center of Analytical Service and Experimentation of HCMC-CASE). The percentages of germination were evaluated for three color rice varieties. The rice grains with the germ were randomly selected, counted in the petri dish, and presented by percentage of total grains of the sample.

Microwave Roasting Process

The well-weighted samples of 100g were put into the ceramic container with a thin layer of the roasting process. Three periods of microwave roasting were 1, 2, and 3 min at microwave output of 800W. The microwave oven (Sharp; model IEC 60705, Japan) was warm of 30s prior to taking place the roasting process. The traditional method was conducted by the saucepan at 3.0 min and 110^{o}C as a control sample. The saucepan was heated on the induction hob until it reached 110^{o}C ± 2 prior to putting rice sample for roasting. The roasting time was counted by the timer.

Physico-chemical property determination of rice milk

The rice milk was made for roasting samples at different conditions of traditional and microwave roasting methods. The milk fomula at experimental level was conducted according to the following step: (1) the roasted rice was ground together with the roasted peanut – flavor-pea nut, saccharose, and non-dairy creamer by the soymilk maker (KG609, Kangaroo, China) and predefined water amount to obtain a mixture; The maker has the capacity of 1.5 liters, cooking capacity of 950W, voltage of 220-24V/50Hz, and dimension (width x depth x height) of 24 x 210 x350 mm)); (2) the mixture was then heated and pasteurized at 97^{o}C ±2 for 15 min. The heated mixture was then filtered by clean cotton cloth and heated for 5 min prior to fast cooling step (refrigerator of 5^{o}C±2); (5) the pasteurized milk after cooling was then conducted for filling and bottling step and stored in refrigerator for further analysis. Several physico-chemical properties were determined for the rice milk. Protein content was determined by a Buiret method (**Nowotny, 1979).** Reducing sugar content was measured by the 3,5-dinitrosalicylic acid (DNS) method at 640nm with maltose as the standard (**Chaplin, 1987**). Total soluble solid (TSS) was determined by the handy refractometer (ATago UriconN-Hand held-Refractometer, 0-32% ^{o}Bx, ATago Co., Ltd., Taiwan). The pH was determined by pH meter (pH 510, Eutech Instrument, Singapore). Total soluble solid and pH analyses were performed five times per sample; protein and reducing sugar was analyzed in triplicate. The color of milk samples was measured by a mini hand colorimeter (3NH-NR110, China), using CIE L*a*b* system (**Le and Jittanit, 2015**). All analyses were performed in triplicate.

Viscosity determination

The viscosity of milk product was evaluated by a Digital Brookfield Viscometer (NDJ-9S, Brookfield Engineering, USA) using the spindle number two at 28 ± 1^{o}C and 60 rpm. The viscosity of samples was recorded at an initial day (0 day), 7 days, and 14 days (at 5 ± 2^{o}C). All analyses were performed at 5 times per sample.

Sensory evaluation

The samples of different roasting conditions were conducted for sensory evaluation. Forty panelists, including fourth year bachelor students and staffs in Faculty of Food, Chemical and Environmental Sciences, Nguyen Tat Thanh University, HCMC, Vietnam, participated in sensory evaluation. All samples were coded with three digit random numbers and presented in randomized order. All panelists were rinsed their mouths with clean water before and between evaluations. Sensory evaluation was taken place to test the acceptability of consumers in terms of color, tastes, and smell at different roasting methods using 9-point hedonic scale (1= dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like very much, 8 = like very much, 9 = like extremely).

Image investigation

Images of different roasting time of the microwave were captured to evaluate the visibly physical grains (**Le and Jittanit, 2015**). At least the image capture was taken place for 5 times per sample, then randomly picked up 1 from 5 images. The images were taken after 2 min of the roasting process. The image of each sample was captured by 14.1 mega pixels Canon camera (Canon Ixus 130, Canon Inc, Japan).

