DEVELOPMENT AND QUALITY EVALUATION OF MALAYSIAN JACKFRUIT 'DADIH' USING COW'S MILK AND GOAT'S MILK

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by

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LIST OF SYMBOLS AND ABBREVIATION

Symbol/ Abbreviation	**Caption**
α	alpha
β	beta
ε	Epsilon
κ	kappa
λ	lambda
*a**	greenness/redness
ANOVA	analysis of variance
*b**	blueness/yellowness
CD	control cow’s milk dadih;
CFU/g	colony forming unit per gram
CFU/ml	colony forming unit per millilitre
GD	control goat’s milk dadih
h	hue
k	factor
JCD	jackfruit incorporated cow’s milk dadih
JGD	jackfruit incorporated goat’s milk dadih
*L**	lightness
p	fraction
ppm	part per million
R^2	determination of coefficient

PEMBANGUNAN DAN PENILAIAN KUALITI DADIH NANGKA MALAYSIA MENGGUNAKAN SUSU LEMBU DAN SUSU KAMBING

ABSTRAK

Dadih nangka (*Artocapus heterophyllus* Lam.) telah dihasilkan dengan menggunakan susu lembu dan susu kambing. Empat jenis dadih yang berbeza telah disediakan, iaitu kawalan dadih susu lembu (CD), dadih susu lembu ditambahkan nangka (JCD), kawalan dadih susu kambing (GD), dan dadih susu kambing ditambahkan nangka (JGD). Dalam kajian awal, tekstur dadih telah disiasat untuk mendapatkan formula optimum bagi dadih ditambahkan nangka dengan menggunakan pendekatan kaedah respons permukaan (RSM). Eksperimen yang menggunakan rekabentuk faktorial penuh 3-aras telah menunjukkan bahawa peratusan karaginan dan peratusan puri nangka adalah dua pembolehubah bebas yang signifikan. Kedua-dua bahan ini memberi kesan terhadap sifat tekstur kekerasan, kekenyalan dan kekentalan terhadap dadih yang ditambah nangka. Hubungan antara pembolehubah bebas dan tindak balas telah ditunjukkan dalam persamaan peringkat model kedua dan plot kontur permukaan sambutan. Kondisi optimum dengan tahap kegemaran 0.998 telah dicadangkan dalam penyediaan JCD adalah dengan menggunakan 0.35% untuk karaginan dan 15% untuk puri nangka. Selain itu, penambahan 0.21% karaginan dan puri nangka 20% dengan tahap kegemaran 0.804 adalah formula optimum yang diperlukan untuk menghasilkan JGD. Formula yang diperolehi telah digunakan untuk menghasilkan dadih ditambahkan nangka yang

mempunyai tekstur bersamaan dengan dadih komersial. Ujian pengesahan menunjukkan bahawa nilai-nilai yang diramalkan adalah sangat dekat dengan nilai sebenar; ini mencerminkan kesahihan model ramalan terhadap sifat tekstur JCD dan JGD. Sifat fizikal, kimia, antioksidan, deria dan perubahan penyimpanan dalam JCD dan JGD telah dikaji dan dibandingkan dengan kawalan dadih. JCD dan JGD telah menunjukkan warna yang lebih kemerahan daripada kawalan. Mikrostruktur JCD dan JGD menunjukkan bahawa granul puri nangka melekat pada permukaan dadih dengan rangkaian yang kurang padat dan pembentukan saiz liang yang lebih besar. Komposisi kimia JCD dan JGD mempunyai perbezaan dari segi statistik dengan variasi yang ditunjukkan di kandungan kelembapan, jumlah pepejal, kalori, jumlah pepejal larut, dan mineral. Penambahan puri nangka telah menunjukkan peningkatan pada sifat antioksidan dalam JCD dan JGD. JCD menerima skor yang tertinggi dalam penerimaan keseluruhan di penilaian deria di mana aroma dan rasa berkait rapat dengan penerimaan keseluruhan di dadih. Perubahan dalam penyimpanan sampel dadih telah menunjukkan bahawa corak pengurangan serupa dalam pH dan keasidan dengan kenaikan syneresis yang tidak diingini. Pertumbuhan mikrob di sampel dadih telah meningkat dan menandakan perubahan kualiti sampel sepanjang penyimpanan dingin selama 20 hari. Penambahan puri nangka sebagai bahan tambah nilai telah menyumbangkan peningkatan kepada kualiti dadih berkaitan dengan warna, jumlah larutan pepejal, antioksida, dan penerimaan dadih ditambahkan puri nangka.

