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Combining Radio Frequency Drying with Hot Air Oven for Energy Reduction in GABA Rice

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Abstract

Fresh GABA (gamma-aminobutyric acid) rice contains high moisture content approximately 38% wet basis (wb). Most of fast drying process require high energy consumption and affect negatively to its quality. Beside that, the microorganisms are easily grown in the wet grain. Therefore, immediately drying to maintain high quality product and to prevent the growing of microorganisms is needed. This study was conducted in order to compare the effectiveness of different drying methods to decrease the moisture content (MC) of the fresh GABA rice (36% MC) to 14% MC and to evaluate their efficiency in controlling microorganisms on the dried product. The treatments were 14 drying methods which were hot air oven drying (50°C and 60°C), 27.12 MHz radio frequency (RF) drying at 65°C, 75°C and 85°C and the combination of hot air drying and RF drying by applying first the hot air oven drying at 50°C to the samples until they decreased their moisture to 30%, 25% and 20% and thereafter apply the RF drying at 65°C, 75°C and 85°C until the final grain moisture reached to 14%. The specific energy consumption (SEC) was calculated. The moisture content, the cooking quality were determined followed by their viscosities as well as microorganisms decontaminations were detected according to Bacteriological Analytical Manual (BAM) and the GABA contents were determined. The results showed that using solely RF dryings took significantly shorter drying periods than the other methods. SEC value confirmed that the hot air oven drying consumed higher energy (52.56-17.37 MJ/kg) than those combination treatments with RF drying (between 12.43–6.21 MJ/kg) while drying solely with RF resulted the SEC between 0.81-0.42 MJ/kg. Drying treatments with RF decreased remarkably the number of microorganism contamination. Furthermore, their treated rice provided better cooking qualities. However, the highest number of GABA content was found in the treatment of combined hot air oven method to 20% followed by RF 65°C, 75°C and 85°C treatments. Therefore, it concluded that RF drying combine with conventional hot air drying is an promising technique for saving energy consumption in GABA rice drying process whereas the microorganism decontamination could be achieved with the positive improvement on the cooking qualities.

Introduction

GABA rice is a healthy food product that contain with high nutrients especially of gamma-aminobutyric acid (GABA) which play an important role in central nerve system (Akama *et al*., 2009; Komastsuzaki *et al*., 2007). GABA rice is produced by soaking rice grains in water to promote germination and GABA content accumulates during this process. After soaking process, fresh GABA rice enhanced high moisture content approximately 38% wet basis (wb). Several microorganisms occurring during this process causes fermentation, leading to undesirable odor of products, poor quality and shortened shelf life of GABA rice. Thus, immediately drying to prevent the growing of microorganisms is needed. Most of fast drying process require high energy consumption and affect negatively to its quality. Drying with radio frequency (RF) technology has been reported in many agricultural products (Akaranuchat, 2009; Janhang *et al*., 2005b; Sumeerath *et al*., 2010; Wang *et al*., 2003, 2007). The effectiveness of heating within short timing and energy saving are known and being used for many purposes and reported in many publications (Tang *et al*., 2000). Investigating the treatment effects on GABA rice qualities and RF drying time in order to optimize the process for better GABA content and energy saving is still needed. Therefore, this experiment aimed to investigate the potential of drying technique on energy saving, eliminating microorganism with maintaining cooking quality and GABA contents of the product.

Material and Methods

The experiment aimed to compare the effectiveness of different drying methods in decreasing the moisture content (MC) of the fresh GABA rice Khao Dowk Mali 105 variety (36% MC) to 14% MC and to control the microorganisms on the dried product. The treatments were hot air drying (50°C and 60°C), radio frequency (RF) drying at 27.12 MHz at the temperatures of 65°C, 75°C and 85°C and combination of hot air and RF drying by applied first the hot air drying at 50°C until MC decreased to 30%, 25% and 20% and thereafter apply RF drying at 65°C, 75°C and 85°C until the final moisture reached to 14%. The specific energy consumption (SEC) was expressed in MJ/kg and calculated by dividing total energy supplied in drying process to the amount of water removed during drying. The treated rice were determined for their moisture contents (AOAC, 2005), the cooking quality was determined followed by their viscosities (RACI, 1995) as well as microorganism decontamination was detected according to Bacteriological Analytical Manual (BAM) (AOAC, 2005) and the GABA content were assayed and recorded (Sarkar *et al*., 1997). The experiment was design in Complete Randomized design (CRD) with 4 replications.

