UTILIZATION OF JERING (*Pithecellobium jiringa* Jack) SEED FLOUR FOR NEW FOOD PRODUCT DEVELOPMENT

CHENG YUEH FANG

UNIVERSITI SAINS MALAYSIA

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UTILIZATION OF JERING (*Pithecellobium jiringa* Jack) SEED FLOUR FOR NEW FOOD PRODUCT DEVELOPMENT

by

CHENG YUEH FANG

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LIST OF UNITS

%	percentage
µm	micrometre
cfu	colony forming unit
cm	centimetre
cp	centipoise
g	gram
h	hour
M	molar
mg	miligram
min	minute
ml	mililitre
mm	milimetre
N	Newton
^{o}	degree
s	second

LIST OF ABBREVIATIONS AND SYMBOLS

$<$	less than
$>$	more than
a_w	water activity
BJSF	boiled jering seed flour
Cys	cysteine
DPPH	2,2-diphenyl-1-picrylhydrazyl
DW	dry weight basis
HCl	hydrochloric acid
IDF	insoluble dietary fibre
JF	jering flour
Met	methionine
n	number of samples
NaOH	sodium hydroxide
PCA	plate count agar
PDA	potato dextrose agar
PER	protein efficiency ratio
RJSF	raw jering seed flour
RoJSF	roasted jering seed flour
rpm	revolutions per minute
RVA	rapid visco analyzer
SDF	soluble dietary fibre
TDF	total dietary fibre
TPC	total plate count

w/v	mass per volume
W-BJS	wheat-boiled jering seed
WF	wheat flour
WWF	whole wheat flour
YMC	yeast and mould counts
α	alpha

PENGGUNAAN TEPUNG BIJI JERING (*Pithecellobium jiringa* Jack)

DALAM PEMBANGUNAN PRODUK MAKANAN BARU

ABSTRAK

Objektif kajian ini adalah untuk mengkaji kesan pemanggangan dan pendidihan terhadap kualiti tepung biji jering (JSF). Ciri-ciri fizikokimia, penilaian deria dan kualiti penyimpanan bagi 'cookies' dan capati yang ditambah dengan JSF pada aras yang berbeza [0% (kawalan), 5%, 10%, 15%, 20% dan 100%] turut dikaji. Pemanggangan dan pendidihan menambahbaikkan kandungan protein, serat dan serat makanan secara signifikan ($P<0.05$) tetapi merendahkan kandungan lemak dan abu JSF. JSF yang dipanggang dan dididih menunjukkan ketumpatan pukal, kapasiti penyerapan air dan pembengkakan granul kanji yang lebih tinggi secara signifikan ($P<0.05$) daripada JSF yang mentah. Selain itu, ciri-ciri pempesan bagi JSF yang diproses adalah lebih rendah secara signifikan ($P<0.05$) berbanding dengan JSF yang mentah. JSF yang dihasilkan daripada proses pendididihan (BJSF) adalah lebih cerah secara signifikan ($P<0.05$) tetapi JSF yang dihasilkan menerusi pemanggangan adalah lebih gelap secara signifikan ($P<0.05$) daripada JSF yang mentah. Penambahan BJSF ke dalam tepung gandum menyebabkan peningkatan secara signifikan ($P<0.05$) dari segi ketumpatan pukal, kapasiti penyerapan air dan pembengkakan granul kanji manakala kapasiti pembuihan dan penyerakan tepung menunjukkan penurunan. Didapati bahawa ciri-ciri pempesan tepung komposit menurun secara signifikan ($P<0.05$) pada aras penambahan BJSF yang lebih tinggi. 'Cookies' komposit menunjukkan kandungan protein, serat, serat makanan dan abu yang lebih tinggi secara signifikan ($P<0.05$) tetapi kandungan lemak yang lebih rendah berbanding dengan kawalan, iaitu ‘cookies’ gandum. Capati komposit pula menunjukkan kandungan protein dan abu yang lebih tinggi secara signifikan ($P<0.05$) tetapi kandungan lemak yang lebih rendah daripada kawalan, iaitu capati gandum. Pada aras penambahan BJSF sebanyak 15% dan ke atas, nisbah sebaran menurun secara signifikan ($P<0.05$) manakala kekerasan ‘cookies’ komposit meningkat secara signifikan ($P<0.05$). Penambahan BJSF ke dalam capati komposit didapati menurunkan ketinggian pengembungan dan kadar pemanjangan capati secara signifikan ($P<0.05$). Ujian penilaian deria menunjukkan bahawa ‘cookies’ dan capati boleh dihasilkan dengan menambahkan sebanyak 10% dan 5% BJSF ke dalam formulasi-formulasi masing-masing tanpa mambawa kesan buruk terhadap sifat-sifat deria. Kualiti penyimpanan ‘cookies’ komposit dan capati adalah setanding dengan kawalan masing-masing.

