NUTRITIONAL COMPOSITION AND TEXTURAL PROPERTIES OF READY-TO-EAT COMPACT RICE DEVELOPED FROM SELECTED BROWN RICE AVAILABLE IN MALAYSIA

by

NOOR SYAFINAZ BINTI HAIRUDIN

Dissertation submitted in partial fulfillment of the requirements for the of Bachelor of Health Sciences (Honours) Dietetics.

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CERTIFICATE

This is to certify that the dissertation entitled "Nutritional Composition and Textural Properties of Ready-to-Eat Compact Rice Developed from Selected Brown Rice Available in Malaysia" is the bona fide record of research work done by Ms Noor Syafinaz.binti Hairudin during the period from September 2017 to May 2018 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the Degree Bachelor of Health Sciences (Honours) Dietetics.

Main Supervisor,

Professor Dr. Wan Rosli bin Wan Ishak
Lecturer
School of Health Sciences
Universiti Sains Malaysia
Health Campus
16150 Kubang Kerian
Kelantan, Malaysia
Date:

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions, I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and provisional purposes.

Noor Syafinaz binti Hairudin

Date: 9/7/2018

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LIST OF SYMBOL, ABBREVIATION AND ACRONYM

Abbreviations	Meanings
%	Percentage
<	Less Than
>	More Than
≥	At Least
°C	Degree Celsius
μL	Microlitre
ANOVA	Analyses of Variances
AOAC	Association of Official Analytical Chemists
CRP	C-Reactive Protein
CVD	Cardiovascular Diseases
DOM	Degree of Milling
FAO	Food and Agricultural Organization
g	Gram
GI	Glycemic Index
HDL-C	High Density Lipoprotein Cholesterol
kg	Kilogram
kg/s	Kilogram per second
MDG	Malaysian Dietary Guidelines

mg	Milligram
mL	Millilitre
mm/sec	Milimeter per second
NCCFN	National Coordinating Committee for Food and Nutrition
R&D	Research and Development
SPSS	Statistical Package for Social Science
TDF	Total Dietary Fiber
TPA	Texture Profile Analysis
T2DM	Type 2 Diabetes Mellitus
US	United States
vs	Versus
WHO	World Health Organization

KOMPOSISI NUTRISI DAN SIFAT TEKSTUR NASI IMPIT SEDIA-MAKAN DISEDIAKAN DARIPADA BERAS PERANG TERPILIH YANG BOLEH DIDAPATI DI MALAYSIA

ABSTRAK

Beras merupakan makanan ruji bagi hampir dua pertiga penduduk dunia. Walaupun begitu, beras perang kurang disukai berbanding beras putih kerana sifat deria dan teksturnya, di samping sukar untuk diperolehi. Oleh itu, kajian ini adalah salah satu alternatif untuk meningkatkan keberadaan sumber bijirin penuh dalam pelbagai bentuk makanan, seperti nasi impit yang menyelerakan dan sesuai untuk dimakan bersama lauk-pauk, sambil menyumbangkan nutrien yang bermanfaat berbanding nasi putih. Nasi impit daripada beras perang dapat dihasilkan dari tiga jenis beras merah yang berlainan. Apabila nasi impit daripada beras perang dibandingkan dengan nasi impit biasa, nasi impit daripada beras perang menyumbang kepada protein yang lebih tinggi antara 7.00 - 8.63%, lemak yang lebih tinggi dalam bentuk lemak tidak tepu (1.98 - 2.69%), mineral yang lebih tinggi yang ditunjukkan oleh abu sebanyak 0.63 - 0.84 % dan mempunyai karbohidrat yang rendah (10.44 - 10.83%) manakala nasi impit hanya menyumbang 1.55-1.56%, 0.33 - 0.34%, 0.28 - 0.38% dan 17.56 - 17.93% protein, lemak, abu dan karbohidrat. Tetapi, disebabkan kesilapan praktikal dan kaedah memasak, nasi impit daripada beras perang mempunyai kandungan serat yang rendah iaitu antara 7.10 - 9.46 g / 100g manakala nasi impit biasa menyumbang antara 7.43 - 11.30 g / 100g. Analisa profil tekstur dan penilaian deria juga dijalankan untuk menilai tahap penerimaan nasi impit daripada beras perang. Nasi impit daripada beras perang dari tiga jenis beras yang berbeza tidak mampu membentuk nasi impit yang padat kerana ciri-cirinya yang kurang melekit menyebabkan nasi tidak melekat dengan bijirin

yang lain lalu menyebabkan kepada struktur yang tidak kukuh. Antara ketiga-tiga jenis beras perang, beras panjang mempunyai kekerasan, kelekitan, kohesif dan kekenyalan yang hampir sama dengan nasi impit komersil dengan nilai masing-masing ialah 418.60g VS 687.34g, -153.31 VS -162.85, 1.94 VS 2.20 dan 812.55kg VS 1513.27kg. Berdasarkan atribut deria, apabila dibandingkan dengan nasi impit komersial, beras perang istimewa menunjukkan perbezaan yang tidak ketara dari segi aroma, tekstur, rasa dan sifat penampilan. Walaupun beras panjang lebih mirip dengan nasi impit komersil dari segi tekstur, beras istimewa lebih disukai disebabkan pengaruh kelazatan dan penampilannya. Oleh itu, beras istimewa adalah beras perang yang paling sesuai dalam penghasilan nasi impit, kerana ia mempunyai penerimaan yang baik apabila disajikan dengan lauk pauk seperti serunding, lontong dan rendang. Kajian lanjut diperlukan yang difokuskan kepada kaedah memasak yang berlainan di samping memelihara nutrien yang bermanfaat dan mempunyai nilai rasa yang menyenangkan.

