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Influence of Milled Rice Packing Methods on Radio Frequency Heat Distribution in Controlling Aspergillus flavus and Their Cooking Qualities

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proposed outline

This study was aimed to determine the uniformity of heat distributed in different milled rice packages after various radio frequency (RF) heat treatments. The responses from the loaded samples in controlling contaminated *Aspergillus flavus* by heat from electromagnetic field were investigated. Milled rice var. KDML105 with 14 percent initial moisture content was used. Sample was inoculated with *A. flavus* at concentration of 1×10^6 spores per ml and incubated for 7 days. Three different loading densities were packed and evaluated: vacuum full loaded (1), non vacuum full loaded (2) and 85% loose loaded (3). The samples were exposed to RF heat treatments at an operating frequency of 27.12 MHz with temperatures of 80, 85 and 90°C for 1, and 3 minutes. The heat distribution were taken by infrared cameras, kernel moisture content, degree of remained *A. flavus* infection, amount of aflatoxin, amylose content and cooking qualities were determined. It was found that packing methods affected the distribution of heat significantly. The packing type1 showed the most effective in heat distribution resulted to significantly in decreasing *A.flavus* infection, the RF treatment at 90 °C for 3 minutes duration was the best treatment, the fungus was remained 0.64 %, aflatoxin was decreased significantly from 6.68 to 2.8 ppb. The moisture content of all samples decreased with no significant differences. The cooking qualities such as: the percentage of amylose was increased, the gel consistency was decreased, the elongation ratio of rice kernel was increased. There were changes in their viscosities: the rice's final viscosity, setback value and pasting temperature value were increased in contrast, its peak viscosity and breakdown value were decreased. The texture of cooked rice was increased in hardness and cohesiveness but decreased in adhesiveness. Thus, vacuum packing with RF heat treatment could control *A. flavus* and aflatoxin formation effectively with positive changes in their cooking qualities.

Key word: milled rice, *Aspergillus flavus*, cooking qualities, radio frequency, packaging

Introduction

Contamination of fungal and afatoxin in milled rice has become a constraint issue in export Thai rice according to DEF report (2008), there was 180 g. fungal and 0.04 ppm. Aflatoxin contamination found per metricton from 24 tons of imported Thai rice. Besides that aflatoxin B1contamination was found from brown and polished milled rice, Bangkok Central Market which were 0-4.56 ppb. and 0-2.53 ppb. respectively (Chinaputi and Aukkasarakul, 2009). Pratically visible *Aspergillus flavus* contaminated grain removed by hand was the easiest way to control the contamination. Some methods in controlling fungal contaminated lot were reported. Recently, there were the possibilities in using heat from electric field generated from the radio frequency in controlling various fungal contaminations, *Trichoconis padwickii* in rice (Janhang *et al*., 2005) *Fusarium semitectum*, in corn (Vassanacharoen *et. al.*, 2006) *A. flavus*, *Alternaria* sp., *Penicillium* sp. and *Rhizopus* sp. in Barley (Akaranchat *et.al.*, 2007). Their reports provided the effects of temperatures and duration of treatments on physical and chemical properties of the loading materials, Anyhow, there are still some information needed to investigated such as the various method of packing which may influence the heat distribution and the dynamic changes of the product qualities during treatment. Therefore, this experiment aimed to investigate the response of radio frequency heat treatment in controlling A. flavus in various pocking methods, available in the consuming market and its affecting on rice qualities.

Material and Methods

The experiment was conducted at The Postharvest Research Institute Chiang Mai University during May-September 2010. *Aspergillus flavus* was separated from germinated milled rice var. KDML105 and incubated for 7 days at ambient temperature (ISTA, 2006), pure culture was done by cultivated *A. flavus* on potato dextrose agar for 7 day. Spore suspension was then prepared and heamacytometer was used to prepared 1x10^6 spores concentration per mill liter. The experiment was design in CRD with 4 replications. The experimental factors were packing methods, temperature used and treatment durations. 3 methods of packing were full loading packed with vacuum, full loading packed and 85% loading packed. RF generator at the frequency of 27.12 MHz was applied at the 3 levels temperature of 80, 85 and 90 ^{O}C and 1 and 3 minutes duration. Heat distribution was recorded by infrared thermal camera FLIR T200 (FLIR Systems Inc., U.S.A.) *A. flavus* contamination was assayed by PDA method (ISTA, 2006). Rice moisture content, aflatoxin, amylase contents were determined. Starch viscosity parameter and texture profiles were measured and analyzed by Rapid Visco Analyser (RVA) (Newport Scientific, Australia).