UTILIZATION OF JERING (*Pithecellobium jiringa* Jack) SEED FLOUR FOR NEW FOOD PRODUCT DEVELOPMENT

ABSTRACT

The objectives of this research were to determine the effects of roasting and boiling on the quality of jering seed flour (JSF). The physicochemical, sensory properties and storage quality of cookies and chapatis supplemented with JSF at different levels [0% (control), 5%, 10%, 15%, 20% and 100%] were investigated. Roasting and boiling significantly improved ($P<0.05$) protein, crude fibre, total dietary fibre content but decreased fat and ash content of JSF. Roasted and boiled JSF showed significantly higher ($P<0.05$) bulk density, water absorption capacity and swelling power than raw JSF. Besides, pasting properties of processed JSF were significantly lower ($P<0.05$) than raw JSF. Boiled JSF (BJSF) was significantly ($P<0.05$) lighter but roasted JSF was significantly ($P<0.05$) darker than raw JSF. Supplementation of wheat flour with BJSF resulted in significant increase ($P<0.05$) bulk density, water and oil absorption capacity, foam stability and swelling power while there were reduction in foaming capacity and dispersibility. Pasting properties of composite flours were found to reduce significantly ($P<0.05$) at higher BJSF supplementation levels. Composite cookies showed significantly higher ($P<0.05$) protein, crude fibre, total dietary fibre and ash content with lower fat content than control wheat cookies whereas composite chapatis possessed significantly higher ($P<0.05$) protein and ash content with lower fat content compared to control wheat chapatis. At supplementation level of 15% and above, the spread ratio were significantly reduced ($P<0.05$) while hardness of composite cookies were significantly increased ($P<0.05$). The supplementation of BJSF in composite chapatis was found to significantly reduce ($P<0.05$) the puffed height and extensibility of chapatis. Sensory evaluation indicated that cookies and chapatis could be produced by supplementing BJSF up to 10% and 5%, respectively without having adverse effect on their sensory properties. The storage qualities of the composite cookies and chapatis were comparable to that of control cookies and chapatis.

CHAPTER 1

INTRODUCTION

1.1 Background

Overcoming various challenges relevant to food security and sustainability in Malaysia is the need of the hour. In this regard, ensuring food security and overcoming the challenges of producing sustainable foods are vital to the overall development of the community. Food security is directly correlated to the ever-increasing population, poverty as well as rapid depletion of available natural resources (Bhat et al., 2014). Besides, protein-energy deficiency and malnutrition coupled with poverty related issues (up to certain extent) are of high concern in the ASEAN region. These problems arise not only because of afore mentioned reasons, but also due to overdependence of local populations on starch-rich diet (FAO, 1997; Michaelsen et al., 2009). According to previous researchers (Bhat and Karim, 2009; Bhat and Yahya, 2014), insufficient supply and prohibitive costs of animal proteins are major contributing factors to this problem. The increasing costs of commonly used and popular plant-based food materials have been worsening the food situation in the developing world (Kathirvel and Kumudha, 2011). On top of this, switching by most of the world"s population from animal-based protein to a protein-rich vegetarian diet is resulting in scarcity of plant resources in certain developing regions. Hence, this triggers the need to seek for economical and reliable alternative protein sources of plant origin.

Majority of the plants and their products are traditionally utilized for their therapeutic potential. These plant produce can be tuber, stem, seeds, and etc. However, legumes and seeds make up a great portion and contribute significantly as a vital source of human and livestock‟s nutrition (Bhat, 2011; Zhao et al., 2014). Most of the legumes are high in nutrients, especially in protein (18-24%) compared to cereal grains (Noor Aziah et al., 2012). There are many reports on the successful use of underutilized dicotyledonous seeds and legumes as food (Bhat et al., 2007; Kalidass and Mahapatra, 2014; Smith and Hardacre, 2011; Vadivel and Nandety, 2011). Available chemical, clinical and epidemiological evidences indicate an inverse correlation between consumption of legumes and seeds and incidence of some chronic diseases such as cancer, cardiovascular diseases, obesity and diabetes (Bhat, 2011; Kris-Etherton et al., 2002; Rupachandra and Sarada, 2013; Yao et al., 2011).

