A STUDY ON CHEMICAL CHARACTERIZATION OF SEVERAL VARIETIES OF SABAH TRADITIONAL RICE

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ABSTRACT

Sabah has diverse varieties of traditional rice. These rice varieties possess different physicochemical characteristics that might be useful for future breeding programs. In this study, twelve (12) selected Sabah traditional rice were analyzed for selected chemical properties which are the amylose content (AC), the gelatinization temperature (GT) and the gel consistency (GC). The data collected for AC, GT and GC was analyzed using One-Way Analysis of Variance with post hoc Tukey's HSD to check for significant difference within the group. Then, data from AC, GT and GC were analyzed using bivariate Pearson product-moment correlation test to determine presence of correlation between amylose content, gel consistency and gelatinization temperature. The results showed that there is a significant difference in the AC, GT and GC among 12 selected traditional Sabah rice varieties and there is no correlation among selected chemical characteristics. It was found out that Sulug variety had the best cooking and eating quality as it possessed lowest amylose content which implied that it would gives a soft texture when cooked. On the other hand, Wangi Keladi variety had significantly low gelatinization temperature compared to other rice varieties. This indicated that Wangi Keladi only require a short amount of time to cook. Meanwhile, Berinda variety had the softest gel in rice gel consistency compared to other rice varieties. In this study, all of rice varieties used is identified to be good for diabetic patients as they possessed low glycemic index.

ABSTRAK

Sabah mempunyai pelbagai jenis beras tradisional. Beras ini memiliki ciri-ciri fizikokimia yang berbeza yang mungkin berguna untuk program pembiakbakaan masa depan. Oleh itu, sebanyak dua belas (12) beras tradisional Sabah yang terpilih dianalisis untuk menentukan beberapa ciri kimia terpilih iaitu kandungan amilosa (AC), suhu penggelatinan (GT) dan konsistensi gel (GC). Data yang dikumpulkan untuk AC, GT, dan GC dianalisis menggunakan Analisis Varian Satu-Hala dengan HSD post hoc Tukey untuk menyemak perbezaan yang signifikan dalam kumpulan. Kemudian, data dari AC, GT dan GC dianalisis menggunakan bivariat ujian korelasi Pearson produk-masa untuk menentukan kehadiran korelasi antara kandungan amilosa, konsistensi gel dan suhu penggelatinan. Data yang diperoleh menunjukkan terdapat perbezaan yang signifikan antara 12 varieti beras tradisional Sabah terpilih yang digunakan dalam AC, GT dan GC dan tiada korelasi antara ciri kimia yang terpilih tersebut. Kajian ini mendapati varieti Sulug mempunyai kualiti masakan dan pemakanan yang terbaik kerana ia mengandungi kandungan amilosa yang terendah menandakan varieti tersebut akan memberikan tekstur yang lembut apabila masak. Selain daripada itu, varieti Wangi Keladi mempunyai suhu penggelatinan yang terendah berbanding sampel beras yang lain. Hal ini menunjukkan varieti Wangi Keladi hanya memerlukan masa yang singkat untuk masak. Varieti Berinda pula mempunyai konsistensi gel yang paling lembut berbanding varieti beras yang lain. Dalam kajian ini, semua varieti beras yang digunakan adalah baik untuk pesakit kencing manis kerana varieti mempunyai indeks glisemik yang rendah.

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LIST OF SYMBOLS, UNITS AND ABBREBIATIONS

AC	Amylose content
ANOVA	Analysis of Variance
ASV	Alkali Spread Value
°C	Degree Celsius
C_2H_6O	Ethyl alcohol
cm	Centimetre
FAO	Food and Agriculture Organisation
GC	Gel consistency
GT	Gelatinization temperature
g	Gram
ha	Hectare
HSD	Honest significant difference
kg	Kilogram
KOH	Potassium hydroxide
mg	Milligram
mL	Millilitre
mm	Millimetre
m/t	Metric per tonne
NaOH	Sodium hydroxide
nm	Nanometre
%	Percent
t/ha	Tonne per hectare

LIST OF FORMULAE

CHAPTER 1

INTRODUCTION

1.1 Background

Rice is propagated worldwide under a range of conditions between attitudes 45°N and 40°S (Panda, 2010). Based on the research conducted by Chatterjee (1948), rice genus named Oryza has 23 species altogether. Globally, until recent years, wild rice varieties have been tamed from wild species, landraces to domesticated lines (Sharma, 2010). There are two species of rice that have been cultivated by mankind for dosmetic purposes, which are known as *Oryza sativa* in Asia and *O. glaberrima* in African continent (Sharma, 2010).