Germinated red-brown rice milk production at pilot scale

After roasting, the roasted rice was used to produce milk with saccharose and non-dairy creamer at optimal formula. The formula was included roasted germinated brown rice (3.64%), saccharose - rock sugar (2.73%), Non dairy creamer (2.27%), flavor-pea nut (0.45%), and water (89.80%) which were conducted at pilot level (40L/batch). The appropriate roasting samples were chosen to produce milk.

The process of milk production was conducted by the following steps: (1) the roasted rice was ground together with the roasted peanut – flavor-pea nut by the stone mill, and predefined water amount to obtain a mixture; (2) the mixture was then transferred through a stainless tank with paddle and heater (the tank with cooking capacity of 100 liters, power supply of 220/380V-50Hz, capacity of 7-15Kw, stirring speed of 30-120 rpm, and the size of 1300*750 & 700 mm); (3) the process of heating and mixing with other ingredients were carried out including saccharose and non-dairy creamer; (4) Then the mixture was pasteurized at 97^{o}C ±2 for 20 min and filltrated by clean cotton cloth prior to fast cooling step (the milk fluid flows inside the coil through a pump and outside is refrigerant - ice and salt. The flow rate was adjustable by the valve); (5) the pasteurized milk after cooling was then conducted for filling and bottling step.

Rice milk product composition determination at pilot scale

Protein content was determined by FAO 1986 method. Carbohydrate content was determined according to the Food and Drug Administration method. Lipid content was measured by FAO (1986) and Pb content was evaluated by AOAC 999.11 Method. Vitamin B1 content was determined by HPLC/UV-VIS method (CASE.CT.0071). The content of Gamma Amino Butyric Acid (GABA) was determined by HPLC-Le systems Pico-tag pour l' analyzer des acids amines en provenance d'hydrolysats due proteins CASE.SK.0083 (LC/MS/MS) method. Total sugar content was determined by **Issara and Rawdkuen (2014).** Aflatoxin content was determined by AOAC 990.33 method. *E.coli* was determined by ISO 16649-3: 2015. All analyses were performed in triplicate.

Survey of liking product according to gender

A survey was carried out at HCMC at various careers, ages, and incomes to determine the general liking according to gender. The numbers of 150 random people were asked and the results were treated using the Chi-square method. The survey was to determine whether there is a significant difference in general liking of the product with gender. Three scales of liking was used such as like, dislike, and no opinion.

Statistical analysis

Data was shown by mean with standard deviation of replication by Microsoft Excel 2010. Difference analysis was analyzed using ANOVA by SPSS v20 (SPSS Institute Inc., Cary, NC). The Chi–square test was used to analyze the association of gender and opinions of consumers.

RESULTS AND DISCUSSION

Effect of color rice varieties on germinated percentage

The percentages of germination were evaluated for three color brown rice varieties. The rice grains perceived the germ were counted and presented by percentage of total grains of the sample. The results of germinated percentage among three selected color brown rice varieties are shown in Figure 2.

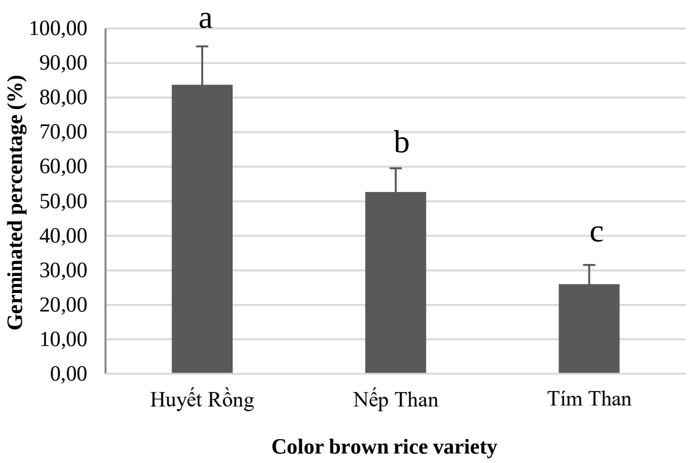

Figure 2 Germinated percentages influenced by different varieties (Different superscripts on the bar differ significantly ($p < 0.05$)*;* Error bar presented as mean ± SD, n = 9)

