Effect of Humidified Hot Air on Change of Free Fatty Acid Content of Brown Rice during Storage

Nittaya Junka[1*], Chalermchai Wongs-Aree[2], and Chaiwat Rattanamechaiskul[3]

[1] Division of Crop Production Technology, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Muang, Nakhon Pathom 73000, Thailand
[2] Postharvest Technology Program, School of Bioresources and Technology, King Mongkut's University Technology Thonburi, Bangkhuntien Campus, Bangkhuntien, Bangkok 10150, Thailand
[3] Department of Engineering, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon Campus, Pathiu, Chumphon 86160, Thailand

[*] Corresponding Author: nittaya717@hotmail.com, TEL: +66 3426 1065, FAX: +66 3426 1065

Abstract

The aim of this research was applying fluidized bed drying to inactivate lipase enzyme to prevent hydrolysis of lipids in rice bran that gave rise to free fatty acid content (FFA), which resulted in undesirable rancidity for consumers during storage. The paddy with post harvested moisture content of 33.3% (d.b.) was dried by hot air (HA) and humidified hot air (HHA) in a range of temperature of 100-150ºC. At such a drying temperature range, the relative humidity (RH) was given in the range of 1-3% and 6-31% for the HA and HHA. The result of drying kinetics revealed that the drying time of HHA was longer than that of HA because the difference of water vapor concentration between paddy surface and drying air was lower. The grain temperature of treated sample by HHA rapidly increased during the early period of drying process since the condensation of water vapor released the latent heat of state change from vapor to liquid. For analyzing of FFA content, that content of reference sample dried by sun drying obviously increased with increasing the storage time for 3 months (analyzed every month). The FFA formation of dried sample decreased with increasing the drying temperature and RH. At the storage time for 3 months, the sample was dried by HHA at 150ºC and RH of 7% had the lowest FFA content.

Keywords: Humidified hot air, Free fatty acid, Storage

1. Introduction

Rancid brown rice produces unpleasant smell after long retention because the hydrolysis process of lipids in rice bran had turned into FFA by lipase enzyme [1-3]. The rancid smell was the main problem for determination of the rice price because such smell was unwanted by the consumers. Even though the research work has shown that the reaction of lipase enzyme could be reduced through control of the retention temperature as low temperature would reduce FFA formation during storage [4] but such method could not be applied in case of storage of a large amount of rice stock for a long period of time if the capital expenditure on construction of the temperature control room and the energy cost were taken into account.

The paddy rice drying process with hot air fluidization technique was an alternative to reduce the rancid smell in paddy rice because such drying process could employ the temperature more than 100ºC during the drying process. The research work in the past has found that the thermal process could inactivate lipase enzyme, thus, the products with lipids in their component might decrease FFA formation during the storage [5-7]. In addition to hot air as the drying media in the drying process, this technique could apply the humidified hot air in the drying process. The humidified hot air generated from saturated vapor spraying injection into the system to blend with the hot air in the drying chamber would turn to the humidified hot air. The special quality of the humidified hot air was that the media would condensate during the initial state of the drying process. Since the temperature of the paddy rice was lower than the dew point temperature, while the condensation process was going on, the water vapor would release heat energy during the transition of phase change to the paddy. Thus, the temperature of the paddy rice would rapidly increase to the level higher than the drying process with hot air at the same drying temperature [8-10]. Such information showed that the humidified hot air might reduce the deformation of FFA better than the hot air.

Therefore, this research was studied on deformation of FFA formation of paddy with hot air fluidization technique in comparison with humidified hot air. After the kinetic data on drying process has been tested, including FFA quantity during the storage, it would be analyzed to determine the appropriated drying condition for deformation FFA storage during storage.

2. Materials and methods

2.1 Materials

The paddy rice, Pathumthani 80, from the same field and planted under the control of the specialists from Pathumthani Rice Research Center, Thailand was used in the test and the paddy rice had moisture after the harvest at 33.3% dry basis (d.b.).