NUTRITIONAL COMPOSITION AND TEXTURAL PROPERTIES OF READY-TO-EAT COMPACT RICE DEVELOPED FROM SELECTED BROWN RICE AVAILABLE IN MALAYSIA

ABSTRACT

Rice is a staple food for nearly two-thirds of world population. However, brown rice is less preferred compared to white rice due to its sensory and textural attributes, in addition to lack of availability. Therefore, this study is one of the alternative to increase the availability of wholegrain sources in different form of meal, such as compact rice with nice palatability and match well with any side dish, while contributing beneficial nutrients compared to white rice. Compact brown rice able to be produced from three different varieties of brown rice. When compared compact brown rice to compact white rice, compact brown rice contributes to higher protein ranged between 7.00 – 8.63%, higher fat in form of unsaturated fats (1.98 – 2.69%), higher minerals (0.63 – 0.84%) and has low carbohydrate (10.44 – 10.83%) meanwhile compact brown rice only contribute 1.55 – 1.56%, 0.33 – 0.34%, 0.28 – 0.38% and 17.56 – 17.93% of protein, fat, total ash and carbohydrate percentages respectively. However, due to practical error and cooking method, compact brown rice has lower total dietary fibre content which is ranged between 7.10 – 9.46 g/100g while compact white rice contributes between 7.43 – 11.30 g/100g. Texture profile analyses and sensory evaluation are also conducted to assess palatability level of compact brown rice. Compact brown rice from three different rice varieties are not able to form a uniformly structured compact rice due to its property of less stickiness which cause less ability to stick with other grains therefore lead to unsolid structure. Among the brown rice varieties, long grain brown rice has the nearest hardness, adhesiveness, cohesiveness and gumminess compared to commercial

compact rice with the values of 418.60g VS 687.34g, -153.31 VS -162.85, 1.94 VS 2.20 and 812.55kg VS 1513.27kg respectively. Based on sensory attributes, when compared to commercial compact rice, specialty brown rice shows insignificant difference in term of aroma, texture, taste and appearance attributes. Even though long grain brown rice is more similar to commercial compact rice in term of textural properties, specialty brown rice is more preferred as it might be influenced by its palatability and appearance. Hence, specialty variety is the most suitable brown rice for development of compact rice, as it also well-accepted when served with popular side dishes such as *serunding, lontong and rendang*. Further study is needed which centred on different treatment of cooking method while preserving beneficial nutrients and has nice palatability.

1. INTRODUCTION

1.1. Background of Study

Oryza sativa L., scientific name for rice is a staple food for nearly two-thirds of world population (Parenga et al., 2010). Rice grain consists of brown rice kernel enclosed by husk (Belsnio, 1992). Whole brown rice is the unpolished whole grain, which are comprised of bran, embryo, and endosperm layers (Liu et al., 2015).

Rice properties are known to be dependent on the variety of rice, processing and cooking conditions. Dehusking and milling process removes the outer part of paddy rice (husk and bran) to make it edible. Degree of milling (DOM) is a quantification of the amount of bran that has been removed from kernels during the milling process (Roy, Orikasa, Okadome, Nakamura & Shiina, 2011). DOM of rice grains determine the variety of rice produced, typically as brown rice and white rice. Milling process removes the bran and germ components of whole grain rice to left the refined white rice.

Although both rice derived from the same grain, it is agreed that regardless any human population around the world would prefer to take white rice compared to brown rice (Govarethinam, 2014) due to its texture, taste, colour, price, tradition and brand preference (Zhang et al., 2010). Precisely as much as 81.25kg average of rice, mainly milled rice consumed per capita daily in Malaysia in year 2013 (FAO, 2018).

Among Southeast countries such as Indonesia, Singapore, Brunei and Philippine (Sudiarto, 2014), the consumption of rice is also contributed from compact rice or known as 'ketupat' in Malaysia. 'Ketupat' is made from rice, which is commonly white rice. To produce 'ketupat', rice grains are left in a pouch of woven palm and boiled until cooked. As the rice cooks, the grains expand and filled the pouch to produce compressed rice (Darnys, 1991).

