International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Coarse Rice Products by Must Flow Fluidization Techniques for Diabetes Patients

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Abstract: ***Rice is the food of mankind contains the most important nutrients that human body need. It is the most important economic crop of Thailand that sold as an income in form of foreign currency. On the other hand, if it is produced in from of particular products for specific consumer, it will increase in value as well. For example, patients with diabetes has an excessive sugar syndrome that should not be eaten white rice, but able to eat coarse rice normally. Therefore, in this paper, the fresh harvested paddy (Rough Rice) from field that dried by Must Flow dryer and then de-husked into Coarse Rice is studied their opportunities for diabetes patients consume. In this research, Rough Rice of "Hom-Mali-Daeng" from Nakhornnayok provience of 700 tons are dried by Must Flow dryer to meet the commercial Rice Mill standard. Hot air temperature of 150^{0}C is used to remove the water evaporated from Rough Rice to the final moisture content of 14.9-15.1%wb within one-pass operation with unlimited initial moisture contents. It is then de-husk into Coarse Rice and test their nutrients. It is found that have higher nutrients contents than fluidized Bed dried Coarse Rice. Test results of clinical neurology for diabetes patients who always eat this Coarse Rice could be control the sugar level in blood within the normal range and this could be another way to relieve the diabetes symptoms. In addition, the texture of Coarse Rice is tenderness, aroma and no dullness meets with the nutritious therapy. The most important is that the lower level of energy consumption of Must Flow Dryer operation.***

Keywords: Dryer, Dehydration, Must Flow, Rough rice, Coarse rice.

1. Introduction

Health is most important factor of human being. If you have a good health, your lifestyle is then good as well. Also, if the citizen has good health, faster development of country could be finally obtained. It is known that for those who not eating properly would causes various diseases. For example, eating high carbohydrate or more sweet would causes diabetes. But, for those who eating in the right way, it might encourage the good health. Typically, rice is the major source of carbohydrate for human body. It is the compound of carbon, hydrogen and oxygen that composed into molecule of the small until large size. It is the most important nutrient for life because it is the main source of energy. It could classified by physical and chemical properties into two types as sugar that would soluble in the water and starch and cellulose that would not soluble in the water. The smallest molecule of carbohydrate classified into three types;

1. Monosaccharide such as glucose, fructose and gallactose
2. Disaccharide such as Maltose, Lactose and Sucrose
3. Polysaccharide such as Starch, Glycogen and Cellulose

It can be seen that monosaccharide carbohydrate in form of glucose could be directly absorb through the intestinal wall to change into energy that the human body required by means of metabolism process. An excessive carbohydrate would keep in form of glycogen in the liver to maintain the level of glucose in blood. For others form of carbohydrate such disaccharide and starch that the human body could not directly absorb must have enzymes to decompose into the form of monosaccharide carbohydrate. As mentioned earlier, Rice is known to be an important source of carbohydrate. To obtain the high quality carbohydrate and safe for eating, the process of quality management of rice must be done neatly and appropriately. In generally, Rice is the seasonal crop and simultaneously harvested at the same time. Therefore, if handling with an improper process, it could cause losses in both quality and quantity, particularly, moisture content inside grain which is the most important factor that might accelerate the losses of rough rice. Then, the rough rice must control their moisture content into an exactly level with highly delicate process because of the following reasons. 1.Moisture can affect the spoilage of rough rice during storage due to microbial growth that could occur when the moisture content is enough for the growth of microorganisms such as bacteria, yeast and fungal. 2. Moisture can affect the food safety of rice due to the growth of pathogen microbial that produce the toxic substances such as aflatoxin and patulin that harmful for human health. 3. Moisture can affect the physical and chemical properties of rough rice such as boiling point, melting point, conductivity and specific heat capacity. 4. Moisture can affect the appearance texture that represents the quality of rough rice such as crispness, hardness, toughness and cake homogeneity. 5. Moisture can affect the chemical reaction of rough rice during storage such as Browning Reaction and Lipid Oxidation. 6. Moisture affect the selling price of rough rice that varied according to the level of moisture content. From the foregoing reasons, it is necessary to invent and design the new dryer that have neatly and appropriately operation to reduce and control moisture content of the rough rice into the same level.