Malaysia being a tropical country is rich in biodiversity and encompasses valuable natural resources. Although there is a wide array and varieties of legumes available in the market, the use of legumes is generally confined around soybeans, chickpeas and lentils (Ong and Norzalina, 1999). There are many other seed resources that still remain underexplored. It is a fact that almost 80% of the general population relies on Ayurvedic treatments in primary medical care and most of them are of seeds (Bhat, 2011). Hence, a wide gap exists in which many other legumes or seeds whose nutritional and functional qualities are overlooked. As such, this has driven current research focus towards exploring the potential of local underutilized legumes to serve as alternative raw materials in food product development (Bhat and Sridhar, 2008). This could be of high significance towards their wider utilization as they can be further processed into novel, low cost, economically feasible food products, which can be immense help to attain self-sufficiency and minimize the supply and demand gap.

According to Noor Aziah and Komathi (2009), the bakery industry has grown immensely over recent years. Wheat flour is an important raw material for the production of baked products due to its functional properties wherein other cereals or grains are lack of. However, developing countries such as Malaysia are relying on wheat importation since production of wheat is not feasible under tropical climate. Hence, this triggers research efforts towards the application of local raw materials to replace wheat flour (Noorfarahzilah et al., 2014). Composite flour is defined as a mixture of flours obtained from non-wheat crops such as legumes, cereals, roots and tubers with or without the addition of wheat flour (Milligan et al., 1981; Shittu et al., 2007). Other than to reduce wheat importation, the uses of composite flour in food products are to enhance the overall applications of domestic agricultural materials and to improve nutritional, functional as well as sensory properties of food products (Bibiana et al., 2014; Hasmadi et al., 2014; Jisha et al., 2008; Julianti et al., in press). Legume flour is known to be a great source of nutrients. As such, the use of wheat-legume composite flour is able to uplift the overall nutritional quality of food products. Successful applications of legume flours such as green gram, chickpea and pigeon pea flour in baked goods such as cookies and chapatis have been reported by previous researchers (Kadam et al., 2012; Okpala et al., 2013; Rajiv et al., 2012).

Nowdays, cookies have become one of the most popular and well accepted baked products worldwide among all the age groups. This is due to the fact that cookies are good source of energy and are „ready-to-eat" products. The low manufacturing cost as well as stable shelf-life (owed to low water activity) renders the cookies to serve as a valuable source of instant nutrition. Moreover, cookies can be produced in large quantities with minimal time requirements and enables very widespread distribution (Zucco et al., 2011). In the past, many studies have reported on the supplementation of cookies with legume flours such as pea (Kamaljit et al., 2010; Ndife et al., 2014) and gram flour (Yousaf et al., 2013). These studies have indicated successful improvement in the nutritional values of the cookies.

In addition, chapati, an unleavened flat bread of Indian origin is popular in majority of the households in Malaysia. Basically, chapati is prepared using wheat flour (whole wheat/ atta flour). It is baked at high temperature for a short time period to cause rapid steam formation and eventually results in puffing of the chapati. Previously, researchers have reported on successful supplementation of chapati with legume flour such as faba beans (Abdel-Aal et al., 1993), chickpea (Gupta and Kawatra, 1992), lentils and chickpea flours (Shahzadi et al., 2005a). From the reports, it was noticed that the nutritional and textural characteristics of the composite chapatis had improved. However, to our knowledge there is no report available on utilizing of jering seed flour in the development of any bakery products such as cookies and chapatis.

1.2 Research focus

The legume- *Pithecellobium jiringa* (Jack) which is commonly known as „jering" in Malaysia is an underutilized legume in Malaysia. Jering seeds are commercially available in the local markets throughout the year. The seeds are traditionally consumed raw or cooked prior to consumption (Bakar et al., 2012). For instance, jering seeds are boiled as accompaniment with rice or served as decoction in heated or non-heated water (Muslim and Abdul Majid, 2010; Ong and Norzalina, 1999; Roosita et al., 2008). In view of the paucity of information regarding the effects of domestic processing methods on chemical composition, functional properties, pasting properties and colour of the seed flour, the effects of common domestic processing methods such as boiling and roasting, on the quality of jering seed flour are evaluated. This is due to the reason that such information is essential in order to further increase the versatility and usage of this underutilized food source in Malaysia,

Jering seeds are believed to have the effect of blood purification, able to overcome dysentery and indigenously extolled for treating diabetes, high blood pressure and bladder stones (Azliza et al., 2012; Ong et al., 2011; Shukri et al., 2011). However, the utilization of jering seeds is limited to traditional therapeutic uses only. Currently, there is no study on the feasibility of utilizing jering seed flour in food formulations such as cookies and chapatis. Such study is important as the information generated could provide in-depth scientific database which can be of health for local food industries. As such, this creates a research gap which ought to be addressed. Hence, this research is aimed to evaluate the effects of supplementing wheat flours with jering seed flour in terms of functional and pasting properties; and to study the physico-chemical composition, physical, textural, colour, sensory properties as well as storage quality of composite cookies and composite chapatis developed.