Results and Discussion

The heat distribution of 3 methods of packing found that heat distribution within bag of full loading packed with vacuum regularly better than full loading packed and 85% loading packed (figure 1). Table 1 demonstrated the influenced of RF heat treatments on various grain qualities. There was no significant different in grain moisture after treatments. *A. flavus* inoculated sample showed their decreasing in percentage in contamination significantly by methods of packing and temperature used. The higher temperature of RF treatments, the better in resulting fungal control. Anyhow, every method of packing resulted positive responsed in controlling *A. flavus*. The 90 °C 3 minutes duration provide the best result, the *A. flavus* showed the least number of remained contamination. Beside that it was also found that the amount of aflatoxin B_1 has decreased significantly after RF treatment, compared to those from control treatment, however the initial percentage of aflatoxin B_1 assayed from all the token samples before subjected to the RF treatment were lower than the FAO limitation (< 20 ppb.). The short incubation period of *A. flavus* might resulted in low amount of found aflatoxin. Amylose contents from all RF treated samples were increased. The increased amylose percent were not as high as the low amylose content rice groups which is 10 – 20 percent amylose content and the increased amylose content treated sample did not appeared high than those amylose content which belong to Rice var. KDML105 characteristic

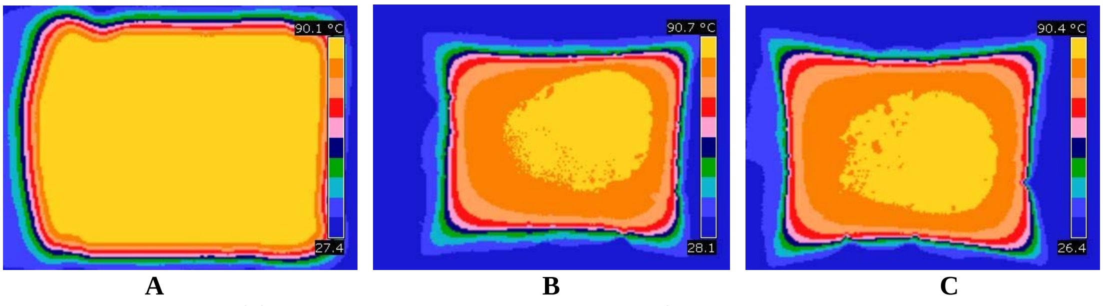

Figure 1: Heat distribution of full loading packed with vacuum (a), full loading packed (b) and 85% loading packed (c) after radio frequency heat treatment.

The cooking qualities also demonstrated in Table 1. Vacuum packing milled rice after treated with 90 °C 3 minutes exposure duration presented the shortest gel consistency with 9.38 cm. The results supported the report from Sumreerath (2010). There was significantly differences in grain elongation after various heat treatments. After cooking, RF treated rice grain showed their encouraging in rice expansion, especially the length. The overall elongation of the grain influenced and resulted the increasing in volume, their texture was loose, fluffy and soft. Table 2 presented the rapid viscosity assessment and their texture profiles. The RF heat treatment influenced the break down value. The break down value represented the durability of the starch granules. The similar report was stated by Naivikul (2007) which the toughness was decreased after flour stirring. Besides that, it was found that the pasting and set back temperature were significantly increased compare to the control treatment. The result supported the results from Wiset *et al.*, (2005) which reported that after subjected high temperature to rice grain , the pasting temperature was increased, pasting temperature is the temperature, which starch granules are gelatinized, the starch granules will begin to change their viscosity before the dough inflates fully. This is related to the amylose content in the grain, the more content of amylose the harder the starch granules which therefore, cooking rice will need more time and energy. The set back value was highly significantly differences with the control treatment. The set back value involved with retrogradation which occurred after starch gelatinization, within this process, the amylose molecules separated from the starch granules. This resulted less broken number of rice found after cooking (Perez and Julino, 1982). This occurring related to the texture of cooked rice after subjected to high temperature and long exposure duration. There was significantly increased in hardness value whiles adhesiveness value decreased compare to control treatment. Therefore, cooked rice texture after subjected to high temperature with long duration resulted in hardness increasing and adhesiveness decreasing. These results supported the report from Sumreerath *et al.,* (2008) which stated that increasing temperature and timed used resulted in hardness increased and adhesiveness decreased.

Conclusions and Outlook

Application of RF heat treatment on KDML105 rice in vacuum packing decreased significantly the incidence of *A.flavus* infection. *A. flavas* contamination was decreased and under control in all temperature and duration used. The aflatoxin was essayed and found in the minimum level. The amylose percentages after treatments remained in the category of the low amylose rice group. The cooking quality and their texture have been modified after treatment by increasing in hardness and decreasing in adhesiveness. This resulted in friable cooked rice after cooking which is preferable by consumer.