2. Must Flow Dryer

This research paper aims to study the moisture reduction process of "Rough Rice" that mean the paddy that freshly harvested from the field and never pass any process before which contain moisture content of 33%wb , 30%wb, 28 %wb, and 38%wb when harvest at the morning, afternoon, evening and during the rain fall, respectively. If there not manage neatly and properly, it could cause losses in both

quality and quantity of rough rice. There are now two different ways to manage rough rice in Thailand. First way is drying to reduce the moisture and then mill and contain in commercial size bags for sale in the market. Second alternative way is drying to reduce moisture and then stored in silos in form of rough rice and waiting for sale with an appropriate marketing opportunity. From the present practice that the rough rice might keep in silos for a long time before mill and sale in the market, if there still have excessive moisture content in rough rice grain, some microorganism such as bacteria yeast and mold could be growth and causes deterioration. Therefore, the most important process is the drying process to reduce moisture content of rough rice before storage and mill. It has many of research in the past develop the more effective moisture reduction machine. Hence, LSU and Fluidized bed dryer is now the standard dryer for rough rice in Thailand. It is generally used in commercial rice mill but still have some pros and cons. With today world trade of rice which has the system to control the quality of rice to meet the specific standard and specification of moisture content of each grain, therefore, the more neatly drying process is required. Must Flow Dryer which is the newly develop dryer that could reduce the moisture content of each paddy grain into nearly the same level of final moisture content within one-pass operation either if it has any initial moisture content seem to be more appropriate for rough rice drying to meet the world trade specification and standard. The schematic diagram of Must Flow dryer shows in Figure 1.

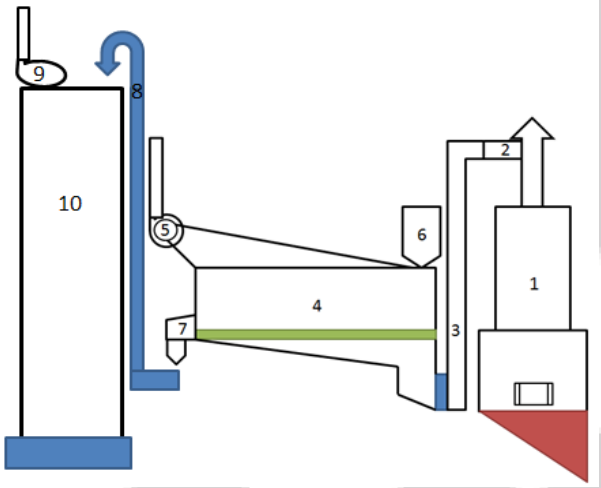

Figure 1: Schematic of Must Flow Dryer are 1.Furnace Renewable Energy, 2. Baffle Valve & Safety Device, 3.Hot Air Main Duct, 4.Must Flow Chamber, 5.Exhoust Blower, 6.Feed Hopper, 7.Discharge Port, 8.Bucket Elevator, 9.Moisture Suction Fan and 10.Silo Tank.

Figure 1 illustrates the component and system of Must Flow Dryer that develop to have the more effective moisture reduction of rough rice. It designs for working continuously and uses for the purpose of moisture content reduction to the final moisture content required that can be stored without any change of rough rice features. It has 20 t/h operating capacity, 700 x 120 x 140 cm in length x width x height of drying chamber, 120 x 700 cm in width and length of hot air distributor plate. It also equip with 3,000 MJ/h hot air generator at the air inlet of drying chamber, 3 kW suction blower on the top of drying chamber and 200 tons capacity of storage silo at the paddy outlet of drying chamber.

Working principle of Must Flow Paddy dryer can be briefly described as follows; fresh harvested paddy with high moisture content is fed into the Feed Hopper (6). The feed rate can be control by feed valve. Then, the paddy was dried in the drying chamber of Must Flow Dryer (4) that operate with 0.6 m/s of hot air velocity and 150^{o}C of hot air temperature which forced to move alternately up and down with frequency of 280 rpm. The paddy is then move along the drying chamber obtain the heat and transfer the mass with hot air until finally reach the Discharge Port (7) and Bucket Elevator (8). The paddy grain will then be conveyed to silos to cooling and tempering for 10 hours. Hot air obtained from rice husk burning is flow from the top of Furnace (1) through Baffle Valve & Safety Device (2). It then flow through Main Duct (3) and mixed with fresh air to get the desire temperature. Then, this hot air is sucked through the Must Flow Drying Chamber (4) and pass the layer of paddy and finally discharged through Blower (5) with a dehydrate moisture from paddy grain.