Among three-color rice varieties, Huyết Rồng rice variety obtained the best capacity of germination. More than 80% grains have germination capacity. The results were similar to the result of **Cung *et al.* (2013)** who conduct the study of Vietnamese color rice varieties. The Huyết Rồng brown rice variety (the red-brown rice) could be germinated at the 30 - 40^{o}C and limited at the over 40^{o}C. The content of GABA obtained from the Huyết Rồng brown rice (the red-brown rice) in this study was 133 mg/kg. The Huyết Rồng rice – the red-brown rice variety with the highest GABA content in this study was used for the rest of the following experiments.

Image investigation of various microwave-roasting periods

The surface image capture of various microwave-roasting periods were shown in Figure 3.

(a) (b) (c) (d)

Figure 3 Effect of microwave roasting periods on the appearance of germinated red-brown rice: Control = traditional roasting - TT (a), MR1 (b), 2 (c), and 3 (d) = microwave roasting at 1, 2, and 3min.

The germinated red-brown rice, roasted by the traditional method (control) was burnt on the surface of the grains; the grains were flaking off and some grains were puffed (Figure 3a). Color of grains was more black brown and the grains seemed to be more fissured; some pigment color was flaking off, which might be the reason of nutrition reduction. For microwave roasting, the microwave roasting at 1 min (MR1) and 2 min (MR2) provided the intake roasted grains while the microwave roasting at 3 min (MR3) was appeared of some puffed grains, similar to the traditional roasting. However, the color tended to be browner and darker as the roasting time increased (Figure 3d).

Effects on reducing sugar

The results of reducing sugar measured for different samples presented in the Figure 4.

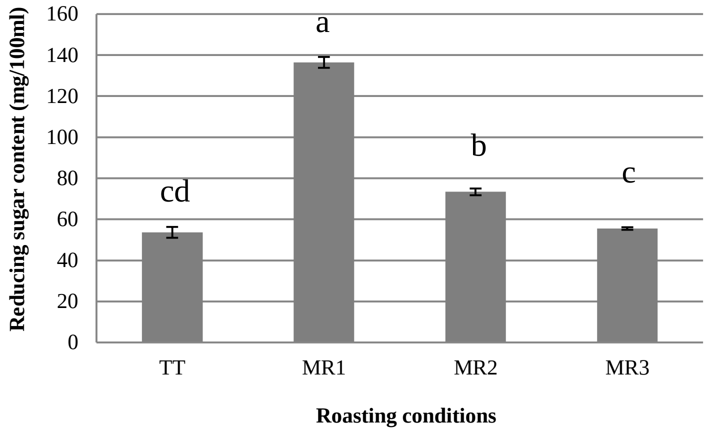

Figure 4 Reducing sugar content at different periods of microwave roasting (Different superscripts on the bar differ significantly ($p < 0.05$); Vertical error bar represents standard deviation, n = 3); TT= sample is roasted by the traditional method; MR 1, 2, and 3 = samples are roasted by microwave at 1, 2, and 3 min.

Milk solutions produced from different periods of microwave roasting time and traditional method were significantly different in reducing sugar content. According to Figure 4, MR1 provided the highest content of reducing sugar in the sample, 136.42±2.63 (mg/100ml), compared to the counterparts. The content of reducing sugar at traditional sample was insignificantly different to that of MR3, 53.628±2.63 and 55.49±0.66 (mg/100ml). The sample of MR1 and MR2 was also different (136.42±2.63 mg/100ml and 73.39±1.64 mg/100ml). The results indicated that as increased microwave heating time led to decrease in reducing sugar content. The content of reducing sugar could be higher than that of traditional methods in case of shorter roasting time of the microwave. In the three periods of roasting, it could be concluded that microwave roasting could maintain reducing sugar in compared to traditional method at the appropriate roasting time. The longer heating time might produce more chemical changes such as the Maillard reaction, which can lead to reduce the reducing sugar together with protein (mentioned later). Rice milk is pronounced for lactose intolerance; however, the commercial rice milk is normally processed by milled rice, or rice starch, which contains almost no protein, extremely high carbohydrate (sugar) and low lipid content (**Pineli *et al.*,2015; Sethi *et al.*, 2016**). The extremely high in sugar do not interest by consumers in term of healthy aspect. Therefore, using the microwave roasting method could manipulate the rice milk in terms of being more balance in nutritional values.