1.3 Hypothesis

Roasting and boiling will significantly affect the physicochemical, functional, pasting properties and colour of jering seed flour. Wheat flour supplemented with jering seed flour will display significant improvement in functional and pasting properties. Composite cookies and chapatis supplemented with jering seed flour will show significantly better physicochemical and physical characteristics than control wheat cookies and chapatis. There is no significant difference in terms of sensory properties and storage qualities between composite cookies and chapatis incorporated with jering seed flour as compared to control wheat cookies and chapatis.

1.4 Objectives

The general purpose of this study is to explore the potential of utilizing local underutilized legume seed, jering to develop supplemented food products, especially baked foodstuffs (cookies and chapatis). The main objectives of this research are as follows:

1. To study the effects of common domestic processing methods (roasting and boiling) on the quality of jering seed flour.

2. To evaluate the effects of supplementing wheat flour with jering seed flour in terms of functional and pasting properties.

3. To determine the physicochemical properties, physical and textural characteristics, colour and sensory properties of composite cookies and chapatis developed.

4. To conduct storage quality (shelf-life) studies on the composite cookies and chapatis developed.

CHAPTER 2

LITERATURE REVIEW

2.1 Legumes

The term „legume" refers to all crops of the pea and bean family (Fabaceae) which comprises three subfamilies (Papilionacea, Mimosaceae and Caesalpinaceae) (Bhat and Karim, 2009; Sauer, 1993). The importance of legumes as food crops is ranked second only to cereals. They act as a good source of plant proteins and minerals for human and animal nutrition (Graham and Vance, 2003; Noor Aziah et al., 2012). Legumes are being recognized as alternative protein sources to animal products such as meat, fish, and etc. owing to their relatively lower cost. As such, legumes are protein sources which are more affordable to people especially the downtrodden community in countries where legumes are widely consumed (Subuola et al., 2012). Underutilized legumes are also regarded as neglected or undervalued legumes. Based on Ebert (2014), underutilized legumes are relatively low in market value and production volume. They are normally restricted to a more local consumption pattern. One of the limiting factors that led to underutilization of legumes is that some legumes possess hard testa that is hard to cook (Subuola et al., 2012).

Malaysia is a tropical country that is rich in various valuable and useful food crops. There are many plant resources could be used in different food applications. Although there are many kinds of legumes available in Malaysia, only some of them are commonly known and widely consumed as commercial food crops. For instance, soybeans, chickpeas and lentil are among the popular legumes in the local market (Ong and Norzalina, 1999). There are many other indigenous legumes often being neglected and remaining underexplored for their potentials to act as alternative legume sources for the locals as well as to be used in food applications. Table 2.1 shows some examples of the underutilized legumes grown in Malaysia and their traditional uses.

Table 2.1 Traditional uses of some reported local underutilized legumes of Malaysia

Legume	Common name	Traditional use	References
Clitoria ternatea	Butterfly pea	Seeds, leaves and roots are used as brain tonic and enhance memory Powdered seeds are consumed along with ginger to serve as laxative	Mukherjee et al. (2007) Mukherjee et al. (2008)
Gnetum gnemon	Belinjau	Seeds are used to prepare soup, crackers and used as coffee substitute In Northeast India, the leaves are consumed by cooking with alkaline water and dried fish	Lim (2012) Terangpi et al. (2013)
Canavalia virosa	Kerandang	Seeds are good source of protein	Djaafar et al. (2013)
Leucaena leucocephala	Petai belalang	Seeds are edible	Rushkin (1984)
Moringa oleifera	Moringa	Seeds are used to treat diabetes Flowers are used to treat inflammations Juice of the leaves is used to stabilize blood pressure Pods are consumed to reduce joint-pain Roots are used to cure rheumatism Barks are chewed as digestion aid	Oliveira et al. (1999) Karin et al. (2011) Mbah et al. (2012)
Oroxylum indicum	Beko	Young leaves and fruits are eaten raw or cooked to treat stomachache and jaundice Root bark is used to treat dysentery, diarrhea, diaphoretic and rheumatism Fruits are used as expectorant Bark and seeds are used to treat fever, bronchitis, pneumonia, hypertension, respiratory disorders and hoarseness Seeds are used as laxative	Kamkaen et al. (2006) Dev et al. (2010) Harminder et al. (2011) Krüger and Ganzera (2012) Deka et al. (2013) Zazali et al. (2013)