3. Experimental Set Up

In this paper, hot air temperature of 150^{o}C is settled for rough rice drying inside the drying chamber of Must Flow Dryer. At the feeding point, initial moisture content of rough rice is around 28.1-38.3%wb. The drying chamber shakes at 280 rpm frequency by the operation of lifting arm. Hot air velocity above the air flow distribution plate of 0.6 m/s is then sucked through outlet blower. Rough rice inside drying chamber is then start to move forward periodically along the drying chamber length by means of lifting force generated by lifting arm combined with suction force generated by outlet blower. These forces make rough rice periodically suspends in the air and causes the heat and mass transfer by latent heat evaporation, these phenomena called “Must Flow Bed Drying”. Moisture inside rough rice grain started to move to the grain surface and then transported into air stream and the final moisture content of 14.9-15.1%wb could finally be obtained. After that, dried rough rice is conveyed to store in silos tank for 10 hours. Rough rice samples of 500 g are collected every 1 minutes before and after pass through Must Flow Dryer to check the final moisture content that is weather in accordance to the commercial sale standard or not. The Laboratory testing of nutrients such as dietary fiber, niacin, calcium ferrous zinc and etc., is conducted by rough rice grinding. The testing results will given as a specification of each lot of rough rice in silo tank that waiting for de-husking into course rice when it has an order from customers. While the rough rice move freely inside drying chamber, it is forced to suspend periodically in the air stream and cause the force convection heat and mass transfer phenomena same as a thin layer drying. Rough rice is well mixed with hot air. Rough rice grain is travelling forward along the drying chamber length in the different distance depend on their own density. It is then dried rapidly due to the large relative velocity different during the gravitational free falling down of rough rice grain with air stream during a periodically moving forward. The cavity between rice grains is clearly observed and resulting in the very high bulk density rough rice bed and cause large amount rate of heat and mass transfer that may varied directly to the bulk density. Due to the high relative velocity and short exposure time of rough rice grain to the hot air stream inside drying

chamber, it may cause the little amount of micro cracking and low level of dullness of grain.

4. Result and Discussion

This paper tested the drying 700 tons of "Hom Mali Dang" Rough Rice harvested from Nakhon Nayok province by Must Flow Dryer with temperature of 150°C to give final moisture content of 15 %wb for the production of Course Rice by the order number 14012577. As shown in Figure 2 and Figure 3 that was observed in the first 40 cm of drying chamber that called Preheat stage, rough rice grain start to move forward and expose to hot air, and in this stage it will have started to change and adjust their movement depend on their size and shape. And in the following 200 cm, it is the drying process during the constant drying rate period. Subsequently, in the next 600 cm, it is dried in the reduction drying rate period, the moisture of rough rice grain is reduced by exposure to hot air at a relatively high speed, with the suction of the fan. And finally in the last 100 cm length of drying chamber, it is the adjustment moving of rough rice grain, which is a stage of delicate moisture transpiration.

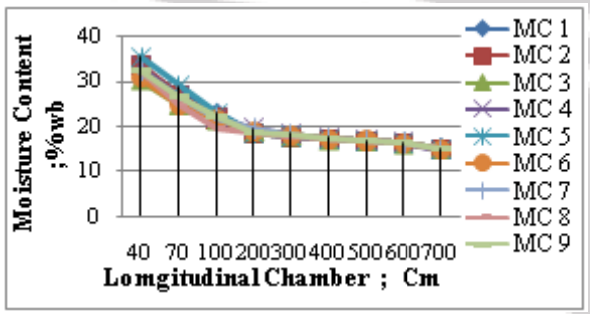

Figure 2: Moisture content reduction at the different position of drying chamber for rough rice with different initial moisture content.