DEVELOPMENT AND QUALITY EVALUATION OF MALAYSIAN JACKFRUIT 'DADIH' USING COW'S MILK AND GOAT'S MILK

ABSTRACT

Dadih incorporated with jackfruit purees (*Artocapus heterophyllus* Lam.) was made by using cow's milk and goat's milk. Four types of different dadih was prepared, namely control cow's milk dadih (CD), jackfruit incorporated cow's milk dadih (JCD), control goat's milk dadih (GD), and jackfruit incorporated goat's milk dadih (JGD). In the initial study, textural properties of dadih were investigated for the optimum formulation of jackfruit incorporated dadih by using response surface methodology (RSM) approach. The experimental study was carried out by using 3-level full factorial design which revealed that the percentage of carrageenan and percentage of jackfruit purees were the two significant independent variables. These two ingredients affected the textural properties such as hardness, springiness and gumminess of both jackfruit incorporated dadih made from cow's milk and goat's milk. The relationships between independent variables and responses were indicated in the second order model equations and response surface contour plots. The optimum condition with desirability level of 0.998 was suggested in the preparation of JCD by using 0.35% for the carrageenan and 15% for the jackfruit purees. Besides, the addition of 0.21% carrageenan and 20% jackfruit purees with desirability level of 0.804 as the optimum formula required for producing the JGD. The formulae obtained were used to produce both jackfruit incorporated dadih with textural properties compatible with the commercialized dadih. The verification test revealed that predicted values were very close to the actual values, which reflected the validity of predicted models for textural properties of JCD and JGD. Physical, chemical, antioxidant, sensorial properties and storage changes of JCD and JGD were respectively studied and compared with those of control dadih. The JCD and JGD were shown to be more reddish in colour than the control. The microstructure of JCD and JGD showed that the jackfruit puree granules were attached on the dadih surface with less compact network and larger pore sizes formation. The chemical compositions of JCD and JGD were statistically difference with variations showed in moisture, total solid, calorie, total soluble solid, and mineral contents. The incorporation of jackfruit purees showed improvement on the antioxidant properties of JCD and JGD. The JCD received the highest score in overall acceptance of sensory evaluation whereby aroma and taste were highly correlated with the overall acceptability of dadih. The storage changes of the dadih samples were shown similar in reduction patterns of pH and titratable acidity with increment of undesirable syneresis. The microbial growths of dadih samples increased which indicated changes of sample quality throughout chilled storage for 20 days. The incorporation of jackfruit purees as value-added ingredient contributed to the improvement of dadih quality in terms of the colour, total soluble solid, antioxidant, and acceptability of jackfruit incorporated dadih.

CHAPTER 1

INTRODUCTION

1.1 Background Studies

Dadih is one of the traditional dairy desserts popularly found in Northern region of Peninsular Malaysia and West Sumatera of Indonesia. In Malaysia, the distinct characteristic of dadih is the physically soft-like custard structure and sweet taste that gives a pleasant sensorial sensation and make it favourable as side dishes in various ceremonies, restaurants and food markets (Sughita, 1985). Dadih is made from fresh milk, originally buffalo's milk was used in ancient time and cow's milk is replacing its role where it is easily available nowadays. Some criteria such as cow's milk allergy, lower digestibility, and lactose intolerance dilemma are found in dairy products made from cow's milk. This crisis leads to an idea where cow's milk is substituted by goat's milk in the production of dadih. Past studies have reported that goat's milk can represent an alternative for cow's milk mainly due to smaller fat globules, higher number of short chain fatty acids and different proportion of milk protein have advantages over cow's milk (Haenlein, 2001; Park, 2006).