Results and Discussion

The results showed that drying GABA rice with hot air oven at 50°C took the longest period of drying time (14 hr.). While hot air oven drying at 60°C took 8 hr. However, drying GABA rice with RF at 65, 75 and 85°C resulted shorter drying time more hot air oven drying with 1.15, 0.38 and 0.20 hr., respectively. Moreover, drying GABA rice using the combination of hot air and RF drying could divide into 3 groups according to the duration of drying time. Group 1 was fast drying group (combination of hot air and RF drying by applied first the hot air drying at 50°C until MC decreased to 30% and thereafter apply RF drying at 65°C, 75°C and 85°C) took drying time approximately 3 hr. Group 2 was medium drying group (combination of hot air and RF drying by applied first the hot air drying until MC decreased to 25% and thereafter apply RF drying at 65°C, 75°C and 85°C) took drying time approximately 7 hr. Group 3 was slow drying group (combination of hot air and RF drying by applied first the hot air drying until MC decreased to 20% and thereafter apply RF drying at 65°C, 75°C and 85°C) took drying time approximately 10 hr. Higher temperature leads to higher temperature gradients which allow water to accelerate drying. High temperature also results in an increased diffusion of water in the grain. In addition, the combination with hot air and RF drying method resulted relatively shorter time compared to using solely hot air drying. The RF drying time was shorter than those from hot air drying because during drying with RF heat source, RF wave can penetrate into the GABA rice inter molecules and it was converted to thermal energy to assist a more rapid heating mechanism. The energy from RF wave can be absorbed directly by the rice kernel with low heat loss to the surrounding. Heating begin from every dipolar molecules which create heat or thermal energy from vibration to the magnetic polarity in a very short period leads to effective heat transfer in the medium. This is result in significant reducing drying time. According to Mekkaphat *et al*.(2011) reported that RF was an alternative way with high potential on drying with saving energy and also reducing time used more than using only solely hot air drying. Oberndorfer *et al.* (2000) investigated that using electromagnetic waves, radio frequency and microwave in drying process, energy consumption was related with grain moisture content. High moisture content of grain was absorbing more energy and conducive to efficient heat transfer in grain. According to drying condition, SEC value completely confirmed that hot air drying (50 and 60°C) consumed higher energy (52.56-17.37 MJ/kg) than the combination with RF (between 12.43–6.21 MJ/kg) while solely RF drying expressed the SEC between 0.81-0.42 MJ/kg. The SEC was found to decrease with drying temperature increased. However, using higher temperature was related to more power energy consumption. The SEC was found to decrease while drying temperature increased. Higher temperature was associated with shorter drying time. Results from the drying conditions indicated that under RF drying (65, 75 and 85°C) provided lower SEC value than those from hot air dryings. The very short drying time is the main reason of the lower number of SEC value that leading to saving energy consumption better than those from other drying treatments. This result was similar to Mekkaphat *et al*. (2011) and Bualuang *et al*. (2011)). Drying GABA rice with high temperatures, the number of microorganism significantly decreased. The result showed the number of microorganism (bacteria, yeast, and mold) contamination on dried GABA rice. The drying treatments with RF at 75 and 85°C, the combined hot air drying to 30% MC and then followed with RF 65, 75 and 85°C and the combined hot air drying to 25% MC and then followed with RF 65°C these treatments resulted the best group reducing the microorganism contamination in GABA rice to 17.33, 7, 9, 12.33 and 5.67 x10^6CFU/ml, respectively. According to Akaranuchat *et al*. (2007); Chaisathidvanich *et al*. (2010) and Janhang *et al.* (2005a) demonstrated that RF heat treatment is an alternative way with high potential to control fungi in the products. The mentioned treatments resulted in better treatments in controlling microorganism were related to the higher initial MC of the samples before subjected to RF treatments. Moreover, Vassanacharoen *et al*. (2006) also reported that initial moisture content of the product was the main factor that could be increased the efficiency of RF treatment in controlling fungi infection.

