Rice Bran Protein Powder Production Using Spray Drying Technique: Effect of Temperature, Feed Flowrate and Air Flowrate

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Abstract. Rice bran is quite a novel subject in the food and pharmaceutical research area. It is the by-product of the rice milling process that is rich in proteins and many other nutrients. However, rice bran is commonly used to feed cattle, also as fertilizer and fuel but not as a source of nutrients for humans. Thus, this study proposes another protein source and explore its production methods for food and supplement industry. This research focuses to produce rice bran protein powder and protein concentration using spray drying technique. Since rice bran protein is used in food consumption, the extraction of protein from rice bran was done using physical extraction method which water as the medium of extraction. The relationship between the spray drying parameter; inlet temperature (130 – 200°C), feed flowrate (10 – 40%) and air flowrate (225 – 625L/Hr) were investigated based on the OFAT method. As conclusion, spray drying process of rice bran protein powder has the capability to maintain the nutritional value present in the rice bran. Rice bran protein powder could be an alternative source of hypoallergenic plant-based protein supplement to humans in the future with further research.

1. Introduction

Rice bran and soybean contain high amount of various antioxidant compounds that impart beneficial effects on human health. Those in rice bran include vitamin E (tocopherols and tocotrienols), vitamin C, anthocyanins, isoflavones, beta-carotene, polyphenols and oryzanol[1]. The nutritional value of rice bran (RB) is interesting for using as food ingredients in any healthy beverages[2]. Protein is widely known as a sensitive macronutrient that can easily be denatured and hydrolyzed under various situations when exposed to certain conditions of temperature, pH and salt concentration[3]. Proteins have a major role in the growth and maintenance of the human body and are, along with carbohydrates and lipids, the energy giving nutrients in the diet. In addition, proteins also pose a wide range of other functions in the body, such as enzymatic activity and transport of nutrients and other biochemical compounds across cellular membranes [4][5].

It is reported that due to rice bran as significant amount of micronutrient such γ-oryzanol and vitamins such as tocotrienols and tocopherols, rice bran has the extraordinary properties that render its suitability...
to produce added value products in nutraceuticals, pharmaceuticals and also in food industry. Gamma oryzanol was found out to have more antioxidant activity compared to the other compounds. Thus, due to its higher antioxidant properties, it helps in lowering plasma cholesterol and serum cholesterol. Protein on the other hand, may treat hyperlipidemia and hyperglycemia, lower menopause disorders, increases muscle mass and even control Type I and Type II Diabetes Mellitus [5]. Rice bran confirms its potential for development of food products, this can be proven by [6] developed breakfast and dinner recipes by substituting cereals with stabilized rice bran at different levels, hence attaining results where 25% incorporation of rice bran had a good acceptability[7], also prepared a highly nutritious cookie by supplementing heat stabilized rice bran up to 10% is suitable for cookie production as it enhances the taste and add nutritional value to it. The production of corn flakes and tortilla chips was studied and it was found that cereals containing 10% -30% rice bran has better nutritional content and is healthier as it increases the protein content [8].

Phytosterol or plant cholesterol can be essential in combating cholesterol. Phytosterols displace cholesterol from intestinal micelles, reducing the pool of absorbable cholesterol, but they are also rapidly taken up by enterocytes and increase expression of the adenosine triphosphate-binding cassette A1 sterol transporter. Phytosterol esters dissolved in food fat reduce LDL-cholesterol by 10% at a maximum effective dose of 2 g/day, [6] thus indicate the important of daily phytosterol intake.

Preservation of rice bran extractant in solid using spray dry have been seen in previous study such as instant soymilk powder by ultrafiltration, spray drying and fluidized bed agglomeration [7] and Instant organic rice bran milk: A nutritional quality aspect [2] where the sample are coming from Thailand. In Malaysia Rice Bran Water Extraction through Autoclaving and Sonication: Protein Content and Amino Acid Profile [3] show the potential for protein extraction for Malaysia rice bran. Nutrition Laboratory at Institut Haivan, Kluang also reported that Rica Bran have 14.9% of crude protein. in 89.5 dry matter. The recovery rates for cholesterol, stigmasterol, and sitosterol were about 100%, but recovery rates for tocopherols were low (25% for d-tocopherol and 66% for g-tocopherol) and varied according to compound structures [8].