Originally, 'ketupat' is a seasonal food commonly served during Eidul Fitri festivities celebrated by Malaysian populace. Presently, 'ketupat' also is served with a few popular dishes such as *sate, lontong* etc. and can be found at any seasons/occasions and at any time since ketupat has a commercially prepared form which is called 'nasi impit'. 'Nasi impit' (commercial compact rice) usually featured as perforated plastic packaging contained rice grains which form a compact rice when it is boiled.

Recently there is rising evidence showing that there is positive association between white rice intake with metabolic syndrome (Song et al., 2012). Malaysian population has shown overgrowth of metabolic syndrome which shown by 25 to 40% of adult population is affected by it (Lim & Cheah, 2016). Major dietary factor that can lead to this phenomenon is the lack of wholegrain intake. Bran layer of rice grain is concentrated with many beneficial nutrients such as proteins, fats (in form of unsaturated fats), vitamins, mineral and dietary fibre (Sharma, Chauhan & Agrawal, 2007).

1.2. Problem Statement

Metabolic syndrome is defined as a cluster of abnormalities such as glucose intolerance, hypertension, dyslipidemia and central obesity with insulin resistance as the source of pathogenesis (Shin, 2013). These abnormalities are risk factor to promotes into more chronic diseases such as cardiovascular disease (CVD) (Zarich, 2006) and type 2 diabetes mellitus (T2DM) (Shin, 2013). About 25 to 40% of Malaysian adult has been affected by metabolic syndrome. Obese children are risky to have those abnormalities, and the risk is increasing with age. Among Malaysians, Indian ethnicity has the highest rates of metabolic syndrome, followed by Malay and Chinese (Lim & Cheah, 2016). The incidence of metabolic syndrome is occurred due to several major factors such as physical activity factor and dietary factor (Albert, Zimmet & Shaw, 2005).

Dietary fibre acts as main role in management of metabolic syndrome (Singh and Kochhar, 2011) as there is growing nutritionists' opinions on benefits of increased dietary fibre intake able to control metabolic disturbances clustered by metabolic syndrome. Numerous studies in humans and experimental animal models proved that efficacy of dietary fibre intake gives benefits in regulating body weight, food intake, glucose homeostasis, insulin sensitivity and also cardiovascular disease biomarkers; lipid profile, hypertension and systemic inflammatory markers (Davy & Melby, 2003; Delzenne & Cani, 2005; Venn & Mann, 2004).

Dietary fibre recommended intake until recently was 20-35 g/day; however, World Health Organisation (WHO) has advocated the increment of recommended dietary fibre intake to 25-38 g/day. Compared to the recommendation, it is reported that United

States and British only take 15 g/day and 18 g/day of dietary fibre respectively based on their habitual intake. According to WHO, dietary fibre intake of >25 g/day can be achieved by taking at least 400 g/day of vegetables and fruits, and with diet rich in wholegrains (Ng, Chow, Chan, Lee & Lim, 2010).

However, Malaysian is reported to take only 10.7 to 16.1 g/day of dietary fibre (Ng, Chow, Chan, Lee & Lim, 2010) even though Malaysian Dietary Guidelines (MDG) recommended to take at least half of grain products are from whole grains which may contributes to 20 – 30g of dietary fibre intake, in addition of sufficient vegetables and fruits (NCCFN, 2017). Meanwhile, less than 3% has achieved US quantitative whole grain recommendation of 48 g/day among children and adolescents (Norimah et al., 2015). The consumption of wholegrains products among children and adolescents is significantly associated with the availability towards wholegrain products of the household itself.

This phenomenon can indicate that Malaysian diet gives low contribution towards wholegrain intake, since Malaysian staple foods usually are white rice and breads (Norimah et al., 2015). 'Ketupat', or compact rice is an accessible food that usually paired with many type of dishes. It is usually made from white rice therefore it is also included in contributing low source of dietary fibre. Therefore, this study carries importance to increase the availability of wholegrains in Malaysian diets to decrease the risk of metabolic syndrome.

1.3 Research Questions

- How to develop compact rice by using brown rice?
- How the nutritional value of compact brown rice differs from white rice?
- What is the acceptability levels of compact brown rice when it is served with popular dish?

1.4 Research Objectives

- **Main objective**: To determine nutrition composition and textural properties of ready-to-eat compact rice developed from three different brands of brown rice available in Malaysia.

- **Specific Objective:**

1. To develop compact rice from three different brands brown rice in Malaysia.
2. To determine and compare the nutritional value of compact brown rice and compact white rice.
3. To evaluate the sensory component of compressed brown rice in term of aroma, texture, taste, appearance and overall acceptance when are served with selected popular dish in Malaysia.

1.5 Research Hypotheses

Null Hypothesis (H_0)

- There is no significant mean difference in nutrition composition of ready-to-eat compact rice developed from 3 different brands of brown rice available in Malaysia.
- There is no significant mean difference in textural properties of ready-to-eat compact rice developed from 3 different brands of brown rice available in Malaysia.

Alternate Hypothesis (H_1)

- There is significant mean difference in nutrition composition and textural properties of ready-to-eat compact rice developed from 3 different brands of brown rice available in Malaysia.
- There is significant mean difference in textural properties of ready-to-eat compact rice developed from 3 different brands of brown rice available in Malaysia.