The most important basic food for most human races is rice, especially in Asian regions, the Middle East and West Indies. The public community has taken cognizance of the importance of healthy diets lately and they are searching for a better variety of rice and effective techniques in preparing rice that to be consumed by diabetics (Ashish *et al.*,2012). Thus, it is proven that the quality traits of the rice grain have become a priority for world's human population.

The quality of certain rice varieties is highly borne by amylose especially in terms of its cooking and eating quality. This statement is supported by Cruz *et al.* (1989) as they has discussed that amylose content is one of the important starch elements which affect the cooking and eating features. In terms of structural arrangement, amylose is the one-dimensional fraction of starch in the non-adherent varieties, while amylopectin, the forked fraction, which are remaining of the starch. Amylose content in rice causes the rice to be waxy and moist.

There are differences in amylose content and gelatinization temperature in rice grain of non-Asian rice-growing countries, which varies from high, intermediate to low amylose content and gelatinization temperature. According to Calingacion *et al.* (2014), the gelatinization temperature of rice grain is highly correlated to its amylose content. This is shown when the rice grain posses low and intermediate gelatinization temperature, the amylose content of the rice grain will be low (Appendix H).

Due to several factors such as cultural and geographical, there are different preferences for different regions of waxy or non-waxy rice. This situation is mainly affected by the amount of amylose content in rice. According to Calingacion *et al.* (2014), in several countries, for examples, Japan, Taiwan, Cambodia, Thailand, parts of Lao PDR, Egypt and Australia, the consumers prefer low amylose rice, as do consumers in the northern and south-western provinces of China, and southern Vietnam. Meanwhile, rice with intermediate amylose content is preferred in Iran, Pakistan, Malaysia, Philippines, many states in India, and some provinces of China, Vietnam, Indonesia and Uruguay. On the other hand, high amylose varieties are popular in Myanmar, Sri Lanka and Indonesia.

Jennings *et al.* (1979) purposed that gel consistency in rice able to classified rice with high amylose content into three categories which are very flaky, flaky and soft. The duration of rice to be cooked is determined by the gelatinization temperature. Gelatinization temperature is the point in temperature at the moment water is taken in and the granules of starch loss its crystallinity due to irreversible swell condition. It is proven that rice that have high gelatinization temperature property will become inordinate soft due to overcooking.

The exact data of amylose content of Sabah traditional rice have not yet been published. Besides, there are not many reports or established works on Sabah traditional rice regarding their amylose content. The establishment of knowledge of amylose content on Sabah traditional rice is important as a guide for end-product consumers who in need of selecting good rice species for healthy lifestyles.

1.2 Justification

This research was conducted because there is lack of previous literature that had been done that focus on this research scope. By conducting this research, many important chemical characteristics of rice varieties can be analyzed and recorded for future reference. Furthermore, it is important and beneficial to identify if there is any possible useful trait among all the tested varieties to be promoted as a good choice of rice for medication purposes. For example, traditional rice with high amylose content able to serve as a healthy diet for diabetics. Moreover, it is crucial to prove that there is significant difference in the chemical characterization of traditional Sabah rice varieties.

1.3 Significance of Study

This research will provide informations regarding the amylose content, gel consistency and gelatinization temperature of traditional rice in Sabah as a guide for future research. Apart from that, the data collected from this research can be used to determine availability of possible useful trait in Sabah traditional rice as a healthy diet for diabetics.

1.4 Objectives

The main objectives of this study are to determine chemical qualities of rice grain (amylose content, gel consistency and gelatinization temperature) of the various traditional rice of Sabah.

1.5 Hypothesis

H_0: There is no significant difference in the amylose content, gel consistency and gelatinization temperature among 12 traditional Sabah rice varieties used

H_A: There is a significant difference in the amylose content, gel consistency and gelatinization temperature among 12 traditional Sabah rice varieties used

CHAPTER 2

LITERATURE REVIEW

2.1 Taxonomy and Classification of *Oryza Sativa*

Rice (*O. sativa* L.) is a staple food for more than half of the world's population. It is also the most important human food crop in the world (Itani *et al.*, 2002). *O. sativa* is a diploid species having 24 chromosomes.