Effects on Protein

The results of protein changed by different roasting process condition are presented in Figure 5.

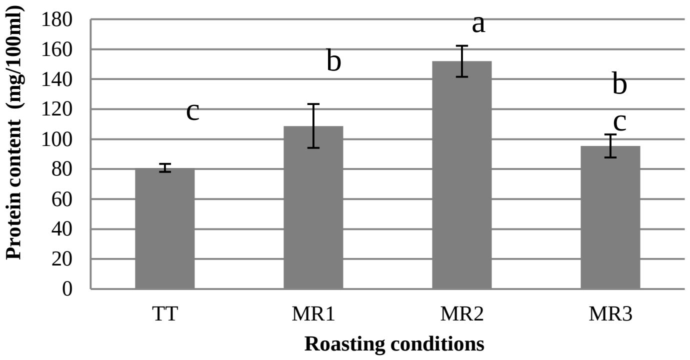

Figure 5 Protein content (mg/100ml) at different periods of microwave roasting (Different superscripts on the bar differ significantly ($p < 0.05$); Vertical error bar represents standard deviation, n = 3); TT = sample is roasted by the traditional method; MR 1, 2, and 3 = samples are roasted by microwave at 1, 2, and 3 min.

According to the Figure 5, protein content changed significantly at different microwave roasting time. The content of protein was changed differently at different roasting time in which MR1 and MR3 were not significantly different but those were different with the MR2. The lowest content was found in the traditional method in compared with the counterparts. The content of 80.78±2.58, 108.76±14.62, 151.94±10.32, 95.38±7.74 (mg/100ml) were corresponding for traditional, MR1, MR2, and MR3. The changes in protein content of different samples might be due to protein denaturation under heat generation. Depending on heating mechanism and heat generation follow by, the content of protein could be increased or decreased. The protein structure might be changed and the hydration property was reduced, especially at high temperature (>200°C); many of amino acids could be lost or isomeric together with protein denaturation. Many of racemic were created and therefore, the values of protein were reduced, might be over 50%.

Results indicated that roasting by the traditional method mostly is of conduction and convection heat transfer manner; the target temperature increase is prolonged and this lead to nutrient reduction. Based on this problem, microwave heating with a unique mechanism of heating up during treatment process could overcome such a loss of nutritional values.

Effects on pH, TSS (Brix), and color of the milk solution

The changes in pH and Brix values of the two roasting methods are shown in Table 1.

The neutral pH in the range from 7.00 to 7.15 respectively was the pH of germinated brown rice milk in this study. The values of pH of both the traditional and microwave were not significantly different. The pH of 7.15±0.07, 7.15±0.07, 7.10±0.00 and 7.15±0.07 were of traditional, microwave roasted for 1 min, microwave roasted for 2 min, and microwave roasted for 3 min, respectively. According to current data, the pH values in germinated red-brown rice milk samples were not significantly different when the samples were roasted in two different roasting methods, and different periods of microwave roasting.

Similar to pH values, Brix values of the milk solution were insignificantly changed with two different roasting methods and different periods of microwave roasting. All samples had the Brix values of 13±0.01. Although the rice, roasted by the traditional method had fissured surface and flake off grains, the starch granules and their structure might be somehow changed, values of Brix of milk were similar and no significant difference among samples.