The annual milk production in Malaysia has increased annually for usage in various food industries and the total consumption of dairy product is likely to be about 1000 million liters annually (Heiner and Kum, 2010). This growing trend of dairy market was particularly due to the extensive promotions on the consumption of dairy products which have increased public awareness especially middle to upper income group of consumers are directed to the increase in dairy market today. Most of the dairy consumptions are generally based on various types of products such as non-fat milk, fermented milks, yoghurt, ice cream, butter, cheese, whole milk products, and infant formula.

In Southeast Asian countries, the demand for dairy products has increased tremendously due to the modernisation of marketing infrastructures, growth of economy and populations. Moreover, the expansion of dairy market is mostly related to the dietary preferences shift to more Westernization with the rapid growth of fast food restaurants and aggressive sales promotion (Feng, 2005). It was noticeable that the high consumption of dairy products are virtually in Western style which involve products such as sterilized milk, ice cream, yoghurt, full cream and milk powder, butter and cheese (Heiner and Kum, 2010). The demand on dairy products is generally focused on cow's milk products; however the demand for products of goat's milk is in an upward trend particularly due to the beneficial effects on human health and the drawback affliction of cow's milk allergies and other gastro-intestinal ailments (Haenlein, 2004).

In the case of dairy production, Malaysia government has attempted to increase domestic milk production through direct investment in farms, school milk programs, educational campaigns, and restrictions on entry of imported dairy products (Zhang et al., 2003). Assistants from government have led to the establishment and operation of the Milk Collection Centres (MCC) or Dairy Industry Service Centres whereby the milk produced is collected and wholesale to the large dairy processing plants or domestic dairy manufacturers (Heiner and Kum, 2010). The efforts on milk production will be continued and the dairy market in our country is expected to brighten for the prospective years.

In Malaysia, traditional preparation of dadih involved fermentation of milk with small pieces of dried asam gelugur to form whey. The whey is used to acidify the milk with sugar and salt addition followed by steaming to coagulate the milk. Later, the process evolved to acid and enzyme methods with improvement on the milk gel formation of dadih (Sughita, 1985; Hamzah, 1983). All the stated methods focused on the rearrangement structure of milk protein to induce milk gel coagulation. According to Manan et al. (1999), these methods were found to be less competent due to frequent milk coagulation problem, texture inconsistency, and occurrence of syneresis which resulted in relatively shorter shelf life. These defects were probably due to easy breakdown of the gel network or the gel undergoing structural rearrangement which gave a weak and thin body structure to dadih (Lucey and Singh, 1998). In addition, problems such as watery, rough surface, and numerous pore sizes are critical to the textural quality of dadih.

There is inadequate past research studies on dadih; however some investigations have been reported to improve the physical and sensorial characteristics of dadih by supplementing with inulin and kesinai (*Streblus asper*) leaf extract (Ruzaina et al., 2006). According to the article reported from RTC (2011), Malaysian dadih can be easily prepared by utilising food hydrocolloids so as to give a better physical quality and reduction in preparation time. Food hydrocolloids are nowadays widely applied in confectionery for new processing improvements, texture variations, and economic alternatives in product development. In the present study, the food hydrocolloid, namely carrageenan was chosen as an alternative with the purpose to enhance the textural properties of dadih.

Carrageenan derived from seaweed is widely consumed by vegetarian to replace the gelatin in which it is extracted from animal sources. Moreover, various hydrocolloids such as xanthan gum, gelatin and gum arabic encountered fluctuations in the market price over the recent years (Phillips and Williams, 2000). Therefore, carrageenan becomes a good selection for dadih preparation due its stability in market pricing. Indeed, carrageenan is a good thickening, gelling, and stabilising agent that has long been used in dairy industry as reported by Imerson (2000). According to Robinson and Tamime (2000), addition of hydrocolloids increased the total solids content of milk which might directly improve the firmness and rheological properties of the dairy products.