1.6 Significance of Study

A hypothetical healthy diet to achieve recommended intake of dietary fibre was built by Ng, Chow, Chan, Lee and Lim (2010). However, the planned diet can only contribute to total of 16.4 g dietary fibre per day. However, Jacobs, Pereira, Meyer and Kushi (2000) stated that the intake of fibre from whole grain gives more benefits compared to the intake of fibre from other foods, as their study showed that women who consumed whole grain fibre has lower mortality rate compared to women who consumed non-whole grain fibre.

Other than that, based on the recommended diet, the incorporation of brown rice in diet to substitute white rice may increase the amount of dietary fibre consumed since a cup of brown rice provides 14.0% of dietary fibre (Liu, 2002). Therefore, this study carries importance to increase the availability of wholegrains in different form of food available in Malaysian diet such as 'ketupat' or compact rice.

2. LITERATURE REVIEW

2.1. 'Ketupat', White Rice and Its Nutritional Composition

White rice is 'Ketupat' is a rice-based food which mainly prepared using white rice. Young palm leaves are woven to form a pouch that can fill rice grains. When the rice grains are filled into the woven leaves pouch, the pouch is boiled to let the rice grains expand and filled the space in the pouch to form compressed rice (Sudiarto, 2014). Nowadays, due to increasing needs and demand, a perforated plastic packaging contained rice grains will form a compact rice which is usually called 'nasi impit' after being boiled.

'Ketupat', or also known as compressed rice is originally being a seasonal and festival food served during Eidul Fitri celebration. Recently, it has been an accessible food which is frequently served together with various popular dishes. Some of popular dishes which commonly accompanied 'ketupat' can be referred to Appendix 3.

Since white rice is typically used in the preparation of 'ketupat', it has the similar nutritional values as white rice. White rice is a polished rice which mainly consist of the endosperm of the grain. The process of polishing or whitening of rice grains involved the removal of outer bran layer and the germ of the grains. After undergone this process, alteration of nutritional composition occurs which may create nutritional hazard (Parenga et al., 2010).

Since Asian populations is the largest consumer of white rice as staple food, various studies have been conducted. The studies have concluded that consumption of white rice is a dietary factor for development of constellation of metabolic syndrome which included abdominal obesity, insulin resistance which lead to comorbidity such as type 2 diabetes mellitus. It is proven by a study conducted in Tehrani which recorded of mean daily consumption of white rice below 430 g in a day (more than 25% of total energy intake per day) increased the risk of the metabolic syndrome in men and women approximately up to 66% (Bahadoran, Mirmiran, Delshad & Azizi, 2014).

Other than that, white rice has high glycemic index (GI) which can increase the risk to develop type 2 diabetes mellitus. According to Livesey, Taylor, Hulshof and Howlett (2008), regular high GI foods could induce metabolic changes which involve the wearing out beta-cells of pancreas and insulin resistance. Afterwards, negative changes in the concentration of 'good' cholesterol, high-density lipoprotein (HDL) cholesterol and oxidative stress will occur (Livesey, Taylor, Hulshof & Howlett, 2008). In addition, the intake of minerals and vitamin also reduced. The nutrients that often found deficient in diets of white rice eating people are vitamin B1 and lysine (Parenga et al., 2010).

2.2. Brown Rice: Nutritional Composition and Benefits

A cup of brown rice provides 14.0% of the daily value for dietary fibre (Liu, 2002). Wholegrain consists of both types of dietary fibres; soluble and insoluble fibre which benefit human body through specific mechanisms (Singh and Kochhar, 2011). Cereals, such as wheat, rice and rye are mainly considered a good source of insoluble fibre, and as much as 25% of soluble fibre. Brown rice is the under-milled grains that had only removed the hull and retain the bran layers to results in brown colour grains. Insoluble fibre constituent in brown rice responsible for lowering postprandial blood glucose concentrations (Seki et al., 2005).

Aside from fibre, brown rice is a nutrient-dense grain product, since the bran and the germ parts of the grain are rich in many types of micronutrients. Therefore, it can be concluded that adequate amount of fibre can also supply minerals, vitamins, phenols, phytoestrogen and unsaturated fatty acids (Govarethinam, 2014). Generally, bran layer of the grain is concentrated with vitamin B complex (Janet et al., 2002) and the major source of thiamine and niacin (Parenga et al., 2010). Both bran and germ also source of vitamin E (alpha-tocopherol), which is 95% is more concentrated in bran layers (Govarethinam, 2014).

A cup of brown rice may supply for numerous minerals which are important to accomplish various functions to maintain human response and health (Cesar, 2005). Minerals that are being supplied by brown rice are magnesium, manganese and some other trace minerals such as copper, selenium, molybdenum etc. (Govarethinam, 2014). The supply of vitamin and minerals through consumption of brown rice may provide protection effect against diabetes and metabolic disorders (Shepherd, Betteridge & Van Gaal, 2005).

