Chemical Compositions and Physical Properties of Selected Malaysian Rice: A Review

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Abstract. Rice is the main food for most countries in Asia and, about 90% of the global rice area, production and consumption are concentrated on Asia. In Malaysia, the main varieties of rice found in retail outlets are ordinary local and imported white rice, brown unpolished rice and specialty rice. In short, conventional rice or white rice is a medium-length, white kernel with translucent endosperm. Brown rice is also called unmilled rice that is produced by removing the outermost layer of the grain. Specialty rice is the rice with special characteristics which includes pigmented rice, fragrant rice, parboiled and glutinous rice. Various rice varieties have various chemical and physical properties. This staple food is found to have received the utmost attention because of its potent antioxidant properties especially pigmented rice. These properties were related mainly to their phytochemical content which was associated with the provision of health benefits in chronic disease reduction. Therefore, this paper will comprehensively review the chemical compositions and physical properties of the Malaysian rice and its relation with health benefits.

1. Introduction

Since 1961, the paddy production area has risen tremendously from 51,649 hectares to a peak land area of 766,180 hectares in 1972 and continued to stagnate within the range area through 1980. The land area for paddy plantations decreased from 716,873 hectares in 1980 to 698,544 hectares in 2000. Therefore, through 2014, the paddy production land area has remained at an average of 677,000 hectares, giving paddy harvest area a growth rate of 0.2 percent [1]. Malaysia is only a small producer of rice opposed to global rice production, contributing about 0.4% of global total output [2]. Four decades later, rice production in Malaysia increased from 914,550 tonnes in 1970 to 1,685,236 tonnes in 2013 [1, 2].

Asian rice or Oryza sativa L. is Asia’s cereal crop, and the majority of the world’s population [3]. Rice is important as roughly one half of the world population is usually dependent upon rice as staple food. Malaysia imported rice from other countries especially Thailand because the production of rice in Malaysia can only occupy about 75% of the local demand due to the geographical state of Malaysia that is occupied with rainforest. However, these days, Malaysia’s government implemented laws and helps farmers in producing large scale production of rice which in a few years time, Malaysia will be able to export rice to other countries. These days, there are many varieties of rice produced by local farmers with the help of the government such as white rice, glutinous rice, black rice, red rice, brown rice and aromatic rice.
A rich source of protein, vitamins and other bioactive compounds in brown rice is obtained from paddy by the dehulling process [4]. Rice can also be graded by scent as aromatic and non-aromatic rice. In cooking, aromatic rice emits a special aroma. The flavour is used in aromatic rice as one of the most important factors in market business, distinguishing aromatic rice from ordinary rice [5, 6]. The primary source of this compound is its 2-acetyl-1-pyrroline content [7], which typically plays a role in rice’s market acceptability [8]. Glutinous rice is differentiated from other rice varieties by having no or negligible amount of amylose and high amounts of amyllopectin which are the components of starch. The amyllopectin is important in giving the glutinous rice’s sticky quality. Glutinous rice may be used either milled or unmilled while the milled glutinous rice is white and fully opaque unlike non-glutinous rice that is translucent. The bran of the rice may offer a purple or black colour to unmilled glutinous rice [9]. Therefore, throughout this paper, a comparative study on chemical compositions and physical properties of Malaysian rice will be analyzed and discussed.

2. **Morphology of the rice grain**

Morphological structure of rice grain is shown in Figure 1. About 70% of the rice grain is composed of endosperm, 21% of hull, 8% of rice bran and 1% of embryo [10]. Starchy endosperm is the highest composition in rice caryopsis (89-94%), while the other components i.e., aleurone, seed coat and nucellus (4-6%), embryo (2-3%) and pericarp (12%) exist as minor components.