2.2 Methods

The sample was dried with fluidized bed dryer consisting of 21 kW electrical boiler for generation saturated water vapor at 103ºC, 12 kW heater controled with PID controller, accuracy ±1ºC, stainless cylinder drying chamber with 20 cm in diameter and 1.5 kW centrifugal blower as shown in Fig. 1.

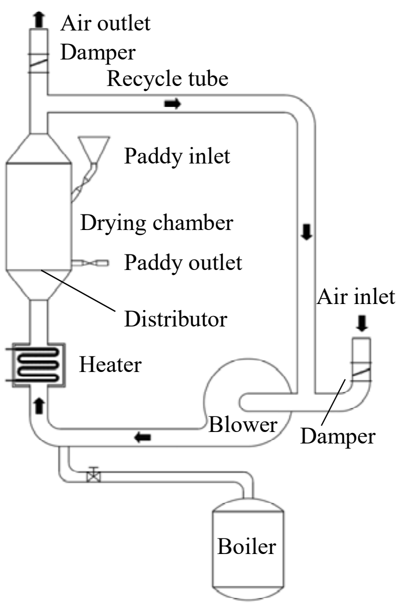

Fig. 1 HA and HHA fluidized bed dryer diagram

The air would be passed through the heater to increase the temperature until the temperature had reached the required level and 80% of the heated air would be recycled. The vapor was injected into the system to increase the relative humidity. The drying temperatures used in process were 100, 130 and 150ºC, RH percentage of HA and HHA of 1-3% and 6-31%, the air velocity of 3.0 m/s and bed height of 10 cm. During drying, the rice grain sample at different drying conditions was taken out of the drying chamber at each drying time, for example, 30s, 1, 2, 4, 6 and etc., until the moisture reached to 22.0% d.b. Those samples were measured the grain temperature by tempered in the enclosed jar, with installed thermocouple, and moisture content by method of Approved Method of the American Association of Cereal Chemists or AACC [11]. Then, each sample at 22.0% d.b. was ventilated with ambient air for 30 minutes until the moisture reduced to 13-15% d.b. The dried paddy by HA, HHA and referenced sample, reduced the moisture through sun drying, would be dehusked and contained in the polypropylene woven bag at the room temperature for analysis of FFA content during 3 month storage (analysis every month) in accordance with the AACC method [11].

3. Results and discussion

3.1 Drying kinetics

Fig. 2a illustrates the changes in moisture content of paddy during drying by HA at temperature of 100, 130 and 150ºC. The hot air during test had controlled humidity ratio at average of 25 g water/kg dry air, thus, the RH value of the hot air at 100, 130 and 150ºC was at 3.4, 2.1 and 1.3%, respectively. From the figure, the moisture of paddy rice started at 33.3% d.b. when the drying process commenced, the moisture of the paddy rice had decreased rapidly, particularly at the temperature of 150ºC since the moisture evaporation of the drying mechanism was dependent on water diffusion inside the paddy to the surface for vaporizing to drying media. The diffusion ability was dependent on the temperature of the paddy.

