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Effects of Ingredients Ratio on Physicochemical Properties of Convective-Microwave Nutritious Dried Rice Meal

Nurul Ainaa Amerah Mohd Saifudin[a], Thaibah Ali[a], Yanti Maslina Mohd Jusoh*[,a], Dayang Norulfairuz Abang Zaidel[a], Ida Idayu Muhamad[a], Zulkifli Khair[b], Shahrulzaman Shaharuddin[a]

[a]Department of Bioprocess Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310, Skudai, Johor, Malaysia
[b]Department of Human Resource Development, Faculty of Management, Universiti Teknologi Malaysia, 81310, Skudai, Johor, Malaysia
yantimaslina@utm.my

During emergency situation, such as natural disasters or war, diseases outbreak can occur due to lack of nutrition. Due to this issue, a wholesome dried rice meal (DRM) was conceptualised as emergency, quick, nutritious, functional and comforting food for natural disaster and war victims, particularly during the critical period of post-disaster or war period. The DRM was designed so that it can be consumed as dried cracker or semi-solid porridge. The objective of this study was to evaluate the effect of rice (100 g and 200 g), minced chicken meat (30 g and 40 g) and mixed vegetables (25 g and 35 g) ratio on the energy content, vitamin C, and expansion ratio of convective-microwave DRM. The convective-microwave drying method was chosen for DRM preparation to obtain the final product with specific puffing condition which enhances rehydration process and also to shorten the total production time of DRM. The experiments were conducted using factorial design. The experimental results showed that the highest DRM energy content of 1.60 kCal could be achieved by cooking 200 g rice with 40 g minced chicken meat and 25 g mixed vegetables. The DRM with highest vitamin C content of 0.018 g was achieved using 100 g, 30 g minced chicken meat and 25 g mixed vegetables. The DRM with the highest expansion ratio of 1.13 was achieved using 100 g rice, 30 g minced chicken meat and 25 g mixed vegetables. Empirical models for predicting energy contents, vitamin C and expansion ratio of the DRM were also obtained.

1. Introduction

Rice (*Oryza sativa L.)* is the human staple food for a large part of the world population especially in the Asia region. The ultimate aim of this work is to produce a nutritious dried rice meal (DRM) which can be consumed as dry cracker or instant porridge by adding room temperature water to it. The DRM is recommended as ultimate functional food for emergency period, as it is formulated to contain vitamins and necessary nutrition. Abundance of instant food available commercially however these foods are normally lacking in vitamins, which are crucial during the emergency period. In this preliminary study, the focus of the study is to evaluate the effects of rice, minced chicken meat and mixed vegetables ratio on the energy content, vitamin C content and expansion ratio of DRM. Rice, minced chicken meat and mixed vegetables were used in this study as the key sources for energy, protein and vitamin C. During emergency situation, such as natural disasters or war, diseases outbreak can occur due to lack of nutrition.

Besides the ingredients, drying techniques are also vital in development of DRM. Combination of drying techniques can potentially offer better qualities of end product and economise energy consumption, instead of using only one drying technique. The combination of microwave and hot-air drying has been employed by Le and Jittanit (2015) in development of instant brown rice. They found that microwave drying has significant impact on volume expansion of brown rice. Microwave drying produces more porous structure (Le and Jittanit, 2012)

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which more porous structure leaded to better rehydration quality (Ramesh and Srinivisa Rao, 1996) which is good for the production of instant rice or porridge.

2. Experimental

2.1 Raw Materials and Chemicals

The ingredients for making DRM were jasmine rice (R), minced chicken meat (MCM), mixed vegetables (MV), Cooking salt, garlic and onion powder were purchased from AEON Taman Universiti, Skudai, Johor. The chemicals used were phenol, sulphuric acid, ethyl alcohol, ethyl ether, bovine serum alsumin (BSA), buiret reagent, potassium hydroxide, ascorbic acid (vitamin C), metaphosphoric acid, bromine water, thiourea and 2-4-DNPH. All these chemicals were purchased from local suppliers.