Table: Effect of drying techniques on GABA rice drying period, Specific energy consumption (SEC), microorganism contamination ,GABA content and Viscosity of GABA rice

Treatment	Drying Time (hr)	SEC	BAM (CFU/ml)	Viscosity (centipoises, cP)					GABA (mg/100 g)
				Peak viscosity	Breakdown	Setback	Final viscosity	Pasting temperature	
Hot 50°C	14	52.56	50.67bc	236.67g	132.67g	117.33j	355.00i	71.95de	7.58d*
Hot 60°C	8	17.37	31.33de	578.00d	272.00c	302.33f	880.33f	72.05de	10.18c
RF65°C	1.15	0.81	49.00c	941.00b	363.00a	515.00e	1456.00e	73.57de	10.02c
RF75°C	0.38	0.42	17.33efg	1073.00a	337.00b	600.67d	1673.70bc	72.53de	8.15d
RF85°C	0.20	0.44	7.00fg	1069.00a	245.00d	735.00a	1804.00a	81.15abc	7.46d
Hot30%+RF65°C	3.43	9.19	9.00fg	984.33b	319.00b	739.67a	1724.00b	75.72cde	7.94d
Hot30%+RF75°C	3.30	9.09	12.33fg	955.00b	328.33b	695.00b	1650.00c	72.52de	4.28f
Hot30%+RF85°C	3.15	10.65	5.67g	862.33c	283.00c	671.00c	1533.30d	84.57a	9.55c
Hot25%+RF65°C	7.58	6.21	34.00cde	350.00e	167.67ef	189.67h	539.67g	78.82abcd	6.36e
Hot25%+RF75°C	7.29	6.44	45.00cd	350.33e	171.67e	192.67h	543.00g	70.45e	9.62c
Hot25%+RF85°C	7.11	9.00	77.00a	364.00e	165.67ef	224.33g	588.33g	73.32de	8.13d
Hot20%+RF65°C	10.18	7.81	46.00cd	288.67f	147.33fg	164.67i	453.33h	78.58abcd	14.8a
Hot20%+RF75°C	10.11	8.24	23.00ef	291.00f	140.33g	182.00hi	473.00h	77.52bcd	13.00b
Hot20%+RF85°C	10.07	12.43	66.33ab	322.00ef	137.33g	233.00g	554.00g	82.78ab	12.78b
F-test	-	-	*	*	*	*	*	*	*
CV (%)	-	-	29.86	4.41	6.3	3.26	3.71	5.46	3.83

*Different letter within row indicate that means are significantly different (P≤0.05)

Viscosity of GABA rice flour was determined by RVA result the viscosity of the starch during heating cycle. The temperature and time of drying significantly affected on pasting properties of treated GABA rice. The result showed that peak viscosity, setback and final viscosity tended to increase when the rice exposed to higher drying temperatures. These findings corresponded with the study of Sumreerath *et al.* (2008, 2010) and Bualuang *et al*. (2011). The highest peak viscosity values were found when drying with RF solely at 75 and 85°C. This is because the higher temperature caused the increased degree of gelatinisation in GABA rice. Derycke *et al.* (2005) and Jaisut *et al*. (2007) indicated that influence of amylose-lipid complex formation also increased peak viscosity in rice flour, which might have occurred during drying process. The GABA content of GABA rice after drying significantly changed with drying treatments. The result showed that the highest number of GABA content was found in the treatment of combined hot air oven method to 20% followed by RF 65°C, 75°C and 85°C treatments (between 14.8–12.78 MJ/kg). These result indicated that slow drying technique can prevent GABA content reduction more than fast drying technique.

Conclusions and Outlook

RF drying combine with conventional hot air drying is an alternative way for saving energy consumption in GABA rice process and the microorganism decontamination could be achieved. The slow drying methods maintained better numbers of their GABA contents and provided positive improvement on their cooking qualities.

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