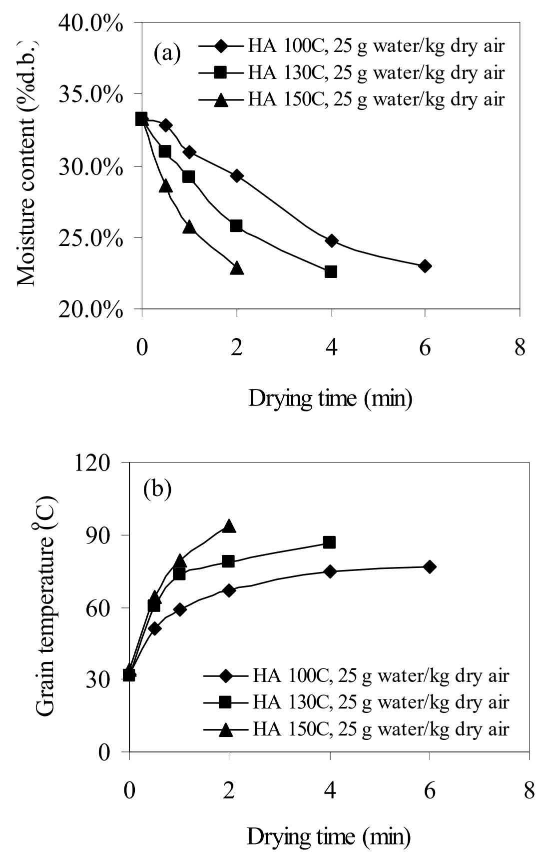

Fig. 2 Change of moisture content (a) and grain temperature (b) of paddy during drying by HA at different drying temperatures

From Fig. 2b, it found that the temperature of paddy rice was directly related to the temperature employed in the drying process. The hot air at 100, 130 and 150ºC could transfer the heat from the air to the paddy grain at the initial temperature of 30-32ºC to increase amongst the drying process. The temperatures of rice grain at moisture of 22.0% d.b. were 77, 86 and 94ºC, respectively. According to such reasons mentioned, the drying process with HA at temperature of 150°C required the shortest drying time for 2 minutes with the temperature of the grain had reached the maximum during the drying process [12 -14].

Fig. 3a illustrates changes in moisture content of paddy during drying by HA and HHA with different RH at 100°C. During the drying test with HHA, saturated vapor was injected into the drying process to increase the humidity ratio. At percent RH greater than HA for about one time, 7.6%, humidity ratio was at 51 g water/kg dry air and at percent RH of 31.3% such ratio was at 280 g water/kg dry air, maximum capacity of boiler to produce saturated vapor. To compare the change in moisture, it found that when the moisture was increased in the system, the moisture of the grain increased during the initial 30s of the heating process due to the condensation of water vapor as evident by percent RH of 31.3%. The condensation occurred from the initial temperature of the grain lower than the dew point temperature of HHA; at RH of 7.6 and 31.3%, the dew point temperature was at 40 and 70°C. The result of the condensation had caused the temperature of the rice grain to increase rapidly, particularly at RH of 31.3% due to water vapor released the heat during phase change as shown in Fig. 3b. After that, when the temperature of the grain was higher than the dew point temperature, the condensation would finish and proceed to the drying period. The drying rate with HHA was lower than that of HA because the humidity ratio of HHA was higher than HA, thus, the convective mass transfer at the surface of the grain to the drying media was absented. As a result, the time used in the drying process with HHA was longer than that with HA at the same drying temparature [8 -10].

Fig. 4a illustrates the changes in moisture content of paddy during drying with HHA at percent RH about 7%. From the figure, it found that during the initial 30s of the drying process, the moisture of the rice grain dried with HHA at 150°C increased about 2% d.b. which was more than that of drying with HHA at 100°C because the difference in humidity ratio. Even though the drying temperature of both medias had the same percent RH but the humidity ratio of HHA at 150°C was higher than that at 100°C. Due to such difference, the temperature of the rice grain during the condensation period was obviously different as shown in Fig. 4b. When it had entered the drying period, comparison on both slopes of drying curves since the second minute showed not difference even though the drying process with HHA at 150°C had the ability to diffuse the moisture better than that of HHA at 100°C. Such result shown that the amount of saturated water vapor in the air affected the ability to transfer the moisture at the surface of the rice grain, subsequently affected the drying rate [9].