2.2 DRM Cooking Process

The objective of this study was to evaluate the effect of rice (100 g and 200 g), minced chicken meat (30 g and 40 g) and mixed vegetables (25 g and 35 g) ratio on the energy content, vitamin C and expansion ratio of convective-microwave DRM. The rice was cooked in a rice cooker with rice to water ratio of 1:2.75 until the mixture boiled. Salt, onion and garlic powder were added into the boiling mixture and mixed. After 5 min, the minced chicken meat and mixed vegetables were added. The rice meal was cooked for total time of 30 min.

2.3 DRM Drying Process

2.3.1 Hot Air Drying (HAD)

A thin layer of cooked rice meal (approximately 0.5 cm) were spread in the petri dish and hot air dried for 3 h at 90 ^{0}C. The temperature and time used in HAD were determined from the preliminary work of drying.

2.3.2 Microwave Drying (MD)

After HAD, DRM subsequent drying using microwave to reduce more moisture and obtain puffing characteristic. Microwave drying of DRM was performed at 500 W for 1 min. This drying method was adapted from Le and Jittanit (2015) with slight modifications.

2.4 Physicochemical Properties Analyses

2.4.1 Determination of Energy

Energy content was determined by multiplying the amount of carbohydrates, protein and fat of DRM with 4 kcal/g, 4 kcal/g and 9 kcal/g. Then sum up all together in the unit of kcal.

2.4.2 Determination of Carbohydrates

The methods for determining carbohydrate content in aqueous solution by DuBois et al. (1956) and Albalasmeh et al. (2013) were used in this study. A stock solution of carbohydrate was prepared by dissolving 0.1 g of dry carbohydrate in 1 L of double milipore water. 2 mL of carbohydrate solution was mixed with 1 mL of 5 % aqueous solution of phenol in a test tube. Then, 5 mL of concentrated sulfuric acid was added rapidly to the mixture. The test tube was allowed to stand for 10 min, vortexed for 30 s and placed in the water bath at room temperature for 20 min for colour development. The reading for absorbance was set at 490 nm.

2.4.3 Determination of Protein

For the protein analysis, biuret method proposed by Leshner et al. (1972) was used. Stock solution was diluted with distilled water to 5 different concentrations (0.1 g/L, 0.3 g/L, 0.5 g/L, 0.7 g/L, and 0.9 g/L) for preparing the standard curve of BSA (Bovine Serum Albumin). 1 mL from each sample was mixed into the new bottles with 2 mL of biuret reagent. The samples were vortex to ensure homogeneous mixture. The mixture stands for 15 min at room temperature. Each standard sample was analysed at 550 nm.
The 0.5 g of samples was transferred to a tared 50 mL centrifuge tube, the tube and the dried rice meal sample was weighed. 40 mL of 0.3 M KOH was added, stirred and incubated at 37 °C in 1 h. It was shaken for 5 min and centrifuged in 4 min at 1,800 rpm. 1 mL of sample solution was mixed with 4 mL Biuret reagent. For blank sample, mix 4 mL of biuret reagent and 1 mL 0.3 M KOH. The solution was left in the dark for 45 min and the absorbance reading was recorded. The protein content was determined by using the standard curve.

2.4.4 Determination of Fat

For the protein analysis, Leshner et al. (1972) method was used. In order to determine fat content, the DRM was grinded and sifted. Approximately 0.5 g of sifted material was added to a tared 15 mL centrifuge tube, the tube and the sample was weighed. 0.5 mL ethyl alcohol and 10 mL ethyl ether were mixed to the sample. The

mixture was shaken for 30 min by using the orbital shaker. The mixture sample was centrifuged at 1,800 rpm for 4 min and the ether was pour off. Another 10 mL ethyl ether was added to the sample and shaken for 30 min, centrifuged and pour the ether again. The sample was dried in the oven at 60 °C. The extracted dried sample was weighed. Difference of original weight and the weight of extracted dried sample was equal to the fat content.