The taxonomy of *O. sativa* according to Integrated Taxonomic Information System (ITIS) showed that rice is belonging to genus Oryza (Appendix I). The cultivated species of *O. sativa* can be further divided into three sub-species based on the morphological, geographical distribution and physiological characteristics of the varieties. The three sub-species are known as *indica, japonica* and *javanica.*

2.2 Total Cultivation Area and Production of Rice

As reported by Panda (2010), although rice is highly cultivated in Asian regions, rice also flourish in temperate countries like Spain, Italy, France, Hungary and Portugal. This can be supported as the highest yields are recorded between latitudes 30° and 45° north and south of the equator.

The rice area, production and productivity level of some important rice growing countries has been reporterd by Food and Agriculture Organization (FAO) (2003) (Appendix J). According to the report, the Asia continent dominated the world production of rice as they produced 523 m/t of rice (Appendix J1). Meanwhile, on the other hand, in the Asia continent itself, the leading countries in rice production in terms of m/t are India and China (Appendix J2).

For Malaysia, the cultivation area, average yield and production of paddy and rice for all seasons are different for each state according to Department of Agriculture Peninsular Malaysia (2014) (Appendix K). Up until 2014, Kedah produced the highest number of production of paddy and rice in term of t/ha.

Meanwhile, in Sabah, the average yield, paddy and rice production fluctuate throughout the year (Department of Agriculture Peninsular Malaysia, 2014) (Appendix L). Since 2004 until 2013, the number of production of rice in Sabah had been fluctuated throughout the years. Therefore, experts should start to find the solution to overcome this problem. There is no verified or complete report yet on the production of traditional rice in Sabah.

2.3 Botany

2.3.1 Morphology

According to Panda (2010), the rice plants are annual grass with round, hollow, jointed culms, rather flat leaves and a terminal panicle. It also has fibrous root. The fibrous root is composed of rootlets and root hairs. Meanwhile, the rice stem or culm is made up of a series of nodes and internodes. The nodes and internodes are in alternate orders. The leaves of rice plants are borne at an angle of every node. The leaves posses two parts, which are the blades and the leaf sheath that wraps the culms. All healthy and well-growth rice plants have the panicles and the spikelets (grains).

2.3.2 Structure of the Grain

A caryopsis or rice grain is a dry fruit which only composed of one seed, with its pericarp that fused with the seed coat. the main parts of the seed are the husk, the pericarp, the endosperm and the embryo (Panda, 2010). Sapre (1968) have described the morphological descriptions on the rice embryo. The shield-shaped scutellum, which is fleshy in nature, acts as the sucking organ for food for the germinating embryo. In the middle of scutellum runs a poorly developed vascular system. Roy (1965) proposed that from the vascular stand, side branches are given off only towards the endosperm.