3.2 Change of FFA content

Fig. 5 illustrates the changes in FFA content of dried brown rice by sun and HA drying at temperature of 100, 130 and 150°C during storage. After the drying

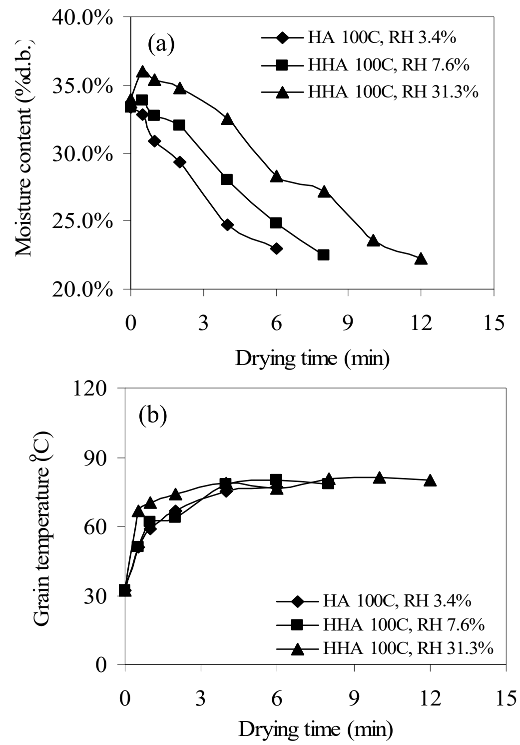

Fig. 3 Change of moisture content (a) and grain temperature (b) of paddy during drying by HA and HHA with different RH at 100°C

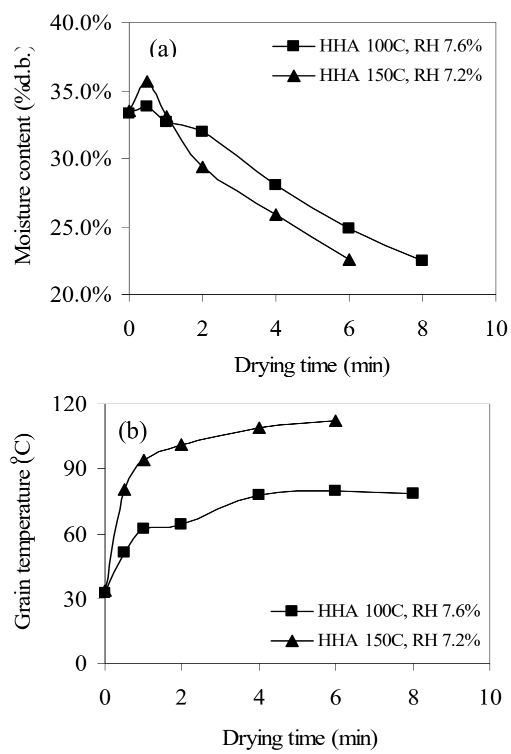

Fig. 4 Change of moisture content (a) and grain temperature (b) of paddy during drying by HHA with controlled RH of 7%

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process, the quantity of FFA of all samples had the range of 58±3 - 64±2 mg/100 g dry matter. After storage for one month, the quantity of FFA of dried sample by sun drying clearly increased in comparison with the dried sample by HA. The quantity of FFA had a tendency to increase continuously throughout the storage period. At the storage period of 3 months, the quantity of FFA of dried sample by sun drying was at 186.7±6 mg/100 g dry matter. For comparison of FFA quantity of dried brown rice by HA, it was found that FFA formation tended to decrease in accordance with the increase in the drying temperature. Using of HA at drying temperature of 150°C had more efficient to inactivate lipase enzyme better than HA drying at low temperature [15]. Resultantly, it could reduce FFA formation during the storage period of 3 months for 50% compared with the content of the dried sample by sun drying.

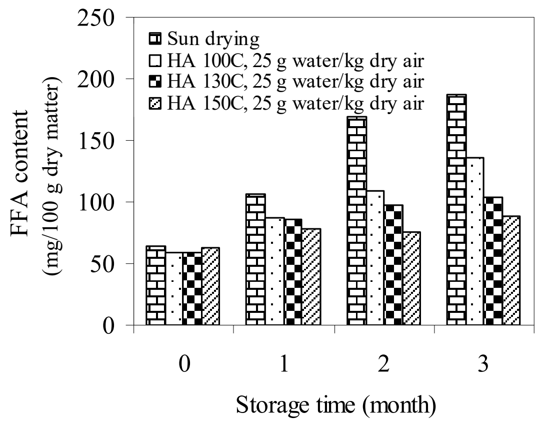

Fig. 5 Change of FFA content of dried brown rice by sun and HA drying during storage