Recently, the focus has been on the improvement in term of the nutritional properties of dadih, by incorporating local fruit as a functional ingredient in dadih. In the present study, the incorporation of jackfruit purees as value-added ingredient added novelty to the dadih. Jackfruit was chosen mainly due to its attractive flavour and nutritional benefits to the dadih. The incorporation of jackfruit puree into dadih product would also to diversify its application besides being consumed fresh or processed into snack crisps. In fact, jackfruit is extensively cultivated among states where Malaysia is one of the major exporting countries of jackfruit (ICUC, 2003).

Jackfruit (*Artocarpus heterophyllus* Lam. Madu), also locally known as nangka, is composed of inner sticky latex layer (flesh), dicotyledonous yellowish edible fruit (pulp), and brownish core of the fruit (seed). Jackfruit edible pulp is a nutritious source of carbohydrate, minerals and vitamins such as calcium, phosphorus, iron, ascorbic acid, riboflavin and niacin (Jagadeesh et al., 2007;

Rahman et al., 1999). Jackfruit has been found to contain antioxidant activity derived from several phytochemical compounds (Alok et al., 2009). The volatile compounds contributed to the unique and attractive flavour and aroma of jackfruit. Therefore, the incorporation of jackfruit purees in dadih may significantly improve the physical, nutritional, chemical and sensorial properties of dadih product. These significant improvements were investigated by comparing the jackfruit incorporated dadih with control dadih (without incorporation of jackfruit purees). Extensive researches on innovation and improvement of dadih were carried out in order to popularise dadih as a commercial dairy product.

1.2 Objectives

The specific objectives of the present study are:

1. To improve the textural properties of jackfruit incorporated dadih made from cow's milk and goat's milk by addition of carrageenan utilising response surface methodology (RSM) experimental design.

2. To analyse and compare the quality of jackfruit incorporated dadih and control dadih in terms of physical, chemical, radical scavenging activity, and sensorial properties.

3. To study the chemical and microbial changes of jackfruit incorporated dadih and control dadih during chilled storage for 20 days.

CHAPTER 2

LITERATURE REVIEW

2.1 Milk

Milk is defined as secretion fluid of mammals that serve as most complete nutrition food for newborns and children. Milk typically refers to the milk available from cow and other sources of milk are provided from domestic ruminants usually goat, sheep, buffalo, yaks, and camels. Most of these milks appear naturally as opaque white to yellowish liquids depending on pigments, amount of fat, and non fat present.

Milk provides dietary sources of energy, amino acids, essential fatty acids, minerals and vitamins which may not be easily available from other sources. The plenty sources of milk have an important role in physiological functions whereby it has significant impacts on prevention of obesity, hypertension, diabetes, osteoporosis, and cardiovascular disease (Huth et al., 2006; McCarron and Heaney, 2004). In addition, milk becomes the most important source of biologically active peptides upon enzymatic proteolysis, fermentation, and food processing. The bioactive peptides are shown to exert various health effects on body functions which involve in antimicrobial, antioxidative, antihypertensive, antimicrobial or immuno-modulatory activities (Korhonen and Pihlanto, 2001).

2.1.1 Structural and Chemical Compositions of Milk

Milk is described as a complex biological fluid mainly comprising fat emulsion, dispersion of protein, and true solution. The oil-in-water emulsion is made up of milk solid with fat globules dispersed in the continuous serum phase. The particles such as casein micelles, globular proteins and lipoprotein are the constituents for colloidal dispersion of protein. The true solution of milk consists of lactose, soluble proteins, minerals, vitamins, and other components (Walstra, 1999). In addition, these compositions of milk can be influenced by various factors including the breed, feed, management, and geographic variations on the ruminant milk.