![Figure 1: Morphological structure of rice grain [11].](image)

3. **Chemical Composition**

Pericarp removal lowers the contents of lipids, protein, fibre and ash, lowering carbohydrates and total sugars, as well as minor components such as vitamins, free amino acids and free fatty acids [12, 13]. Phenolic compounds are secondary plant metabolites. Flavonoids, the major class of phenolic compounds in plants are made up of 15 carbons, organized into two aromatic rings linked by a three-carbon chain [14]. They can be divided into different groups, being the most common anthocyanidins which are responsible for most of the plant's red, pink, purple colour that attracts the animal to pollinate and disperse seeds. Pericarp colour is associated with phenolic amount in the grain and is usually higher.
in the red and black pericarp grains. It has been reported that the dark purple colour group had a higher content of polyphenol and anthocyanin than the red brown colour [15, 16]. There are three main chemical compositions that were analyzed which are proximate analysis, anthocyanin content and antioxidant activity.

3.1. Proximate analysis

Proximate analysis refers to the quantitative study of macromolecules in foods. These values are generally referred to as nutritional facts, which are usually seen on the food items label [17]. Table 1. tabulated the proximate analysis of selected rice. In general, carbohydrate content was the highest in white rice (exceed 80%) as carbohydrate is the major component of the rice. Moisture content was the second highest content in the rice which varied between 10.04-12.88%. Moisture content plays an important role in controlling the shelf-life of the rice. Ash content is highest in black rice and lowest in white rice. White rice also contains the lowest percentage of protein. The fat content ranged between 0.07% up to 1.74% which black rice recorded the lowest in fat content and known as a good source of fibre that recorded the highest percentage (8.47%).

| Rice Samples        | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Carbohydrate (%) | Total Dietary fibre (%) | Total Energy (kJ per 100 g) |
|---------------------|--------------|---------|-------------|---------|------------------|-------------------------|---------------------------|
| White rice          | 12.08        | 0.39    | 5.96        | 1.24    | 80.14            | 7.07                    | 1523.57                   |
| Brown rice          | 12.88        | 0.55    | 6.48        | 1.74    | 78.21            | 8.37                    | 1487.90                   |
| Pigmented rice      | 11.07        | 0.90    | 6.35        | 0.07    | 78.26            | 8.47                    | 1457.72                   |
| (Black)             |              |         |             |         |                  |                         |                           |
| Glutinous rice      | 10.04        | 0.82    | 8.14        | 1.12    | 78.89            | 7.47                    | 1502.65                   |

3.2. Anthocyanin content

Anthocyanins are coloured plant pigments that belong to the class of flavonoids and commonly used for antioxidant and other medicinal properties. Pigmented rice contains about 2.839 mg/g of anthocyanin compared to white rice and glutinous rice which normally in the range of 0.262-0.342 mg/g (Table 2). Rice anthocyanin acts as antioxidants that can prevent inflammation throughout the body, act as an anticancer agent, promote blood circulation and inhibit platelet aggregation [18].

| Rice samples       | Anthocyanin content |
|--------------------|---------------------|
| White rice         | 0.262 mg/g          |
| Glutinous rice     | 0.342 mg/g          |
| Pigmented rice     | 2.839 mg/g          |
3.3. Antioxidant activity

Antioxidant activity of the rice normally associated with the anthocyanin and phenolic contents in the rice. Antioxidant activities are proportionate to the anthocyanin and phenolic contents. Grains with black and red pericarp usually displayed greater antioxidant activity than those with a light brown pericarp colour [19]. Study conducted by Lee [20] found that black rice shows higher antioxidant activity compared to red rice. This can be seen from the half maximal inhibitory concentration (IC50) values recorded by black rice (39.86%) compared to red rice (78.68%). IC50 values lower than 50% indicates a strong antioxidant activity.