Spray drying process is one of the most common drying methods available among various methods such as oven drying, drum drying and microwave-vacuum drying [9]. Spray drying is defined as the production of highly dispersed powders from a fluid feed by evaporating the solvent [10]. It is a continuous operation to produce dry powders from a liquid, a slurry, an emulsion, a suspension, or low viscosity paste through spraying the feed into a hot gaseous drying medium, usually air which causes the solvent to evaporate uniformly and quickly via direct contact [9]. Therefore, spray drying is being used widely in the pharmaceuticals, dairy, soap and detergents, beverages, plastics and resins productions [9]. Conversely, other methods of drying inclusive of oven drying, freeze drying or rotary evaporators produces a mass of material requiring further processing (i.e. grinding and filtering), and thus producing particles of irregular shape and size [10]. Nonetheless, spray drying offers much control over powder particle properties in terms of reducing the size of powder particle and lowering the moisture content [10].

The main benefit of the spray drying technique was the ability to control particle size in terms of shape and morphology (amorphous/crystalline form, porosity). It also has as simple and easy operation. [12] spray dryer has the capability to be scaled-up, thus it is suitable to be used in various industries. At the same time, it has a low operating cost, it uses energy efficient technology, and it is a fast process. Spray drying has high encapsulation efficiency, extended shelf life and finally it has the potential to process of heat sensitive substances with low risk of degradation [13]. Spray drying produces low particle size powder, which leads to a product with higher bulk density and in addition to that, buyers prefer spray-dried products owing to their better stability and enhanced solubility [10]. In a similar note, the flexibility of drier designs provides opportunities to produce the powders that consistently meet industrial specification [12]. The process is continuous and easily automated which can reduce labour costs plus, there are less sticking and corrosion problems in spray drying given that, the material does not contact the equipment walls until it is dried [11]. Therefore, in this study, the parameter involved in
production of rice protein powder using spray drying techniques is evaluated such as temperature, air flowrate and feed flowrate.

2. Experimental

2.1 Rice Sample
Rice Bran were collected from local rice BERNAS factory in Perlis and pretreated immediately using microwave oven to prevent the rancidity before keep in refrigerated -21°C Condition before further extraction process. Next the rice bran were extracted in schott bottle with mixture 20:1 distilled water and Rice bran ratio and set to condition for 20°C and 0.26MPa for 20 minutes using Hirayama HG-80 sterilizer as modified method from previous study [3]. Then the rice bran extract was cooled into room temperature for 30 minutes. After that the autoclaved lurry was filtered to obtain the filtrate, which contains most of the valuable components whereas the remaining or pellet were removed. The filtrate was used to feed the spray drying process in order to attain the rice bran protein powder to study the effect of feed flowrate, air flowrate and inlet temperature. Then, the rice bran protein powder yield was calculated.

2.2 Parameter
500mL of each group separated liquid was then spray dried using Buchi B 290 Mini Spray Dryer in Universiti Malaysia Perlis (UNIMAP). The condition for spray dryer is 130ºC, 150ºC, 160ºC, 180ºC, 200ºC for temperature, 10%, 15%, 20%, 25%, 30%, 40% for feed flowrate, and 225L/hr, 250L/hr, 325L/hr, 350L/hr, 425L/hr, 450L/hr, 525L/hr, 550L/hr, 625L/hr. The spray dried rice bran protein powder obtained from the result of spray drying was proceed for analysis of yield.

2.3 Analysis of Protein Powder Yield
The rice bran protein powder obtained from the result of spray drying was weighed along with the product vessel to obtain the weight after spray drying. Hence, the protein powder yield was calculated based on the Eq. (1) and (2). Eq. (1), shows that for 180g of raw rice bran was dissolved in 1800ml of water to theoretically give 20g of rice bran powder for every 200ml of feed

$$\frac{180g}{1000ml} = \frac{20g}{200ml}$$

(1)

Yield \( \left( \frac{g \text{ RBP}}{100 \text{ g RRB}} \right) \) = \( \frac{A (g)}{20g} \) \times 100

(2)

Where \( A \) is weight of product after spray drying in product vessel minus product vessel weight.