2.1.1.1 Cow's Milk

Cow's milk is divided into two main categories which are water phase and milk solid based on the solubility. The milk solid mainly comprises fat and non fat components. The non fat content is made up of 3.4% of milk protein, 4.8% of lactose and 0.7% of minerals (Figure 2.1). Milk protein in bovine milk contains about 80% of casein, 18% of whey protein, and small amount of albumin, globulin, peptones, and enzymes which account for 95% of nitrogen while the remainder being non-protein nitrogen (Ennis and Mulvihill, 2000). Non-protein nitrogen such as nucleotides and nucleosides was proposed to have positive effects on intestine and brain systems.

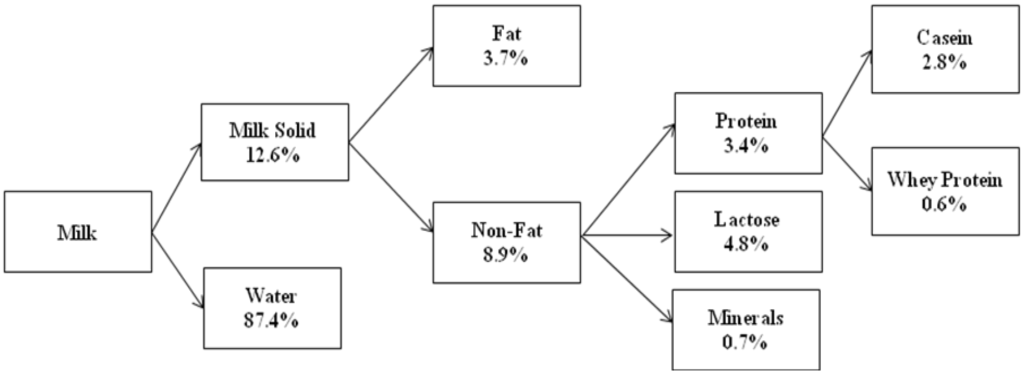

Figure 2.1 Schematic Representations for General Gross Composition of Bovine Milk.
(Source: Ennis and Mulvihill, 2000)

In bovine milk, casein fraction consists of four primary protein subunits namely, α_{s1}-casein, α_{s2}-casein, β-casein, κ-casein, and γ-casein (proteolytically derived from β-casein) and several minor proteins and peptides (Ennis and Mulvihill, 2000). Each casein subunit has its own amino acid composition, genetic variations, and functional properties. The most widely accepted theory, casein proteins aggregates (sub-micelles) form the large roughly spherical colloidal complex, called micelles where subunits of the different caseins are held together by calcium phosphate to form the hydrophobic internal core. Casein micelles are roughly spherical particles, with mean diameter of about 20 to 300 nm and are smaller than fat globules in milk (Walstra et al., 1999). Casein micelles have porous and open structures that permit water to pass though surrounded. Meanwhile, κ-casein attached on the periphery of casein micelles with hydrophilic C-terminal part behaving as hairy brush oriented to the exterior zone of micelles (Fox and Mulvihill, 1990). The negative charges of κ-casein prevented the aggregation of micelles by electrostatic and steric repulsion that contribute to micelles stability (Langendorff et al., 1999). Casein micelles are stable at native pH of milk, however they are insoluble at the isoelectric point of 4.6 and thus precipitate from the whey solution.

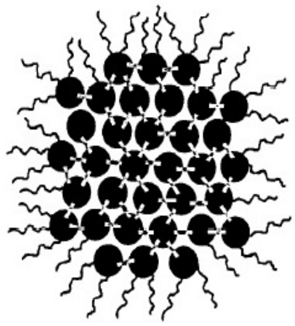

Figure 2.2 Model of the casein micelle. Sub-micelles are held together by calcium phosphate linkages and with the κ-casein oriented towards the surface. (Source: Walstra, 1990)