2.4.5 Vitamin C

The determination of vitamin C (ascorbic acid) in DRM was done based on method proposed in Kapur et al. (2012). The stock solutions of 5 different concentrations (0.1 mg/mL, 0.3 mg/mL, 0.5 mg/mL, 0.7 mg/mL, 0.9 mg/mL) were prepared for plotting the standard curve of vitamin C. To determine the vitamin C content in DRM, dried rice meal was ground. 5 g of the sample was homogenised with 25 mL of metaphosphoric acid-acetic acid solution, then this mixture was transferred into the 50 mL volumetric flask and shaken gently. The mixture was diluted with distilled water until it reached the mark of 50 mL. The mixture was filtered using Whatman filter paper and centrifuged at 4,000 rpm for 15 min. After the centrifugation, 4 mL of the centrifuged sample was mixed with 0.23 mL of 3 % bromine water. A 0.13 mL of 10 % thiourea was added to remove the excess bromine. 1 mL of 2,4-DNPH solution was added to form osazone. The dried rice meal sample was kept at 37 °C for 3 h in a thermostatic bath. It was cooled in ice bath for 30 min and treated with 5 mL of 85 % chilled sulfuric acid with constant stirring. The absorbance of solution will be measured at 521 nm using spectrophotometer. The determination of vitamin C for standard and blank solutions was also done following this method.

2.4.6 Expansion ratio

Expansion ratio of the rice was measured using method and equation proposed by Zheng et al. (2012). The volume of dried rice meal was taken after HAD and MD. Volume taken after HAD is known as volume of dried rice meal before puffing while volume taken after MD is referred as volume of dried rice meal after puffing. The DRM volumes were measured three times to obtain the mean value.

$$\text{Expansion Ratio} = \frac{\text{Volume of dried rice meal after puffing (mL)}}{\text{Volume of dried rice meal before puffing (mL)}} \quad (1)$$

2.5 Experimental Design and Analysis

The experiments were designed using full factorial method with 3 factors involved that were rice (100 g and 200 g), minced chicken meat (30 g and 40 g) and mixed vegetables (25 g and 35 g). A total of 24 experimental runs including replicates were conducted. The data was analysed using JMP software version 12 (SAS, USA).

3. Results and Discussion

3.1 Effects of Ingredients Ratio on Energy Content

Figure 1 shows the effects of rice, minced chicken meat and mixed vegetables ratios on the energy content of DRM. DRM is designed for emergency situation therefore the optimum ratio is expected to produce DRM with the highest energy. From the figure, it can be deduced that amount of rice and minced chicken meat contribute significantly ($p < 0.05$) to the energy content in DRM. By increasing the amount of rice and minced chicken meat, the energy content of DRM also increased. On contrary, the amount of mixed vegetables did not exert significant effect on the DRM energy content ($p > 0.05$). The DRM with highest energy content of 1.60 kcal was obtained by preparing DRM with 200 g rice, 40 g minced chicken rice and 25 g mixed vegetables.

3.2 Effects of Ingredients Ratio on Vitamin C Content

Figure 2 shows the effects of rice, minced chicken meat and mixed vegetables ratios on the vitamin C content of DRM. Statistical analysis shows that all the three ingredients have significant impact on DRM vitamin C content ($p < 0.05$). Increasing the amount of rice, minced chicken meat and mixed vegetables reduced the vitamin C content. It is expected that rice and minced chicken meat will not contribute significantly to DRM vitamin C content. Mixed vegetables also exerted a negative impact on the vitamin C content plausibly due to the processing conditions. Vitamin C, a water soluble vitamin, can easily leach into water especially if combine with heat so high amount of rice affect the vitamin C content as the moisture content in rice also increased. The DRM with the highest vitamin C content (0.018 g) was achieved with combination of 100 g rice, 30 g minced chicken meat and 25 g mixed vegetables.