Table 1 pH, TSS (Brix), and color values of milk solution at various roasting conditions

Attribute	Roasting methods			
	TT	MR 1	MR 2	MR 3
pH	7.15±0.10^{a}	7.15±0.08^{a}	7.10±0.04^{a}	7.15±0.06^{a}
TSS (Brix, °B)	13±0.01^{a}	13±0.02^{a}	13±0.01^{a}	13±0.00^{a}
L*	53.94±3.74^{a}	53.34±1.82^{a}	54.715±1.95^{a}	53.75±0.64^{a}
a*	1.83±0.38^{a}	2.15±0.18^{a}	1.96±0.21^{a}	1.99±0.25^{a}
b*	4.05±0.34^{a}	5.50±0.64^{b}	4.69±0.71^{ab}	4.01±0.23^{a}

Notes: Different superscripts in row differ significantly ($p < 0.05$); n = 9; TT = sample is roasted by the traditional method; MR1, 2, and 3 = samples are roasted by microwave at 1, 2, and 3 min.

The color of the solution of a drink is one of the important attributes of plant milk since it determines the consumer acceptance (**Bastıoğlu *et al.*, 2016**). The color of milk solution was presented by L* (lightness), a* (redness), and b* (yellowness) and shown in Table 1. Generally, the milk solution color of different periods of roasting time by microwave was insignificantly different; however, the values of the color (L*, a* and b*) were changed corresponding to different time. According to the results, the value of L*, and a* were less changed; the b* value (yellowness) was changed among the conditions in which the shorter the roasting period, the higher values of b*. The phenomenon might be due to the least change in color pigments under the short period of microwave heating.

Effects on milk viscosity

Viscosity is another important parameter appealing to consumer in explaining the mouth feel and texture of fluids such as beverages **(Yu *et al.*, 2007)**. Figure 6 was presented the viscosity of the traditional and different microwave roasting time during refrigerated storage (5 ± 2°C) at 0, 7, and 14 days.

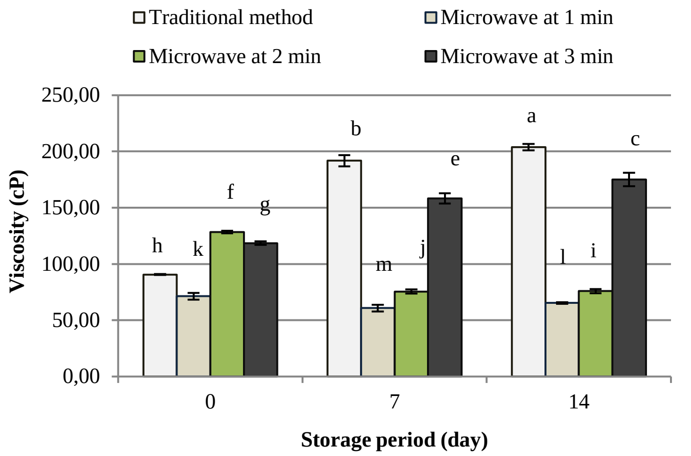

Figure 6 Viscosity of the milk solution at different roasting conditions during storage (Different superscripts on the bar differ significantly (p < 0.05); Error bar presented as mean ± SD, n = 5)

The viscosity was affected by the heating method; microwave heating at 2 and 3 min led to higher in viscosity of the milk while that of 1 min was lower. During storage, the viscosity of traditional heating increased from 90.6±0.55 cP (day 0) to 191.7±4.92 cP (day 7) and 203.70 ± 2.80 cP (day 14). For that of microwave roasting, the viscosity of the sample at 1 and 2 min tended to decrease: the MR1 viscosity value was 71.30±3.01 cP (day 0) to 60.8±2.95 cP (day 7), and 65.40±0.74 cP (day 14); the MR2 was 128.4 ± 1.08 cP to 75.5 cP ± 1.80, and 75.9±1.88 cP, respectively (p<0.05). The viscosity of the MR3 was increased during storage, which was a similar trend to the traditional sample. However, the value of increase was lower that of traditional at each period of storage. It could indicate that two different heating methods caused a significant effect on the viscosity of milk. The different changes of two heating methods could be explained by the effect of heating mechanism on gelatinization and retrogradation of the starch, together with the effects on lipids and proteins in this product. The fluctuated changes in different microwave heating were due to its unique heating characteristics.