4. Physical properties

The length of the paddy grain is depending on the length of the awn and the pedicel. The dimension of the paddy grain and milled rice kernel play a vital role in the determination of final grain standards and throughout the processing cycle [21]. The type of paddy is classified according to the length of the whole brown rice grain which consists of extra-long paddy, long-paddy, medium-paddy and short-paddy with 80% of the whole brown rice kernels (Table 3).

| Types of paddy | Length (mm) |
|----------------|-------------|
| Extra-long     | >7.5        |
| Long           | 6.5-7.49    |
| Medium         | 5.5 – 6.5   |
| Short          | <5.5        |

Rice is produced after the dehusking process where the bran is removed from the grain. Rice size and shape are vital in separating impurities and the development of sizing and grading machines. Rice grains that are graded uniformly according to sizes, will provide uniform germination and usually give an increment of harvesting yield. Since rice is produced and marketed according to grain size and shape, the physical dimensions, weight and uniformity are important. Two main physical properties that are important in rice analysis are white transparency and colour analysis. These two physical properties show immediate results which are considered as added values compared to other physical properties analysis.

4.1. White transparency

Rice whiteness was known as one of the indicators for rice quality determination, and higher whiteness associated with better cooked rice taste [22]. Study conducted by Hien et al. [23] on the physicochemical properties and quality measurement of frozen-cooked rice of five Korean rice varieties found that all the varieties tested have whiteness values above 38%. This value is the standard and acceptable whiteness value for the rice quality. The whiteness of the cooked white rice is slightly lower than the cooked brown rice with whiteness values of 39.9 and 41.1%, respectively.

Transparency shows the percentage of light that goes through the kernel of rice [24]. Chalky rice had more air spaces to offer low transparency. Unlike whiteness, cooked white rice had the highest transparency value i.e. 4.02% compared to cooked brown rice (3.25%).

4.2. Colour analysis

Colour is another main criteria to determine the rice quality. The colour of the rice is associated with the anthocyanin content in the grain. Anthocyanin pigment located in the apiculus of the rice hull. Beside anthocyanin pigment, colour of the rice also can be analysed by Lab Colour Space ($L^*a^*b^*$). $L^*$ for the lightness from black (0) to white (100), $a^*$ from green (-) to red (+), and $b^*$ from blue (-) to yellow (+).
Study on the colour analysis of selected coloured-rice shows that non-glutinous black rice and non-glutinous red rice contain higher L*a*b* compared to glutinous black rice even though glutinous black rice contains higher total anthocyanin and total phenolic content [25]. Figure 2 shows different varieties of rice with different and unique colour of the rice.

![Different types of rice](image)

Figure 2: Different types of rice which indicates different colour of the rice [25].

5. **Potential health benefit**

Rice has the ability to reduce blood sugar level where it works as regulators for blood sugar. Brown rice is the best choice to act as blood sugar regulator compared to the white rice [24,25]. Brown rice is also better than white rice in slowing the absorption of glucose in the body because it contains more fiber. The slow absorption of glucose gives insulin in the body more time to disperse the glucose properly. Long grain rice varieties with higher amylose content (19-23%) tend to have lower glycemic index (GI) values compared to short grain rice with lower amylose content. GI values describe how a food containing carbohydrate causes blood sugar or glucose levels to rise.

Rice also acts as a natural anti-inflammatory agent that helps to lower the deposition rate of atherosclerotic plaque inside the walls of the blood vessel. This also reduces the risk of serious heart problems such as heart attacks or strokes. Again, brown rice is more beneficial than white rice due to the content of husk. Most of the nutrients in brown rice are located in the husk [18]. Besides that, anthocyanin in the rice also has the potential as antioxidants which act as anti-inflammatory, anti-cancer, promote blood circulation, anti-aging, reduce cholesterol and blood sugar levels and inhibit gastric acid secretion and platelet aggregation [20 – 22].
6. Conclusion
Rice is a staple food for most countries in Asia. There are lots of varieties of rice planted and consumed in Malaysia, from ordinary white rice, brown unpolished rice to specialty rice. The variation of the chemical composition and physical properties of the rice is also huge and varies. Nowadays, more attention was focused on the specialty rice due to the special characteristic of the rice which contains colour pigment and fragrant. Not to forget the brown unpolished rice which contains a high amount of fiber. All these compounds are always associated with the human health benefit.

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