Table 1. Moisture content (%) , *A. flavus* (%) , Aflatoxin (ppb) , Amylose (%) , Gel consistency (cm.) and Elongtion (cm.) of milled rice packing methods with different temperature (°C) and exposure durations (min)

Treatment	**MC (%)**	***A . flavus* (%)**	**Aflatoxin (ppb)**	**Amylose (%)**	**Gel consistency (cm.)**	**Elongation (cm.)**
control	14.08	100.00	6.68	15.37	9.94	1.24
vacumn 80 °C 1 min	14.05	2.56	4.612	15.92	9.85	1.25
vacumn 80 °C 3 min	13.90	1.28	4.39	15.24	9.73	1.25
vacumn 85 °C 1 min	13.72	1.41	3.84	16.32	9.78	1.26
vacumn 85 °C 3 min	13.91	1.15	3.51	17.45	9.84	1.27
vacumn 90 °C 1 min	13.85	0.77	3.70	17.90	9.48	1.28
vacumn 90 °C 3 min	13.93	0.64	2.80	18.00	9.35	1.28
non vacuum full loaded 80 °C 1 min	14.09	26.28	4.90	16.71	9.76	1.30
non vacuum full loaded 80 °C 3 min	14.06	22.95	4.95	17.51	9.50	1.26
non vacuum full loaded 85 °C 1 min	14.09	18.85	4.21	17.71	9.82	1.27
non vacuum full loaded 85 °C 3 min	14.04	23.33	3.84	17.74	9.71	1.26
non vacuum full loaded 90 °C 1 min	14.05	16.03	3.32	18.46	9.60	1.29
non vacuum full loaded 90 °C 3 min	13.94	17.44	3.02	17.60	9.38	1.27
85% loose loaded 80 °C 1 min	14.19	23.43	5.65	19.56	10.00	1.23
85% loose loaded 80 °C 3 min	13.98	23.69	5.30	19.69	10.00	1.25
85% loose loaded 85 °C 1 min	14.03	21.72	4.81	19.04	9.81	1.23
85% loose loaded 85 °C 3 min	13.93	22.15	4.39	19.56	9.91	1.24
85% loose loaded 90 °C 1 min	14.08	16.39	3.80	19.33	9.78	1.26
85% loose loaded 90 °C 3 min	13.94	18.05	3.16	20.02	9.73	1.29
F-test	ns	**	**	ns	ns	*
LSD 0.05	ns	6.91	0.86	ns	ns	0.04

Table 2 RVA viscosity parameters and Texture profile analysis attributes of cooked rice of milled rice packing methods with different temperature (°C) and exposure durations (min)

Treatment	Viscosity (centipoises, cP)					Texture profile analysis attributes		
	Peak	**Breakdown**	**Final viscosity**	**Setback**	**Pasting Temperature**	**Hardness (g)**	**Adhesiveness (g)**	**Cohesiveness**
Control	2405.96	584.50	4044.66	1729.83	80.60	180.62	-0.19	94.08
vacumn 80 °C 1 min	2228.10	343.60	4131.60	1903.50	79.10	199.14	-0.24	114.24
vacumn 80 °C 3 min	2312.00	355.30	4084.10	1944.10	84.90	193.82	-0.28	106.93
vacumn 85 °C 1 min	2277.80	336.20	4102.30	1944.40	85.20	194.52	-0.27	109.95
vacumn 85 °C 3 min	2214.20	301.80	4256.10	2011.80	82.00	190.65	-0.31	103.28
vacumn 90 °C 1 min	2007.00	220.90	4222.30	2040.00	79.80	192.76	-0.36	108.18
vacumn 90 °C 3 min	2055.90	241.50	4225.90	2028.20	84.60	192.73	-0.22	107.64
non vacuum full loaded 80 °C 1 min	2212.30	356.80	4100.70	1861.30	79.90	181.87	-0.36	95.41
non vacuum full loaded 80 °C 3 min	2175.80	308.80	4073.60	1931.70	81.00	188.32	-0.30	103.14
non vacuum full loaded 85 °C 1 min	2150.40	292.60	4107.50	1950.30	83.10	185.95	-0.20	99.58
non vacuum full loaded 85 °C 3 min	2218.50	309.60	4198.50	1962.70	83.00	186.47	-0.44	100.97
non vacuum full loaded 90 °C 1 min	2176.50	299.70	4181.20	1980.00	82.30	186.84	-0.33	101.42
non vacuum full loaded 90 °C 3 min	2030.20	278.80	4156.50	1950.30	84.00	192.13	-0.30	107.24
85% loose loaded 80 °C 1 min	2204.10	314.60	4165.30	1961.30	83.90	186.56	-0.35	99.37
85% loose loaded 80 °C 3 min	2145.80	291.30	4079.20	1933.40	78.40	186.71	-0.45	99.93
85% loose loaded 85 °C 1 min	2215.70	308.20	4200.80	1985.20	85.00	187.72	-0.46	90.43
85% loose loaded 85 °C 3 min	2293.40	330.40	4258.20	1964.80	83.90	198.20	-0.34	97.72
85% loose loaded 90 °C 1 min	2152.70	282.30	4168.00	2015.30	84.70	180.00	-0.41	111.93
85% loose loaded 90 °C 3 min	2145.10	311.30	4143.50	1998.40	83.80	184.27	-0.27	100.00
F-test	*	**	ns	**	*	ns	ns	ns
LSD 0.05	209.5	75.2	ns	85.99	4.02	ns	ns	ns

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