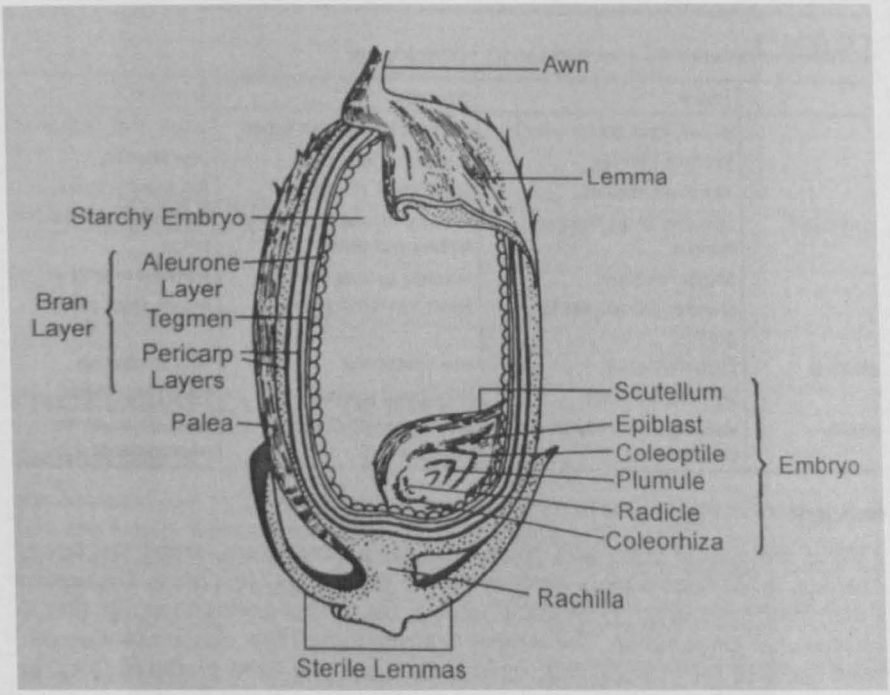

Figure 2.1 Structure of rice grain
Source: Grist, 1953

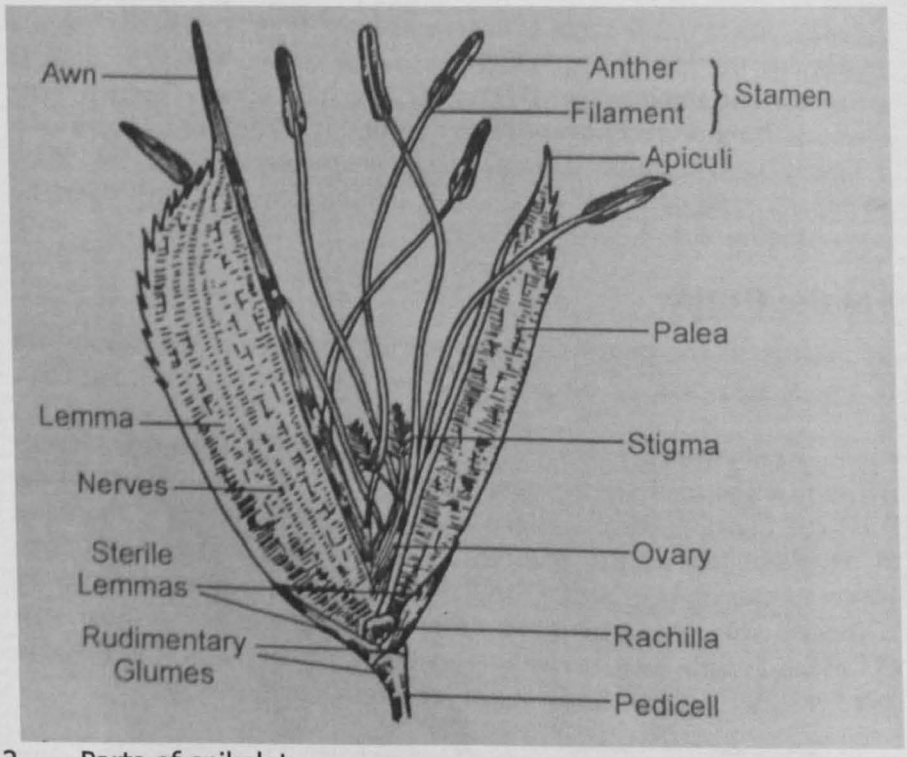

Figure 2.2 Parts of spikelet
Source: Panda, 2010

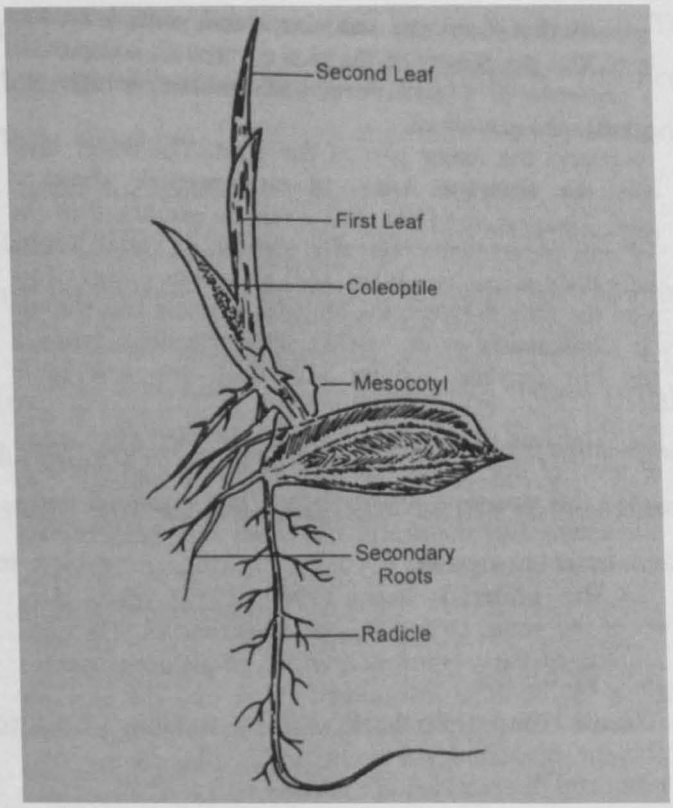

Figure 2.3 Parts of rice germinating seedling
Source: Chang and Bardenas, 1965

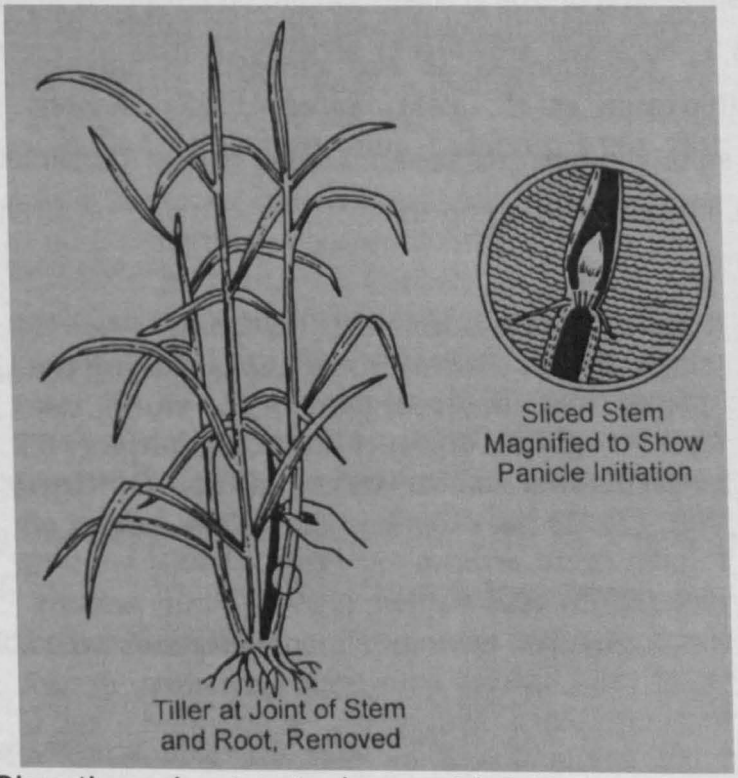

Figure 2.4 Dissecting a rice stem to show panicle initiation
Source: Panda, 2010

The major part of rice grain is occupies by the endosperm. The aleurone layer constitutes the outer layer of the cells of the endosperm. The rice grain is mainly divided into two types. These two types are glutinous (waxy) and non-glutinous (non-waxy); depending upon the ratio between the amylose content and amylopectin content of starch (Ghosh, 1971; Chakravarty *et al.*, 1972). Generally, the glutinous rice grains have low amylose content (around 20-30%) with the starch being amylopectin.

The seed coat of rice grain constitutes the bran layer. Usually, the bran layer will be removed during process of polishing rice grains. Ramiah and Mudaliar (1936) has conducted a study on the pericarp of rice grain and they observed the pericarp structure consist of epidermis, parenchymatous mesocarp, cross sells, tube cells, amd spermoderm.

2.4 Production and Package of Practices of Upland Rice

2.4.1 Seed Treatment