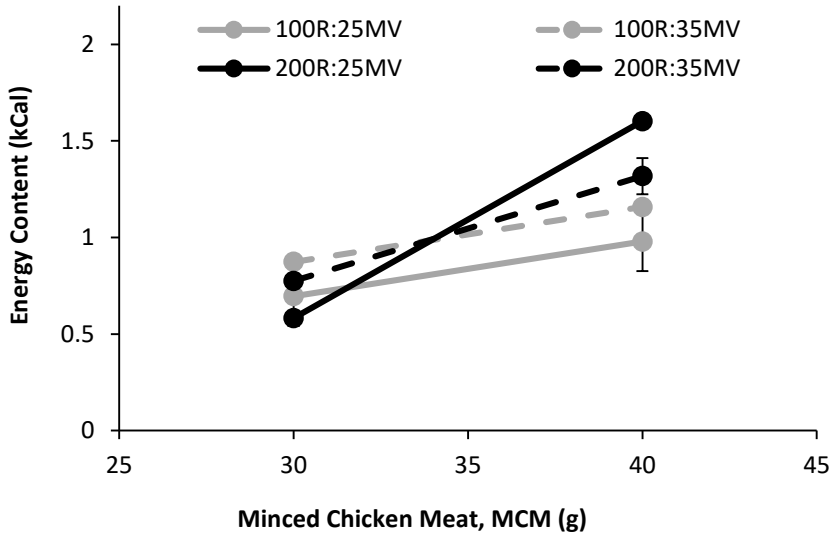

Figure 1: The effects of rice (R), minced chicken meat (MCM) and mixed vegetables (MV) ratios on the energy content of DRM

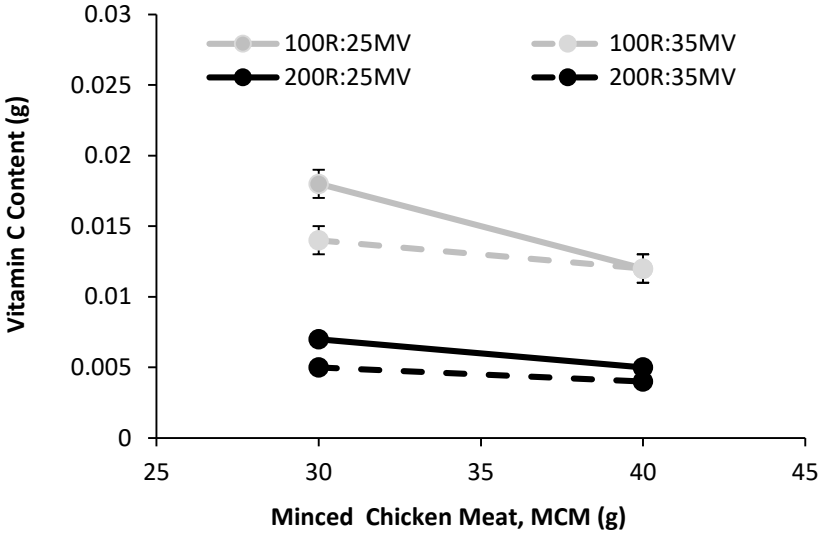

Figure 2: The effects of rice(R), minced chicken meat (MCM) and mixed vegetables (MV) ratios on the vitamin C content of DRM

3.3 Effects of Ingredients Ratio on Expansion Ratio

Figure 3 shows the effects of rice, minced chicken meat and mixed vegetables ratios on the expansion ratio of DRM. Expansion ratio study was performed to evaluate the puffing characteristics of DRM. Rehydration of DRM would be easier and faster if the DRM has higher expansion ratio or puff. From the study, it can be deduced that the expansion the ratio of DRM is significantly influenced only by these two factors, amount of rice and mixed vegetables ($p < 0.005$). High rice content reduces the expansion ratio. DRM with the highest expansion ratio (1.13) was achieved when DRM was prepared using 100 g rice, 30 g minced chicken meat and 25 g mixed vegetables.