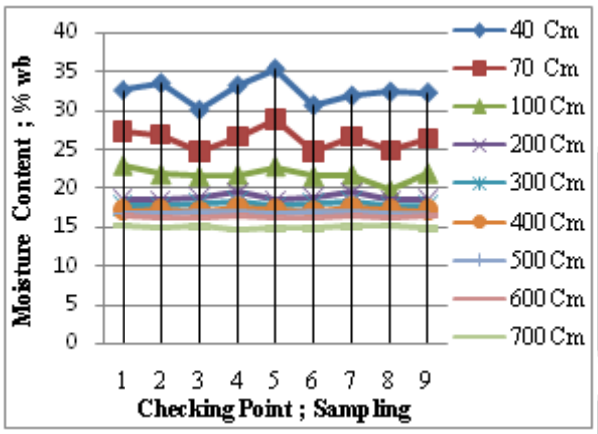

Figure 3: Distribution of rough rice moisture content at different positions of cross section for different traveling position along the drying chamber of must flow dryer.

Figure 2 show that drying of rough rice with different initial moisture content by Must Flow Dryer can reduce moisture into nearly the same final moisture content of 15%wb within one-pass operation. And the dried rough rice is then stored in 200 tons capacity Silos tank for 10 hours. The reason for this newly invented dryer "Must Flow Dryer" can be reduce the moisture content of rough rice to nearly the same level within short time period assumed that the results of behavior of the lifting of rough rice grain and free falling in the opposite direction of the up-coming hot air stream . It causes a very high relative velocity which may resulted in the high rate of moisture transfer at the surface of rough rice grain. This convection moisture transfer might higher than the rate of moisture diffusion from the inside of rough rice grain.

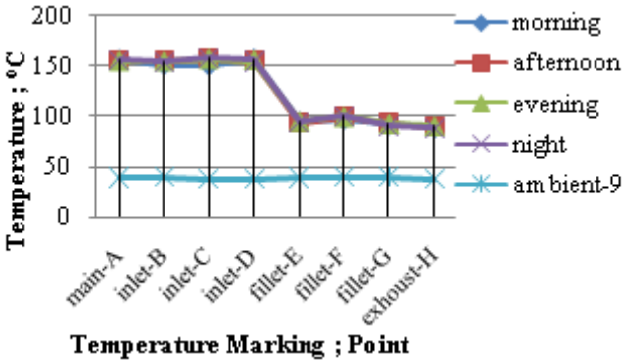

Figure 4: Distribution of air temperature along the drying chamber of must flow dryer for different testing time of working day.

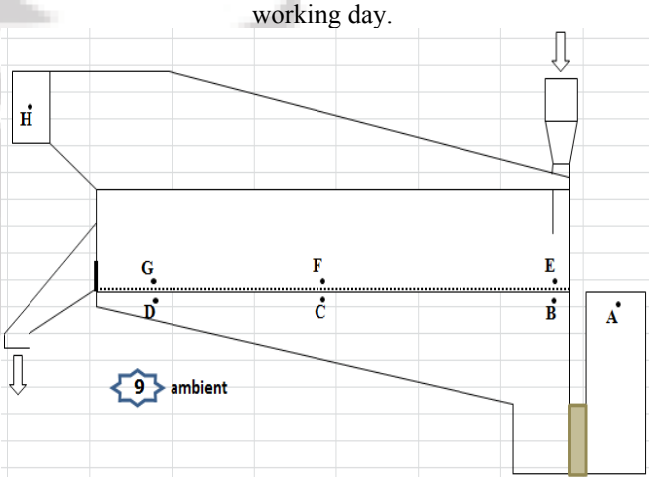

Figure 5: Position of temperature measuring point inside Must Flow Dryer

Table 1: Rough Rice Drying Condition (500 g sample collected for each items) at Capacity 20 t/h, $RH_{average}$ 71.1% Setting, Chamber temperature 150°C