Good seed treatment conducted on the rice grains is able to protect the crop from the seed borne diseases. As stated by Panda (2010), the technique of drying the rice grains under the sun for 4 hours able to destroy most of the spores of Udbatta disease. For chemical treatment, it should abide the recommended procedure that has been lined in Annexure-IV. In order to treat the rice grains uniformly, the seed treatment drum should be used (Panda, 2010).

2.4.2 Post-harvest Technology

As recommended by Panda (2010), the early crop should be threshed within a day or two after being harvested. This is important in order to prevent fermentation and discoloration of grains. Panda (2010) stated further, saying that hand operated winnower should be used for the purpose of cleaning the grains.

2.4.3 Growing Criteria of Upland Rice

As mentioned earlier, rice is highly propagated throughout the globe. According to Siddiq *et al.* (2012), for rainfed upland, the paddy is planted on flat lands, terraces or

slopes without levelling and bunding. The dominant varietal type for this type of rice culture are semi-dwarf, medium tall and traditional tall of 120 to 150 cm. The rainfed upland paddy is able to produce 1.0 to 1.5 t/ha.

2.5 Rice Grain Quality

There are few important factors that can alter the rice grain quality. These factors includes varietal characteristic, the crop production environment, harvesting, processing and handling systems (post-harvest treatment). The rice grain quality can be summarized in terms of physical and chemical characteristics (Panda, 2010).