Table 2-1. Continued

Legume	Common name	Traditional use	References
Parkia speciosa	Petai	Seeds are eaten to treat diabetes, hypertension, kidney pain, cancer, hepatalgia, oedema, cholera and to relief flatulence	Suvachittanont and Pothirakit (1988) Jamaludin and Mohamed (1993) Abdullah et al. (2011) Aisha et al. (2012) Kamisah et al. (2013)
Pithecellobium jiringa	Jering	Seeds are crushed and mixed with water before drinking to induce urination, to purify blood, to overcome dysentery, to treat diabetes, high blood pressure and bladder stones	Muslim and Abdul Majid (2010) Ong et al. (2011) Shukri et al. (2011) Azliza et al. (2012)

2.1.1 Food applications of underutilized legumes

Producing sustainable food products by using underutilized legumes is envisaged to have wide application. Legumes occupy an important place in human nutrition as they serve as an important source of dietary protein for large portions of the global population especially in those countries where there is limited consumption of animal protein. Studies have indicated that consumption of legumes can provide rich health benefits as they are rich in bioactive compounds. Legume consumption has been linked to reduction of cardiovascular problems (Ha et al., 2014), cancer, diabetes and hypertension (Kris-Etherton et al., 2002). Hence, increased awareness among global populations regarding the advantages of incorporating legumes in the diet has gained tremendous interest in utilizing legumes and legumes-derived ingredients in developing novel food products. This holds true for underutilized or wild legumes also. Other than serving as a protein source by providing a range of essential amino acids and bioactive peptides, legume proteins have exceptionally good functional properties like that of good water holding, fat binding, foaming as well as gelation properties. These properties can be exploited and modified based on the need and uses in development of novel food products (Boye et al., 2010).

As mentioned earlier, majority of the world"s population are mainly depending on starch-rich diet. Either their knowledge is limited or they have limited amounts of fruits, vegetables and legumes to consume on daily basis. Such diet which is low in nutrients can lead to malnutrition-associated problems. Thus, this spurs the interest to incorporate legumes with other grains to cope with some of the protein-energy deficiency problems. Nowadays, changes in consumer preferences that are demanding for healthier diet with convenient ready-to-eat meals has fuelled interest in the processing of legumes to obtain flours that can be used as ingredients in food product development.

In addition, rise in the incidence of food allergies have resulted growing interest of using legumes as nutrient-rich alternatives to common allergens such as soybean, nuts, gluten and eggs (Boye et al., 2010). This creates opportunities for food product developers to incorporate legumes in their formulations and provide novel allergen-free products. A summary of the food application potential of local legumes and their constituents in food formulation is provided below.

2.1.1 (a) Bakery products

Other than traditional way of consumption, legumes are often milled into flour for various food applications. For instance, wheat-legume composite baked goods were reported by many researchers. Nmorka and Okezie (1983) studied on the nutritional quality of bread substituted with winged bean flour. It was noticed that the composite breads supplemented with 10% to 20% full-fat and defatted winged bean flour showed significant improvement in the total protein of both the triticale- and wheat-based products. The authors concluded that supplementation of cereal-based goods with up to 10% to 20% full- or defatted winged bean flour will provide better nutritional quality than products using either triticale or wheat alone. The usage of winged bean in such well-accepted baked products would help to overcome protein malnutrition in developing countries in which winged bean is native. Besides, this would help to reduce the dependence of non wheat-producing tropical countries on wheat-producing countries for the supplies of bakery ingredients.

Kunyanga and Imungi (2010) investigated the quality characteristics and acceptability of bread supplemented with lablab bean flour. With regard to protein content, the bread incorporated with lablab bean flour was increased by up to approximately 20% while the moisture content was reduced by around 10% without resulting significant changes in bread taste, odour, volume and overall bread quality. It was found that substitution levels of up to 10% produced bread with similar quality characteristics as the control. In terms of sensory attributes (aroma, crumb appearance, texture, crust colour, loaf shape, taste and overall acceptability), it showed no significant variation between the control and the lablab supplemented breads up to 15%. The acceptability of the bread decreased with substitution levels beyond 15% due to the dense texture and strong nutty taste of the bread. Hence, the authors concluded that acceptable breads can be produced by substitution of wheat flour with up to 15% of lablab bean flour.

Gan and Latiff (2011) evaluated petai pod flour for its potential applications in food. Results of the preliminary screening indicated that the pod consists of starches and fibers. In terms of functional properties, petai pod flour showed moderate water-holding capacity and low oil-holding capacity. On the other hand, it exhibited moderate emulsifying activity with high emulsifying stability. In overall, petai pod has the potential to be processed into functional flour as it contains great nutritional value (high in carbohydrates, fiber and protein). The authors suggested that petai flour could be used in bakery production that needs starch as texture supporting agent during the baking process. The flour could be used to produce fibrous bakery products such as bread since it is one of the healthy food trends in the market in which plant fiber is believed to be able to protect consumers from suffering gastro dilemma. The authors also suggested that petai pod flour could be used to replace other commercial flour due to its additional high antioxidant properties. However, other treatments such as heating, sonication or combination of treatments ought to be taken depending on its application to improve the functional properties of the flour.