The lipid or fat content of rice is mainly located in the bran layer (Juliano, 1993). Fat consisted in bran layer mostly consisted of unsaturated fats, which contained about 29 to 42 percent linoleic acid and 0.8 to 1.0 percent linolenic acid (Jaiswal, 1983). Hence, rice bran oil is proven to reduce total cholesterol concentrations (Rukmini & Raghuram, 1991).

2.3. Dietary Fibre and Metabolic Syndrome

The roots of problem of most metabolic disorder is excessive in weight. Excessive weight is related closely with abdominal obesity and abnormal distribution of fat in the body (Singh & Kocchar, 2011). Wholegrain products stabilize weight by slowing down weight gain. Consumption of wholegrains can promote satiety hence avoid overeating, compared to refined grains. The insoluble fibre in the wholegrain products affect the secretion of glucagon-like peptide-1 which act as satiety factor (Howarth, Saltzman & Roberts, 2001).

The accumulation of adipose tissue can affect the insulin resistance. Wholegrain foods may confer protection through potential effects on weight gain or through direct effects on insulin sensitivity and other components of the metabolic syndrome (Sahyoun et al., 2006). Based on the randomized, controlled, single blind, crossover study, it is proved that intake of fibre-enriched bread has improved 8% of insulin sensitivity (Weickert et al., 2006) which is proven by decreasing fasting insulin concentrations (Frayn, 2000). Other than that, dietary fibre which has low glycemic index also help in regulating plasma lipid levels (Liljeberg & Bjorck, 2000).

Excessive weight also one of risk factor of hypertension (Neter, Stam, Kok, Grbbee & Geleijnse, 2003), which is included in the constellation of metabolic syndrome. It is evidenced by a study conducted in Goto Kakizaki Type 2 diabetic rats which resulted in reduced systolic blood pressure after exposing to long-term consumption of cereal dietary fibre (Li, Wang, Kaneko, Qin & Sato, 2004).

Metabolic syndrome also characterized to have higher inflammation. Inflammation marker such as c-reactive protein (CRP) is found to be decreased manner among women with type 2 diabetes when they consumed high intake of cereal fibre (Qi, van Dam, Liu, Franz, Mantzoros & Hu, 2006). There is an opinion on consumption of dietary fibre can reduce lipid oxidation to reduce rate of inflammation (King, 2005).

2.4. Rice Selection

A survey that was conducted in Klang Valley has stated that common Malaysians purchase rice based on quality of rice (which is indicated by the price) and after cook texture. It is agreed that most Malaysians prefer cooked rice with nice flavour and aroma, and the colour of the rice must be white (Abdullahi, Zainalabidin and Ismail, 2011).

Other than that, availability of rice also one of the factors in deciding type of rice to be purchased. Generally, population in central region and urban areas generally consumed higher wholegrain foods. This also can reflect the spending ability of the particular population is greatly influence the consumption of brown rice/wholegrain products. Other than that, consumption of wholegrain products also is highly associated with education level (Norimah et al., 2015).

2.5 Sensory Properties Of Rice

Preference of rice variety can be assessed by sensory properties like odour, flavour, aroma, taste, appearance, tenderness or firmness, springiness, chewiness, adhesiveness and cohesiveness etc (Mohapatra and Bal, 2006; Shabbir, Anjum and Nawaz, 2008; Tomlins, *et al.*, 2005). A study shows that acceptability and preference of Ghana's consumers on rice are related with characteristics such as stickiness, rice odour, creamy flavour, sweet taste, uniform appearance of colour was reported previously (Tomlins, *et al.*, 2005).

In another study, rice that was highly preferred by people was white, with pleasant aroma, pleasant taste, less tenderness, cook moist and did not become hard upon cooling (Shabbir, Anjum and Nawaz, 2008). So most of factors which cause brown rice to be less preferred compared to white rice may be due to its texture, taste and colour (Zhang, *et al.*, 2010).