The result indicated that the microwave heating could change in viscosity of the milk and the value was dependent on microwave heating time and storage time. **Faccin *et al.* (2009)** found the similar result when storing the rice bran beverages during refrigerated storage (4ºC). As MW3 heated, physical (presented earlier) and chemical properties might be changed significantly, especially the starches and protein; the starch could be highly gelatinized when compared to counterparts, which could be comparable to the traditional method. The starch granule and other components such as protein and lipid largely changed under high temperature environment.

Sensory evaluation

A sensory evaluation was carried out by 40 panelists selected randomly at Faculty of Food, Chemical, and Environmental Sciences, Nguyen Tat Thanh University, HCMC, Vietnam. The results in the Table 2 showed that MR1, 2, and the traditional method were not significantly different in color, smell, and total acceptance. Among samples, the sample of microwave roasted at 3 min was set at the lowest score when compared to the rest. According to Table 2, the samples preferred the most by panelist are the traditional method (7.93±1.33) and the least prefer sample is the MR3 (6.60±1.80). MR1 and MR2 were similar in color score (7.60±1.10; 7.07±1.10) and those are not significantly different with the traditional method.

Table 2 Sensory evaluation of different roasting methods

Roasting methods	Sensory attributes		
	Color	Aroma	Total acceptance
TT	7.93±1.33[a]	7.87±1.13[a]	7.60±0.91[a]
MR1	6.60±1.80[b]	6.60±1.50[b]	6.73±1.10[b]
MR2	7.07±1.10[ab]	7.33±1.18[ab]	7.47±1.06[a]
MR3	7.60±1.10[ab]	7.27±0.63[ab]	7.60±0.63[a]

Notes: Different superscripts in column differ significantly ($p < 0.05$); TT = sample is roasted by the traditional method; MR1, 2, and 3 = samples are roasted by microwave at 1, 2, and 3 min.

The panelist also recognized the similar color between samples, excepting for MR3. Most of evaluating score indicated that the aroma of the traditional method was better than that of microwave method, especially for the longer time of roasting. Among the samples of the microwave, the MR1 is preferred the most and similar to TT. For all attributes of sensory evaluation, the highest values were found in the traditional method and the lowest values were for MR3.
The results of sensory evaluation are presented in the Table 2 showed that MR1, MR2, and the traditional method were not significantly different in color, smell, and total acceptance. Among samples, the sample of microwave roasted at 3 min was set at the highest score when compared to the rest. According to Table IV, the samples preferred the most by panelist are the traditional method (7.93±1.33) and the least prefer sample is the MR1 (6.60±1.80). MR2 and MR3 were similar in color score (7.60±1.10; 7.07±1.10) and those are not significantly different with the traditional method. The panelist also recognized the similar color between samples, excepting for MR1. Most of evaluating score indicated that the aroma of the traditional method was better than that of microwave method. Among the samples of the microwave, the MR3 is preferred the most and similar to TT. For all attributes of sensory evaluation, the highest values were found in the traditional method and the lowest values were for MR1.

Composition of germinated Huyet Rong red-brown rice milk produced at pilot scale

The process of germination in this study could bring the content of GABA of 129-139 mg/kg and the content of vitamin B1 of 2.53 -2.63 mg/kg (Table 3). The results are similar to the study of **Cung *et al.* (2013**). **Cung *et al.*** was also conducted at the same rice variety and similar germination process condition.