Ogunsina et al. (2011) evaluated the quality characteristics of bread enriched with debittered moringa seed flour. Results from the study indicated that incorporation of debittered moringa seed flour from 0% to 15% into the bread formulations caused reduction in farinographic water absorption, dough stability, amylograph peak viscosity as well as the overall quality of the bread. The authors reported that the bread with 10% of debittered moringa seed flour had a typical moringa seed taste and was acceptable. The quality of the bread in terms of dough strength was improved by the addition of combination of additives. With regard to the nutritional quality, bread with 10% of debittered moringa seed flour showed higher protein, iron and calcium content. The authors concluded that the incorporation of moringa seeds in bakery products could be taken as an effort to boost nutrition in developing countries where malnutrition is prevalent.

2.1.1 (b) Snack foods

Investigation on the effects of wheat flour substitution with legume flours such as mungbean and chickpea flours on the physicochemical and organoleptic properties in cookies is reported (Noor Aziah et al., 2012). It was found that the protein content of cookies made from mungbean (6.55%) and chickpea composite flours (7.04%) were higher compared to cookies made from wheat flour (5.65%). Besides, the resistant starch content in both legume-based cookies were higher (1.85% and 2.09%, respectively) than that of the control cookies (1.03%). In regard of sensory quality, both legume-based cookies were rated high in flavour, crispiness, aftertaste, colour and overall acceptability with significant difference in comparison to control cookies. The authors concluded that the incorporation of legumes flour into wheat flour did not alter the functional properties of the cookies. However, this increased the protein, resistant starch content and acceptability of cookies.

Ogunsina et al. (2011) evaluated the quality characteristics of cookies enriched with debittered moringa seed flour. It was noticed that the quality of cookies was affected by substitution of wheat flour with 10%, 20% and 30% of debittered moringa seed grits. Cookies that contained 20% of debittered moringa seed grits showed beany taste of moringa seeds and were acceptable. In regard of nutritional quality, the cookies were found to contain higher level of protein, iron and calcium. The authors came into conclusion that the usage of moringa seeds in bakery goods may be employed as one of the ways to improve nutritional status of populations in developing countries where malnutrition is one of the severe issues that ought to be tackled immediately.

According to previous researchers (Voon and Kueh, 1999; Parhusip and Sitanggang, 2011), belinjau have been processed into flour to make traditional cracker which is known as *emping*, a crispy snack prepared by cooking in oil in commercial scale in Indonesia. In Malaysia, the seeds are consumed raw, boiled, roasted or processed by pressing the heated kernels into flat cakes or crackers while in the east coast states of Peninsular Malaysia, the cakes are sun-dried and also used to prepare *emping*. On top of that, the fleshy outer layer of the seed is fried to produce a chewy snack (Walton, 2003).

2.1.1 (c) Noodles

Based on Mbah et al. (2012), moringa seed can be employed as an ingredient to fortify instant noodles due to its high nutritional profile. Other than that, according to Haytowitz and Matthews (1986), mungbean is usually ground into flour and is made into noodle-like product called long rice. Other than that, the flour is used to make similar product which is recognized as cellophane noodles.

2.2 Jering

The legume - *Pithecellobium jiringa* (Jack) belongs to the family of Mimosaceae (Shukri et al., 2011). It is commonly known as „jering" in Malaysia, „djenkol" in Indonesia, „krakos" in Cambodia and „niang-yai" in Thailand. Jering tree could reach approximately 18-25 m in height with bi-pinnate leaves and grey smooth bark (Bunawan et al., 2013). Jering seeds (legume seed) grow as large pods (3-9 seeds/ pod) on the tree in twisted crook shape. The seeds are 3-5 cm across with yellow testa when young, which turns into brown colour at maturity (Barceloux, 2008; Lim, 2012). The seeds are broad and round with dark brown coloured seed coat. The edible greenish-yellow coloured cotyledons are present inside the hard seed coat (Figure 2.1). The cotyledon part is consumed raw, fried or roasted as pulse or as food flavouring agent as well as taken in as decoction (Bunawan et al., 2013; Ong et al., 2011; Segasothy et al., 1995).