The chemical characteristics that can be used to determine rice grain quality may includes gelatinization temperature, apparent amylose content, gel consistency, alkali spreading value and aroma. Meanwhile, the physical characteristics of rice grain quality are its shape and size, colour of grain, chalkiness, bulk density, thermal conductivity, equilibrium moisture content and the flow ability.

Both physical and chemical characteristics are the genetic properties. On the other hand, the acquired properties or environmental factors are moisture content, grain quality, physical and pest damage, cracked grains, presence of immature grains and milling related characteristics.

2.6 Cooking and Eating Quality

Juliano *et al.* (2013) suggested that eating and cooking quality of rice depending on starch properties. The apparent amylose content in rice is governed by linear starch while gelatinization temperature and gel consistency by branched starch properties. Grain quality in rice is very difficult to define with precision and line out the standard preferences as preferences for quality vary from country to country. The concept of grain quality varies according to the preparations for which rice grains are to be used. Although some of the quality characteristics desired by the grower, miller and consumer may be the same, yet each may place different emphasis on various quality characteristics. For instance, the miller's basis of quality is dependent upon total recovery and the proportion of head and broken rice on milling. According to Cruz and Khush (2000), the majority of the consumers project their concept of quality on the

grain appearance, size and shape of the grain, the behaviour upon cooking, the taste, tenderness and flavour of cooked rice.

The cooking quality preferences vary in different countries (Azeez and Shafi, 1966). Rice is a cereal crop that is consumed mainly as whole milled and boiled grain. The desired properties or grain quality may vary from one ethnic group or geographical region to another and may vary from country to country (Juliano *et al.*, 1964). The quality in rice may, therefore, be considered from different aspect which includes milling quality, grain size, shape and appearance and cooking characteristics. The Good grain quality fetched a higher price for the farmers.

2.6.1 Amylose Content

The amylose content correlates negatively with taste panel scores for cohesiveness, tenderness, color and gloss of the boiled rice. For waxy or glutinous rice, amylose is almost absent. Such rice will not expand in volume, are glossy and sticky, and remain firm when cooked. These rice are used as the staple food of people in Northern and Northeastern Thailand and Laos.

Most of rice cultivated from Vietnam, Thailand, Myanmar and the Indian subcontinent have high amylose content. These rice show high volume expansion (not necessarily elongation) and a high degree of flakiness. The rice usually cook dry, less tender and become harder upon cooling. Low amylose rice cook moist and sticky. All of the *japonica* varieties of temperate regions have low amylose content.

The rice varieties grown in the Philippines, Malaysia and Indonesia have intermediate amylose content. The intermediate-amylose rice cook moist and tender and do not become hard upon cooling. A survey conducted by IRRI have shown that the most preferred varieties in the areas where high-amylose rices are generally grown have intermediate amylose. Rice varieties are grouped on the basis of their amylose content into waxy (0 to 2%), very low (3 to 9%), low (10 to 19%), intermediate (20 to 25%) and high (more than 25%) (Kumar and Khush, 1986). Intermediate amylose rices are the preferred types in most of the rice growing areas of the world, except where low-amylose japonicas are grown.

A study by Thomas *et al.* (2013), amylose content was lowest recorded by the brown rice variety. High amylose content rice is known to cook fluffy and dry, but can become hard upon cooling. This is attributed to the retrogradation of the amylose molecules. In a study by Nayak *et al.* (2003), amylose content was reported positively correlated to elongation of rice.

2.6.2 Gel consistency

The hardness of rice grain can be measure through rice gel consistency (Cuevas *et al.*, 2010). According to an article by Ebron (2013), hard gel consistency will give firmer cooked rice. Gel consistency will measure the tendency of the cooked rice to harden after cooling. Varieties with softer gel consistency are preferred within the same amylose group and the cooked rice will have a higher degree of tenderness. Softer gel consistency is associated with softer cooked rice and this feature is evident in low-amylose content rice. Soft cooked rice tends to be stickier. By heating a small amount of rice in dilute alkali, gel consistency can be determined.

Ram and Mishra (2010) have classified gel consistency in rice as follows: hard with the length of the gel in the range of 27 to 35 mm, medium hard in the range of 36 to 40 mm, medium 41 to 61 mm and soft 61-100 mm.

The gel consistency also separates the high amylose content (more than 25%) rice into three classes; very flaky rice with hard gel consistency (length of gel = 40 mm or less), flaky rice with medium gel consistency (length of gel = 41 to 60 mm) and soft rice with medium gel consistency (length of gel more than 61 mm) (Ram and Mishra, 2010).

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