Table 3 Germinated Huyet Rong brown rice milk composition at pilot scale production

Paremeter	Germinated Huyet Rong	Milk solution
Protein	7.92 g/100g	0.18 g/100ml (N x 6.25)
Carbohydrate	78.15 g/100g	7.56 g/100ml
Lipid	2.42 g/100g	0.87 g/100ml
Vitamin B_1	2.58 mg/kg	No detection (MDL = 0.3)
GABA	133 mg/kg	No detection (MDL =10)
Total sugar content		5.98 g/100ml
Pb		No detection (mg/L)
Aflatoxin		No detection B1,B2,G1,G2 (µg/L)
E.coli		No detection (CFU/ml)

Notes: Mean values of triplicate determination

The optimal condition (microwave roasting at 3 min at microwave output of 800W) chosen after the study was taken place to produce the germinated Huyết Rồng brown rice milk at pilot scale. The results were evaluated and shown in Table 3. The milk solution contains carbohydrate (7.56g/100ml), protein (0.18g/100ml), total lipid (0.87g/100ml), and total sugar (5.98g/100ml). Aflatoxin B1,B2,G1,G2, and *E.coli* were not detected in the final product. Moreover, the GABA and Vitamin B1 were less and not detected for the milk solution. The problem is due to the fact that the weight of the rice sample used in the formula was less while other components (water) are huge; it is beneficial for the economic aspect (intention to do). The content of those nutrients could be obtained at a higher level as the ratio of germinated rice increased in the formula. **Bùi *et al.* (2016**) studied the effects of central temperature of the rice milk product by varying from 3-10 min at 121°C using sterilization value F with Z =10°C and T_{ref} = 121.1°C; **Bùi *et al.*** indicated that the sterilized temperature did not affect the content of some nutrients (GABA and γ-oryzanol) in rice milk product; however, the sterilized time could directly affect the color of the final product. In this study, the results demonstrated that the Huyết Rồng red-brown rice variety obtained the highest content of nutrients after germination and its products after microwave roasting and pasterization process still maintained all main compositions of rice such as protein, lipid, and carbohydrate which are relevant for the similar milk product category.

Result of survey of liking a product according to gender

A survey was carried out at HCMC at various careers, ages, and incomes to determine whether there is a significant difference in general liking of the product with gender. Three scales of liking was used, like, dislike, and no opinion. The results provided the information about general liking based on gender (Table 4).

Table 4 Gender-response about general liking of consumer

Response	Male	Female	X^2 (sig)
Like	43 (45.8)	64 (61.35)	1.51 (0.470)
Dislike	9 (6.8)	7 (9.2)	
No opinion	12 (11.5)	15 (15.5)	
Total	150 (100)		

Notes: Pearson Chi-Square <0.05 (0.470), df =2; () = percentage, %

The values of Asymptotic Significance (2-sided) is 0.470 > 5% indicating that no significant association between the gender and the opinion of consumers were found. However, according to the results of the survey, there are 64 (61.35%) females liking the product; this number is much more that of male, 43 males (45.80%). The results showed that there is no significant effect of gender on the general product liking. However, the numbers of female liked the product is more than that of males. Besides, there were 15 female (15.50%) and 12 males (11.55%) never used the product.

CONCLUSION

The microwave heating at shorter time could maintain the nutritional values better than the traditional method. The longer heating time, the more reduction in reducing sugar and protein content. Microwave heating at 3 min caused the roasted germinated red-brown rice to be flaked off and puffed after roasting, which was similar to traditional roasting. The microwave heating at various times and traditional method were insignificantly influenced color, pH, and TSS values of milk. The microwave heating time significantly affected the viscosity of milk product after new treatment and during storage. The microwave heating at 3 min showed an insignificant difference with microwave heating at 2 min and the traditional heating in a sensory evaluation score of color, aroma, and total acceptance of the rice milk product. The lowest total acceptance score was found in microwave heating at 1 min compared to the counterparts. Among 150 random consumers at various ages, careers, and incomes in the area of HCMC, there were 61.35% females liking the product while this of 45.58% males was found in male. No significant association between gender and opinion influencing the liking of the product. Microwave heating can treat the undesirable odor during germinated rice process and also maintain nutrient for the treated material.

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