3. Results and Discussions

3.1 Effect of Inlet Temperature on Spray Drying Process
Figure 1 shows the bar graph of the effect of inlet temperature on RBP powder yield from spray drying process. The effect shown by Figure 1 is when the feed flowrate was 20% and the air flowrate was 388 L/hr throughout the spray drying process. Based on figure 1, the results show that initially the yield of RBP powder obtained increases with an increase in inlet temperature from 130ºC to 160ºC, resulting in a yield of 9.9 g RBP/100g RRB to 18.25 g RBP/100g RRB. Beyond the temperature of 160ºC the RBP powder yield started to decrease from 17.55 g RBP/100g RRB to 15.5 g RBP/100g RRB at inlet
temperature of 170 ºC to 200 ºC respectively. This was because [12] stated that by increasing the
temperature it was causing denaturation of protein and causes a cohesive force between the spray dried
deposition and the wall of the drying chamber. Therefore, inlet temperature of 150 ºC to 180 ºC was selected
as the range of inlet temperature for rice bran protein powder production from spray drying process

![Figure 1. Effect of inlet temperature on protein powder yield from spray drying process.](image1)

3.2 Effect of Feed Flowrate on Spray Drying Process

Figure 2 depicts the effect of feed flowrate from 10% - 40% on spray drying process for RBP powder
production at constant inlet temperature of 160 ºC and air flowrate of 388 L/hr. The effect of feed
flowrate shows a trend of increasing yield up to 20% feed flowrate. The yield began to decrease as the
feed flowrate was increased to 25% and above. This is because higher feed flowrate would decrease the
contact time of the solution in the drying chamber (vaporization chamber), shorter contact time would
increase the possibility for water to vaporize incompletely and hence this would produce lesser yield of
RBP powder [12]. Therefore, the feed flowrate ranges of 15% to 25% was chosen for spray drying
process in order to obtain the spray dried rice bran protein powder.

![Figure 2. Effect of feed flowrate (%) on protein powder yield from spray drying process.](image2)
3.3 Effect of Air Flowrate on Spray Drying Process

Figure 3 shows the effect of air flowrate on the yield of RBP powder. The effect of air flowrate on the yield of spray drying process shows a trend of increasing gradually with slight dip at certain airflow rates. As the air flowrate is increased from 225 L/hr to 350 L/hr, the yield of the spray dried RBP powder increased from 5.75 g RBP/100g RRB to 16.65 g RBP/100g RRB. The effect of air flowrate beyond this shows a gradual fluctuation. Whereby, at air flowrates of 425 L/hr up to 525 L/hr the yield increased gradually from 15.75 g RBP/100g RRB to 16.2 g RBP/100g RRB but then it dipped slightly to 16.1 g RBP/100g RRB at 550 L/hr before increasing to 17.4 g RBP/100g RRB at 625 L/hr. Thus, the acceptable range of air flowrate for spray drying process of rice bran is within 325 L/hr and 450 L/hr. Theoretically, this is due to as the air flowrate increases it increases the yield of rice bran protein powder but the energy required to produce this powder will increase due to higher consumption of energy on higher production power requirement. According to [13] stated that by altering the speed of aspirator (air flowrate), the amount of heated dry air entering into the spray chamber is regulated.

![Figure 3. Effect of air flowrate on the yield of spray dried rice bran protein powder.](image)

4. Conclusions

As a conclusion, the relationship between spray drying parameter such as temperature, feed flowrate and air flowrate with the rice protein powder yield can be obtain through the OFAT method. Based on this relationship, temperature is giving the significant effect on yield meanwhile higher feed flowrate more than 20% are producing the lower yield. The high air flowrate above 350 L/hr not given the significant effect on the protein yield.

As a future work, the study will be continued to explore the used of optimization technique such as Response surface methodology (RSM), artificial neural network (ANN) or multivariable regression method to option the optimal condition in producing protein powder using spray drying process.

Acknowledgement

The financial support provided by the Ministry of Higher Education Malaysia through Fundamental Research Grant Scheme (FRGS 9003-00648) and all the staffs in Department of Chemical Engineering Technology, Faculty of Engineering Technology are acknowledged.
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