Fig. 6 illustrates the changes in FFA content of dried brown rice by HA and HHA with different RH at 100°C. The study found that FFA content of dried brown rice seemed to differ when the storage period was past 2 months and clearly differed at the storage period for 3 months. FFA content of dried brown rice by HA and HHA at RH of 7.6 and 31.3% was 135±3, 125±5 and 103±0 mg/100 g dry matter, respectively. The result showed that the formation of FFA tended to decrease in accordance with the increase in percentage of RH because the rice grain dried with HHA at RH of 31.3% had reached the highest during the condensation stage. In addition, the heating period of such condition was longer, thus, the ability to inactivate lipase enzyme was better than that of HA and HHA at RH of 7.6% [16].

Fig. 7 illustrates the changes in FFA content of dried brown rice by HHA with controlled RH at 100 and 150°C. It was found that the formation of FFA of dried brown rice at 100°C had increased more than that of the sample dried at 150°C. At the storage period of 3 months, the sample dried at 150°C and RH of 7.2% for 6 minutes had FFA content of 94±8 while the

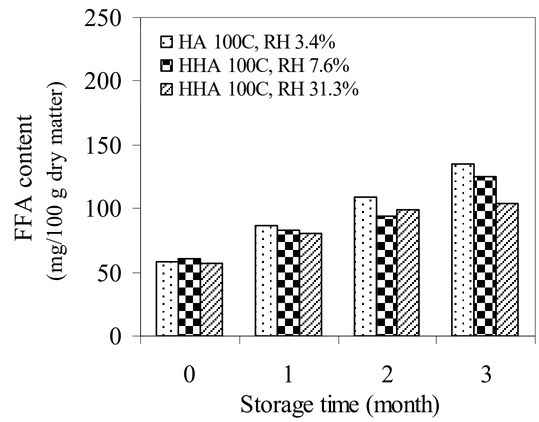

Fig. 6 Change of FFA content of dried brown rice by HA and HHA with different RH at 100°C during storage

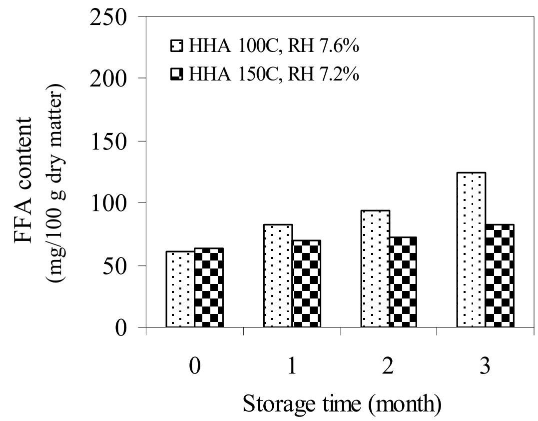

Fig. 7 Change of FFA content of dried brown rice by HHA with controlled RH at 100 and 150°C during storage

sample dried at 100°C and RH of 7.6% for 8 minutes had FFA content of 140±2 mg/100 g dry matter. Comparison on FFA content shows that the drying temperature employed in the process influenced the ability to inactivate lipase enzyme more than the drying period.

4. Conclusions

The condensation occurred when the HHA media was employed, subsequently the temperature of the rice grain rapidly increase during initial state of drying process. The drying temperature and percent RH influenced the drying rate; that rate decreased with decreasing of drying temperature and increasing of percent RH. For the change in FFA formation, when the temperature and percent RH employed in the drying process had increased, FFA formation of dried brown rice during the storage had a tendency to decrease. At the storage period of 3 months, brown rice dried with HHA at 150°C and RH of 7% had the lowest FFA content. Therefore, HHA was able to inactivate lipase enzyme better than HA in the dying process by fluidization technique.

5. Acknowledgement

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7. References

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