Whey protein is the watery liquid remaining after the caseins curds are separated from the milk. It appears as light yellow to green depending on the type and quality of milk (Geoffrey, 2008). Whey protein being a fraction of milk protein which constitutes two principal gene variation structures namely β-lactoglobulin and α-lactalbumin; and blood serum albumin, immunoglobulins, β-casein derived proteose peptones, numerous minor proteins including lactoperoxidase and lactotransferrin, and various enzymes (Ennis and Mulvihill, 2000). In structure, whey proteins are typically compact globular proteins with relatively uniform sequence distribution of non-polar, polar, and charged residues. Whey protein with diameter of 0.006 µm has intramolecular folding structure with the formation of disulphide bonds between cysteinyl residues. It is more water soluble than caseins and does not interact with other proteins in the native state (Varnam and Sutherland, 1994).

Whey proteins can undergo thermal denaturation to form the irreversible whey protein aggregation. The β-lactoglobulin goes through the conformational change of molecule which results in the exposure of a reactive thiol group to external environment. The reactive thiol groups are linked with other thiol groups to form the disulfide interaction. In this case, the denatured whey proteins are also covalently bonded with κ-casein to form the stable micelles complex.

Fat globules in milk are bounded with phospholipids membranes which function to protect the globules from external destruction or enzymatic digestion in milk. The fat globules are composed of the biggest lipid group, triglycerides which accounts for 98% of the total milk fat, while the other minor lipids are monoacylglycerols, diacylglycerols, phospholipids, free fatty acids, cholesterol, and esters groups (Renner, 1989). The triglycerides are made up of varying combinations of fatty acids and glycerol in which triglycerides are responsible for the rheological properties of the milk fat (Park et al., 2007). The fatty acids are varied in compositions depending on the originality factors where fatty acids can either be produced from microbial activity in rumen and transported to secretory cells, or synthesised from the secretory cells of mammary gland (Anderson, 1983).

Milk fat is related to the stability of emulsion and sensorial properties of milk. The milk fat is insoluble in water but soluble in organic solvent. Milk fat does not have a true melting point due to the complex mixture of milk fat composition. However, fatty acids have substantial effects on the melting point of triglycerides where the higher number of double bonds in fatty acids would result in lower melting point of triglycerides (Lawrence and MacGibbon, 1996).

The major carbohydrate in bovine milk, lactose (4.2-4.9%) is a reducing disaccharide comprising alpha-D-glucose or beta-D-glucose molecule and galactose (Park, 2006). Lactose presents in liquid of milk has low solubility (17.8%) where the beta crystalline form of lactose is more soluble than alpha form lactose. Lactose gives the natural sweetness flavour to milk and it is a primary carbon source for the microbial growth in milk. In addition, lactose is an important nutrient because of facilitated the intestinal absorption of calcium, magnesium, phosphorus and vitamin D (Campbell and Marshall, 1975). Besides lactose, small amount of other carbohydrates are found in cow's milk, partly monosaccharide and oligosaccharides such as neuraminolactose and N-acetylhexosamine (Saito et al., 1984).

Cow's milk contains various minerals essential for body physiological functions. The minerals found in bovine milk such as sodium, potassium and chloride are completely ionic and entirely soluble for absorption in the gastrointestinal tract. As common knowledge for people, appropriate intake of milk is essential for the minerals absorption especially calcium has beneficial effects on healthy bone and tooth development for prevention of osteoporosis (McCarron and Heaney, 2004). Milk contains high amount of calcium because approximately 60% of calcium is aggregated in casein micelles of milk. Meanwhile, the distributions of other trace elements such as iron, copper, zinc iodine, manganese and fluorine are found in small varying amounts (Renner, 1989).

On the other hand, vitamin A and B are normally found in bovine milk. The water soluble vitamin B complex in cow milk is synthesized by the rumen bacteria and it serves as a rich source for human dietary requirement. The fat-soluble vitamins including A, D, E, and K exist within the milk fat portion of the milk. These fat-soluble vitamins play an important role to protect milk fat from oxidative degradation (Bergamoa et al., 2003).