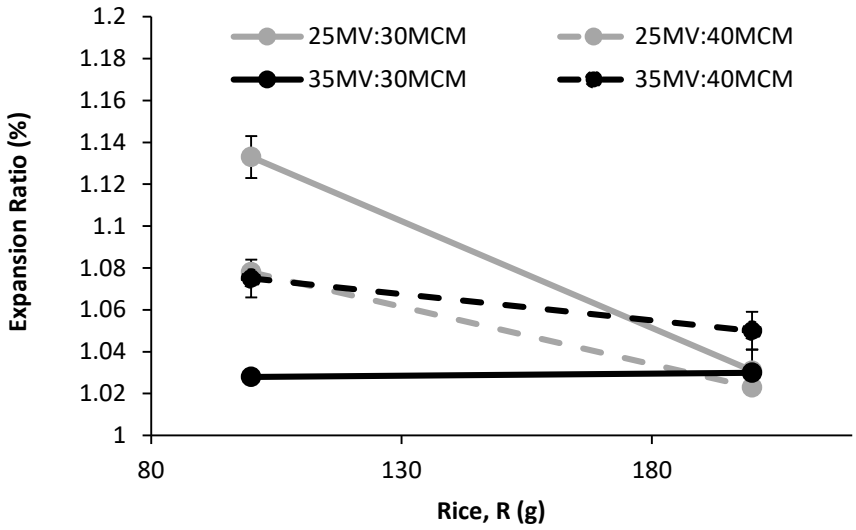

Figure 3: The effects of rice (R), minced chicken meat (MCM) and mixed vegetables (MV) ratios on the expansion ratio of DRM

3.4 Empirical Models for Predicting Energy Content, Vitamin C Content and Expansion Ratio of DRM

Based on the data, the models for predicting energy content, vitamin C content and expansion ratio were developed by JMP software. The models were developed as function of rice, minced chicken meat and mixed vegetables, which all these are represented as X_1, X_2, and X_3. These models were developed to predict the energy content, vitamin C content and expansion ratio of DRM.

$$\text{Energy Content (kcal)} = 0.9981608 + 0.0714042X_1 + 0.2661558X_2 + 0.1245825X_1X_2 - 0.055976X_1X_3 - 0.059461X_2X_3 \quad (2)$$

$$\text{Vitamin C Content (g)} = 0.0098671 - 0.00460X_1 - 0.00109X_2 - 0.001031X_3 + 0.0006096X_1X_3 \quad (3)$$

$$\text{Expansion Ratio} = 1.0560917 - 0.022558X_1 - 0.010242X_3 + 0.0165917X_1X_3 + 0.016425X_2X_3 \quad (4)$$

From the analysis of variance, the energy content of DRM is highly affected by the amount of minced chicken meat and the combination of rice and chicken meat. The vitamin C content of DRM is affected by all ingredients while the expansion ratio of DRM is affected by the amount of rice and mixed vegetables.

4. Conclusions

An initial study on development of Malaysia first emergency food, known as dried rice meal (DRM) has been carried performed. The DRM is formulated from rice, minced chicken meat, mixed vegetables, onion powder, garlic powder, salt and pepper. Emergency food must be made from complete nutrients that able to provide sufficient energy and protection to the victims. In this preliminary study, the effects of rice, minced chicken meat and mixed vegetables ratio on the energy content, vitamin C content and expansion ratio were evaluated. Rice and minced chicken meat significant affect the energy content of DRM while all the three ingredients significantly affected the vitamin C content of DRM. In expansion ratio, only rice and mixed vegetables significantly affect the expansion ratio of DRM. The DRM with highest energy content of 1.60 kcal was obtained by preparing DRM with 200 g rice, 40 g minced chicken rice and 25 g mixed vegetables. The DRM with the highest vitamin C content (0.018 g) was achieved with combination of 100 g rice, 30 g minced chicken meat and 25 g mixed vegetables. The DRM with the highest expansion ratio (1.13) was achieved when DRM was prepared using 100 g rice, 30 g minced chicken meat and 25 g mixed vegetables. Empirical models for predicting the energy content, vitamin C content and expansion ratio of DRM were also obtained.

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