Figure 2.1 A: Whole jering seed with the hard seed coat; **B**: A cut-open seed showing the cotyledon portion (arrow)

Jering seeds are commercially available in the local markets throughout the year. Traditionally, the seeds are consumed raw or cooked for its therapeutic value (Bakar et al., 2012). For instance, jering seeds are crushed and mixed with water before drinking to induce urination (Muslim and Abdul Majid, 2010). Besides, they are believed to have the effect of blood purification, able to overcome dysentery and indigenously extolled for treating diabetes, high blood pressure and bladder stones (Azliza et al., 2012; Bunawan et al., 2013; Ong et al., 2011; Shukri et al., 2011). Other than the seeds, jering leaves and bark also serve their ethnomedicine purposes wherein they are pounded to treat toothache, gum pains, chest pains and skin problems among the Malaysian population (Bunawan et al., 2013).

Mohamed et al. (1987) evaluated some nutritional components in jering seeds. Proximate analysis showed the crude protein content of the seeds was about 5% on fresh weight basis but it contained 47.8% essential amino acid (excluding tryptophan). Voon and Kueh (1999) have reported on the nutritional composition of fruit vegetables and found jering to encompass high protein content (5.0%) and low fat (0.4%). Besides, jering had 40.0% total carbohydrate, 1.7% crude fiber and 0.5% ash per 100 g edible portion. According to the authors, higher nutritional composition of jering is mainly due to the fact that kernels are consumed whereas for the other types of fruit/vegetables, only the aril or whole fruit is used. The authors suggested the need for future research and promotion in order to commercialize the highly nutritious indigenous food crops.

Sridaran et al. (2012) investigated the physico-chemical, functional and cooking properties of jering seed flour. Results on the proximate composition indicated that the crude protein content of seed flour to be 14.19%, which was much higher than that of common cereals such as wheat (13%), rye (11.5%) or rice (7.3%). The seed flour was reported to have relatively low lipid content (1.45%) than many other underutilized legumes such as Canadian pea (2.43%) or beach pea (jackbean, 1.9% and bay bean, 1.57%). The ash content of the seed flour was lower (0.5%) than the other underutilized legumes such as jackbean (3.3%). In addition, crude fiber (1.76%) and total carbohydrate content (25.67%) of the jering seed flour were also relatively low compared to other common legumes like cowpea, kidney beans and peas (3% to 4% and 60% to 70% respectively). In regard of the functional properties of jering seed flour, authors reported that there were significant variations in the protein solubility along with different pH values. The emulsifying activity and stability of the seed flour were found to be the highest at a concentration of 0.4 M. Furthermore, the least gelation capacity of the seed flour was revealed to be reduced by the addition of carbohydrates (lactose, maltose and sucrose). Based on the results, the authors suggested that the concentration, pH and ionic strengths of jering seed flour could be modified appropriately to suit the best in the development of novel food products.

De Lumen et al. (1986) have reported on the amino acid and chemical composition of seeds from jering and an African cereal with high Methionine (Met) and Cysteine (Cys) contents. Immature jering seeds were found to contain 32% protein and 2.8% Met + Cys while mature seeds contained 16% protein and 3.9% Met + Cys. Leucine was reported to be the first limiting amino acid for jering seeds. The authors concluded that the legume not only able to complement cereals but has the potential to supplement legumes with lower Met + Cys contents.

In addition, previous studies have proven that jering possesses gastroprotective properties. It is able to serve an anti-ulcer agent due to its ability to inhibit the formation of oxygen-derived free radicals (Ibrahim et al., 2012). Jering seeds were also discovered to have antimicrobial and antifungal properties. This is due to the presence of lectin in jering seeds (Bakar et al., 2012; Charungchitrak et al., 2011). Not only that, pharmacological studies conducted by previous researchers have indicated that jering shows antioxidant properties as it contains high level of polyphenolic, flavonoids, terpenoids and alkaloid contents (Muslim et al., 2012; Razab and Aziz, 2010). In addition, jering seeds were discovered to exhibit anti-cancer properties. Murakami et al. (1995) reported that the methanolic extract of jering seeds possess *in-vitro* anti-tumor activity.

On the other hand, other than showing desirable physicochemical as well as pharmacological properties, jering seeds were reported to possess some antinutritional factors. Jin et al. (2007) as well as Muslim and Abdul Majid (2010) have mentioned that consumption of jering seeds were reported to cause djenkolism and are likely to result in acute anuric renal failure and spasmodic pain due to the presence of sulphur-containing amino acid, namely djenkolic acid in the seeds. However, cases of such incidence were reported sporadically (Wong et al., 2007). Djenkolism happens when large amounts of raw jering seeds are ingested with low fluid intake. However, it can be prevented by subjecting jering seeds to thermal processing methods like boiling the seeds to eliminate the djenkolic acid or consumption of the seeds in small quantity along with high fluid intake (Sakhuja and Sud, 1999; Subhadrabandhu, 2001). Previous researches on toxicology of jering have shown that jering has strong toxicity (LC_{50}: <100 ppm) for brine shrimp lethality (Mackeen et al., 2000). However, findings reported by Ibrahim et al. (2012) stated that the ethanol extract of jering did not indicate any symptoms of toxicity and mortality up to 5 g/kg.