Item	Volume (tons)	MCi (%wb)	MCo (%wb)	Husk Fuel (kg)	Grain Temp. (°C)	Brown Rice (%)	Husk (%)
1	178	32.6	15.2	1400	66.5	76.98	23.02
2	206	33.5	15.0	1590	66.3	77.49	22.51
3	140	30.1	15.1	1140	65.8	77.15	22.85
4	172	33.2	14.8	1400	65.9	77.31	22.69
5	146	35.3	14.9	1140	65.8	76.81	23.19
6	123	30.7	14.9	1110	66.0	76.88	23.12
7	105	31.9	15.1	1100	66.4	78.92	23.08
8	132	32.4	15.2	1110	66.1	77.91	22.09
9	180	32.3	14.9	1400	66.2	77.94	22.06

Table 2: Comparison of Nutrients test result of Rough Rice collected from Must Flow Dryer (MFD-206, MFD -140, MFD-172, MFD-146) and Fluidized Bed Dryer (FBD-118)

Description	FBD-118	MFD-206	MFD-140	MFD-172	MFD-146
Protein	6.43 g	8.34 g	8.27 g	8.61 g	8.01 g
Fiber	4.23 g	5.22 g	5.31 g	5.24 g	5.28 g
Vitamin B1	0.35 mg	0.48 mg	0.42 mg	0.45 mg	0.44 mg
Vitamin B2	0.06 mg	0.09 mg	0.09 mg	0.08 mg	0.09 mg
Niacin	0.52 mg	0.69 mg	0.67 mg	0.67 mg	0.68 mg
Ferrous	1.42 mg	1.69 mg	1.76 mg	1.71 mg	1.74 mg
Calcium	30.15 mg	33.45 mg	33.26 mg	33.32mg	33.41 mg
Zinc	1.89 mg	2.71 mg	2.84 mg	2.79 mg	2.78 mg
Manganese	1.35 mg	2.05 mg	2.09 mg	2.03 mg	2.09 mg
Iodine	1.98 µg	2.83 µg	2.81 µg	2.79 µg	2.84 µg

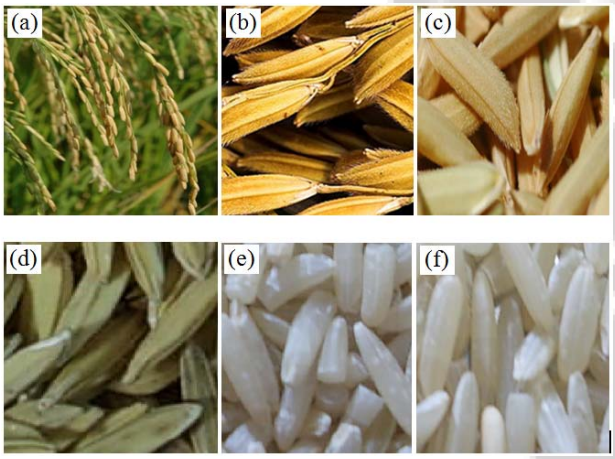

Figure 6: (a) Rough rice on Rice Field, (b) Rough rice from Sun Dried, (c) Rough rice from Must Flow Dryer, (d) Rough rice from Fluidized Bed Dryer, (e) Coarse rice from Fluidized Bed Dryer and (f) Coarse rice from Must Flow Dryer

5. Conclusion

Drying of rough rice by Must Flow Dryer using husk burning as heat source can quickly reduce the moisture content and save energy. Must Flow Dryer can be used to dry rough rice without any limit of initial moisture content as seen from the results of rough rice drying from initial moisture content of 28.1-38.3%wb to nearly the same level of final moisture content of 14.9-15.1%wb in this paper. These data collect from an industrial scale Must Flow Dryer that operated to dry rough rice of 1,328 tons for course rice production and export. Laboratory testing results of nutrients in tables 2 and table 3 show that these course rice suitable for diabetic patient to consume because carbohydrate in form of Monosaccharide is immersed into the fiber and slowly absorbed through intestinal wall that would be the great advantage to control the level of sugar in blood within the limit of human body need. Therefore, Must Flow Dryer is the most suitable machine for course rice production due to their delicate control of the final moisture content of rough rice.

6. Acknowledgment

The authors would like to acknowledge the suggestions of Dr.Khosak Achawakorn Director, Sripatum International College, Sripatum University. And wishes to express their thanks to Nathong Rice Mill Company limited for all rough rice plant dry.

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