2.6 Conceptual Framework

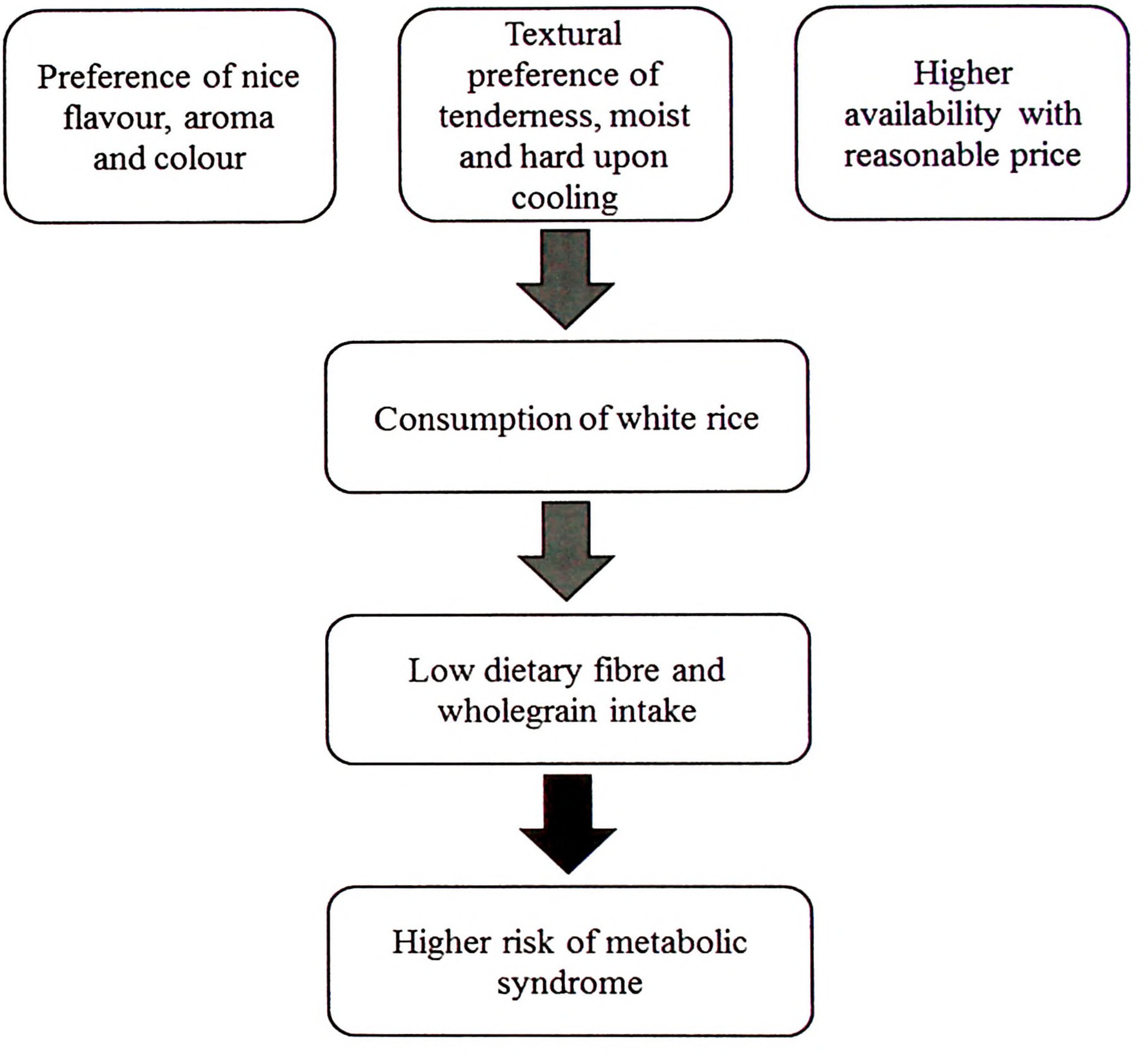

Figure 1: Conceptual framework

3. MATERIALS AND METHODS

3.1. Research Design

This study is an experimental study which involves one control group of compact rice and 3 experimental groups of compact rice. The control group samples are the commercially available compact rice and a self-made compact rice made from locally consumed white rice while the experimental samples are compact rice made from brown rice from different varieties. Self-made compact white rice also included in control group as a benchmark of nutritional composition and textural properties to compact brown rice since unknown rice variety and preparation method are used to produce commercially prepared compact white rice.

This study compares nutrition composition such as proximate composition, dietary fibre, texture profile and sensory acceptability of compact brown rice.

3.2. Sample Inclusion and Exclusion Criteria

Sample Inclusion

- White rice and commercially prepared compact rice that are locally consumed by most people living in Kubang Kerian area.
- Domestic brand of white rice and brown rice.
- Can be purchased in nearest supermarkets, grocery shops and wet markets around Kubang Kerian, Kelantan.
- Completely milled, non-glutinous white rice.

- Unpolished, non-glutinous brown rice.
- In good condition in terms of shape, colour and smell.
- Free of foreign materials and clean.

Sample Exclusion

- Glutinous white and brown rice.

3.3. Sample Collection

Three samples of brown rice of different brands that meet inclusion criteria were purchased from Tesco Hypermarket in Kota Bharu. A sample of local white rice that usually consumed by population in Kubang Kerian was purchased at nearest market to Univerisiti Sains Malaysia, which is Mydin Hypermarket. A sample of commercially prepared compact rice was randomly chosen based on the availability in the market. Below is the list of rice variety samples:

Table 3.1 List of variety rice samples

Sample	Rice variety
R1	Local white rice
R2	Commercially prepared compact white rice
R3	Long-grain brown rice
R4	Specialty brown rice
R5	Unpolished brown rice

3.4. Sampling and Preparation of Materials

Polyethylene (PE) plastic bag with size 2.5-inch x 3.0-inch was chosen as the packaging of the compact rice. PE is a material mostly used to manufacture plastic bags, water bottle, food packaging film and even irritation pipes. This material can be manufactured to be flexible or strong, allowing for more potential applications. Stable covalent bonds of carbon to hydrogen make this material inert therefore it will not easily disintegrate when in contact with other substances (Camann, Dragsbaek, Krol, Sandgren & Song, 2010).