Available scientific databases on physicochemical, functional and pasting properties of jering seed as well as the effects of common domestic processing methods on these properties are extremely scarce. This is due to the fact that the consumption of jering is localized. This hinders the maximization of utilization of jering seed flour in food applications. As such, this shows the need for further research on the physicochemical, functional and pasting properties of jering seed flour in order to provide useful and essential data for novel food product development by using this underexplored local legume.

2.3 Common domestic processing of legumes

Legumes are commonly subjected to various processing techniques prior consumption depending on tradition (Kakati et al., 2010; Rehman and Shah, 2004). Processing methods particularly simple household or domestic processing such as dehulling, soaking, boiling, roasting, fermentation and germination have been practiced by people from developing and under-developed countries for legume utilization. This is due to the fact that domestic processing techniques are generally simple and no sophisticated processing equipments and skills are required (Clark et al., 2014). The purposes of applying processing techniques on legumes are to improve palatability, improve nutrients bioavailability and reduce undesirable beany flavour of legumes (D‟souza, 2013; Uppal and Bains, 2012; Walker and Kochhar, 1982).

According to Subuola et al. (2012), legume processing helps to improve palatability and digestibility, elevate nutritional values, reduce and/or remove anti-nutrients, enhance product shelf-life, ensure food safety as well as promote consumer acceptance and appeal of food products.

The effects of different domestic processing methods on the quality of legumes have been a major concern of many research works as it affects the potential and feasibility of utilizing the legumes in various food applications. In order to have better comprehension on the effects of processing techniques on the quality of legumes, it is deemed essential to understand the principles of the processing techniques.

2.3.1 Dehulling

Dehulling is also commonly known as decortication. It is defined as a process wherein the seed coat or hull of legume is removed from the cotyledon to produce polished seed (Wood and Malcolmson, 2011). Various legumes such as lentil, black bean, mungbean and pea are dehulled prior to further processing for consumption or utilization in food production. This is due to the reason that whole legumes with encased hulls require longer cooking time to reach desired texture (Akinjayeju and Ajayi, 2011; Aykroyd and Doughty, 1982; Balasubramanian et al., 2012; Erskine et al., 1991).

There are two types of dehulling methods such as wet milling and dry milling. The dehulling method is generally adopted based on the type of end products to be obtained. For example, wet milling is chosen when dehulled and split products are wanted. Besides, legume such as cowpea is subjected to soaking before dehulling when it is needed to prepare cooked gravy or deep-fried snacks whereas dry milling will be selected to prepare cowpea flour (Aykroyd and Doughty, 1982; Narasimha et al., 2003; Wood and Malcolmson, 2011). Some legumes such as pigeon pea and mungbean which are considered hard to dehull need pre-treatment (conditioning) before milling while chickpea and field pea that are easy to dehull can be milled directly (Wood and Malcolmson, 2011).

Dehulling of legumes is deemed advantageous whereby it reduces antinutrients such as tannins which in turn help to improve protein digestibility, enhance nutritional compositions, improve texture, cooking quality and palatability of the legumes. On top of that, dehulling facilitates the removal of tannins which often associated with the elimination of undesirable astringent taste in legumes. Dehulling also helps to produce flours with improved colour which are often regarded as flours of higher quality (Aykroyd and Doughty, 1982; Balasubramanian, 2010; Duodu and Minnaar, 2011; Oomah et al., 2010; Wood and Malcolmson, 2011). However, dehulling of legumes reduces both total and insoluble dietary fibres. This could be explained by the fact that the hull which possesses high amount of insoluble fibre was eliminated during dehulling process (Tiwari and Cummins, 2011).

2.3.2 Soaking

Legumes are often subjected to soaking prior to further processing such as cooking, germination and fermentation. Generally, soaking of legumes involves hydration of legumes in water for a certain period of time (Salem et al., 2014). According to Aykroyd and Doughty (1982), different varieties of legumes require different length of soaking period. The soaking period of legumes commonly ranged from several hours up to a night (Rakshit et al., 2015; Salem et al., 2014). The main purpose of this preliminary step is to rehydrate and soften the texture of the legumes