Small holes were formed by using bamboo skewer, and make sure it is not too big to let the rice grains spill. The plastic bag was then filled with 20 gram of rice grains. After that, the rice grains were rinsed with tap water to remove any visible foreign materials. For all brand of brown rice, the rice grains were soaked in clean tap water for 15 minutes as instructed on their packages.

Next, the plastic bag that had been filled with rice grains were manually sealed. Then, 2 litres of water were poured into a saucepan to let the rice grain-filled plastic bag immersed in the saucepan. Different saucepan is used based on rice variety. The rice grain-filled plastic bag then let to boil until cook within 1 hour and 30 minutes.

Samples prepared for nutritional compositions test were dried and homogenized in a blender to form small particles. Meanwhile, for textural analysis and sensory evaluation, fresh samples were used and stored in container in a room temperature.

3.5. Nutritional Analysis

3.5.1. Proximate Composition of Cooked Compact Rice

Proximate analysis is a determination of a group of closely related components together which included moisture, minerals (ashes), fibre, lipid and protein. From the subtraction the sums of all five percentages from 100, a value which also can signifies the value of carbohydrates will be obtained (Hart & Fisher, 1971).

3.5.1.1. Determination of Moisture

Air-oven method is the most common method used to measure moisture of rice. Air-oven method is a rapid, simple, economic and direct drying method which basic principle is evaporation.

Aluminium dishes were pre-heat for 3 hours in an oven at 105°C and then cooled in a desiccator. After attained room temperature, the dishes were weighed, and its weight is noted. Approximate of 5.000±0.001 g of sample was weighed and placed into the aluminium dish.

Sample was left uncovered in oven at 105°C until constant weight was achieved. Moisture content of rice is determined by calculating difference between initial weight and weight after water was removed by evaporation. The test was done in triplicates for each sample.

3.5.1.2. Determination of Total Ash

Conventional dry ashing method is mostly chosen to measure total amount of minerals in food since this method is relatively safe and inexpensive; dry ashing use less sample, not require many reagents and time-conserve method as many samples can be processed at a time (Nielsen, 2017).

Shallow crucibles were dried in air oven at 105°C for 3 hours and cooled in a desiccator until it attained room temperature before being weighed. Next, 0.500±0.001g of sample was placed into the crucible and charred on an electric coil heating rack until it had ceased smoking. Crucibles together with dried sample were then placed in cold muffle furnace and heated at 550°C overnight until whitish or greyish ash was obtained.

After that, dried residues were cooled in the desiccator until constant weight was obtained and it attained room temperature. Finally, cooled crucible together with dried residues was weighed.

Ash content of rice was the whitish or greyish inorganic residue remaining in the crucible. It was determined by calculating the difference between initial weight of rice sample and weight after organic matter in rice had been burnt away. Total ash content represented the total mineral content of rice. The test is done in triplicates for each sample.

3.5.1.3. Determination of Crude Fat

To extract fat in cereals, semi continuous solvent extraction Soxhlet method is used with petroleum ether as the solvent. Foss Soxtec is the improvised machine that can extract solvent more rapidly and with less work load (Anderson, 2004).

Collecting vessels were pre-heat in oven at 105°C for 15 minutes. Dried vessels were weighed after cooling in a desiccator until constant weight obtained. 3.000±0.0001g of sample was weighed and placed into a dry thimble and introduced into extraction equipment. 80ml of petroleum ether is added into each collecting vessel and then the vessel was introduced into extraction equipment.

After the extraction unit closed, cooling water flow and heating started. The thimble was immersed when the solvent began to boil. After half an hour, thimble was extracted from solvent for 25 minutes of reflux washing. During washing process, solvent was evaporated from extract collecting vessel.

The washing process was complete when all solvent is evaporated, and only oil-like residue left in the vessel. The vessel together with the residue are dried in an oven at 60°C for 30 minutes to evaporate residue solvent after extraction completed. Next, the vessel was cooled in a desiccator until cooled to room temperature and then weighed.

The residue of solvent in the vessels represented the fat content of rice. Fat content of rice was determined by calculating the difference between initial weight of vessel and weight of vessel and the residue. The residue which is the defatted sample is dried in the oven and kept for Total Dietary Fibre (TDF) analysis. The test was done in triplicates for each sample.

3.5.1.4. Determination of Crude Protein

Semi-micro Kjeldahl method was used to evaluate total nitrogen content of rice sample. To determine protein content of rice, the amount of nitrogen in rice was multiplied by a conversion factor, 5.95. Kjeldahl system comprised of 3 units; digestion unit, distillation unit and titration unit. 1.000±0.001 g of dried, ground and homogenized rice was weighed and put into long neck digestion flask. Rice sample was then oxidized by heating with 20 ml nitrogen-free concentrated sulfuric acid in a long neck digestion flask, in the presence of selenium as catalyst. The mixture was heated on an electric coil heating rack in an inclined position until it was boiled. Heating was continued for 5 hours at temperature 350°C until the mixture became clear.

The digestion flask together with digester was set aside until it attained room temperature before distillation carried out. After that, the digester was neutralized with concentrated sodium hydroxide solution to release ammonia gas which was trapped in saturated boric acid solution. The distilled solution, which was added with few drops of methyl red indicator solution, was titrated with hydrochloric acid from a burette until the mixture became pink-purplish at the endpoint. The volume hydrochloric acid used indicated the amount of nitrogen liberated from the rice sample.

Blank sample which included all reagents used in the analysis except the sample in every batch of analysis to subtract reagent nitrogen from the sample nitrogen. Protein was calculated by a standard formula as below and the test is done in triplicates for each sample.

$$\text{Protein (\%)} = \left\{\frac{\{[HCL\ (ml) - HCL\ blank\ (ml)] x\ 14.008\ x\ 0.1N\ HCl\ x\ 5.95\}}{weight\ of\ rice\ sample\ (mg)}\right\} x\ 100$$

3.5.1.5. Determination of Carbohydrates

Total carbohydrate of sample was determined by calculating the remaining percentage after all the other proximate nutrients had been measured. Total carbohydrate content was measured by a formula shown as below:

Total carbohydrate (%) = 100% – [moisture (%) + crude protein (%) + crude fat (%) + total ash (%)]

3.5.1.6. Determination of Calorific Value

Bomb calorimeter was used to determine gross calorific value of sample by undergo combustion. Volume of oxygen and temperature are controlled to initiate combustion (Parr Instrument Company, 2007). As homogenized rice sample was too dry, the sample was not able to pellet in a good form. Therefore, only 0.5 ± 0.1g of sample was pelleted using pelleting press to have well-formed pellet.

Next, decomposition vessel was prepared. A combustion crucible was placed onto crucible holder. A cotton thread was fastened onto the middle of the ignition wire with a loop to ignite a combustion of the pellet. After finished setting up the crucible, the decomposition vessel was placed into the filler head of the open measuring cell cover of IKA Calorimeter System C 2000 Basic.

After calorimeter done the measurement, the pressure in the vessel was released before removing the crucible and the result was displayed. The test was done in triplicates.

3.5.2. Determination of Dietary Fibre

Determination of dietary fibre in food was done through enzymatic-gravimetric method. It is a method of elimination of digestible carbohydrates, lipids and proteins by enzyme-catalysed hydrolysis to let fibre, which is resistant to digest to be recovered, dry and weighed (Nielsen, 2017). The common used method is AOAC 985.29 which was introduced back in 1985 and known as Prosky Method (Megazyme, 2018).

Defatted sample as much as 1.000 ± 0.005g was weighed and placed in an incubation flask containing buffer. For each sample, two flasks were prepared. Dietary fibre analysis method consists of two stages; incubation and filtration. The first stage of dietary fibre analysis involving starch and protein removal by treating the sample with suitable enzymes accordingly and altering the conditions of the mixture. There are three major steps in the first stage to remove starch and protein (Megazyme, 2018),

1) starch gelatinization and hydrolysis to dextrins;

- pH was altered to 6.0 ± 0.2 before adding 50 μl alpha-amylase enzyme, 30 minutes, stirred gently every 5 minutes in 95-100^{o}C

2) protein hydrolysis, and;

-pH was altered to 7.5 ± 0.2 before adding 100μl protease, 30 minutes, continuous agitation in 60 ± 1°C

3) hydrolysis of starch dextrin

-pH was altered to 4.0-4.6 before adding 200μl amylogucosidase, 30 minutes, continues agitation in 60 ± 1°C.

After treatment with enzymes, extraction, or precipitation with alcohol (ethanol) was done for an hour to separate soluble dietary fibre polysaccharides from low-molecular weight carbohydrates and starch hydrolysis products (Prosky, 2001). Second stage was started with solvent washing with water, alcohol (ethanol) and acetone. The residues were filtrated using Fibertec 1023 and the residues were dried overnight. The duplicates of dried residues are then analysed for protein and total ash. Finally, total dietary fibre in the sample were calculated as stated below. As there is limited time and chemical resource, the test was done in single replicate for each sample.

$$\text{TDF (g/100g)} = \left\{ \frac{\left[\frac{(R_1 + R_2)}{2} - mg_{Protein} - mg_{Ash} - B\right]}{\frac{(M_1 + M_2)}{2}} \right\} \text{x } 100$$

$$B = \left(\frac{B_1 + B_2}{2}\right) - B_{protein} - B_{Ash}$$

B	= Blank (mg)
B_1/B_2	= Individual blank values
B_{Ash}	= Ash (mg) in blank sample
$B_{Protein}$	= Protein (mg) in blank sample
mg_{ash}	= Ash (mg) in sample residue