2.1.1.2 Goat's Milk

The gross compositions of protein, fat and total solid of goat's milk have been described as generally similar with cow's milk (Jacek, 2009). Some authors have reported that the chemical compositions of goat's milk are higher than that in cow's milk, except for the lactose content which is regarded as lower in goat's milk (Guo et al., 2004; Park et al., 2007). In addition, goat's milk contains higher level of non-protein nitrogen and less casein nitrogen as compared with bovine milk.

Casein proteins of goat's milk are quite different from cow's milk. It is primarily classified as β-casein, κ-casein, and α_{s2}-casein with less or absence of α_{s1}-casein found most abundantly in bovine milk. The proportions of β-casein and κ-casein in goat's milk are relatively higher than cow's milk protein (Park et al., 2007). The lesser α_{s1}-casein and more β-casein of goat's milk have readily provided less allergenic effects to the human body. In fact, this difference is mainly caused by the genetic polymorphism of amino acid substitutions in protein chain, which also contributes to the unique flavour and different digestibility in dairy products made from goat's milk (Rystad et al., 1990). According to Park et al. (2007), goats' milk has better digestibility due to reduced dimensions of casein micelles. Moreover, caprine casein micelles contain low solubility of β-casein, low heat stability, and more calcium and inorganic phosphate (Jenness, 1980). These differences have shown their effects on the cheese making properties of goat's milk.

Whey protein of goat's milk closely resembles to cow's milk. It has similar homolog of α-lactalbumin and β-1actoglobulin (Jenness, 1980). The size, shape and overall conformation of caprine whey protein are virtually comparable from bovine whey protein. Structural differences of whey protein between goat and cow had been indicated by Alexander and Pace (1973), who found that β-lactoglobulin less stable than bovine variants upon denaturation in urea. Another in vitro study revealed that the difference of caprine β-1actoglobulin resulted in faster digestion of goat's milk in the intestine (Almaas et al., 2006). Whey proteins are insoluble at their isoelectric points of pH 5 with very low ionic strength; however, they are soluble at pH 4.6 in the ionic environment of milk (Ennis and Mulvihill, 2000).

Goat's milk contains a higher proportion of small fat globules (less than 3.5 µm in diameter) which has advantages over digestibility and more efficient in lipid metabolism as compared with cow's milk fat (Park, 1994). Triglycerides are the biggest group of milk fat in goat's milk while other simple lipids, complex lipids, and liposoluble compounds are also presented. A high number of short to medium branch-chain fatty acids (C6–C10) are found in goat's milk (36%) but not in cow's milk (21%), promoting potential in human nutrition and medicine for treating gastrointestinal disease (Haenlein, 2004). These fatty acids can be absorbed directly by the intestine to provide a rapid energetic supply for people encountered malnutrition or fat malabsorption syndrome. The consumption of goat's milk may reduce total cholesterol levels especially on LDL content by limiting cholesterol storage and improving its mobilisation (Hanlein, 1992). Past in vivo studies support the findings that smaller fat globules and higher proportion of short to medium fatty acids in caprine milk enhance the fat assimilation and energy supply (Alferez et al., 2001; Hachelaf et al., 1993).

Carbohydrate in goat's milk contains mainly lactose which less than that contained in cow's milk (Chandan et al., 1992). Apparently goat's milk is a better alternative for the lactose-intolerance consumers which it is the dilemma common for people who are lack the enzyme lactase at their adolescent stage. Other carbohydrates found in small amounts in goat's milk are oligosaccharide, glycopeptides, glycoproteins, and nucleotide sugar (Larson and Smith, 1974). Oligosaccharides in goat's milk contain four times higher N-acetylneuraminic acid (sialic acid) than bovine milk. This characteristic indicates that goat's milk promotes the anti-inflammatory and antigenic properties, in addition as a prebiotic source for intestinal flora of human. The minor carbohydrates such as gangliosides (sialic acid) contain glycosphingolipids located on the fat globules which may act against enterotoxins and infections in newborns (Raynal-Ljutovac et al., 2008).

Mineral contents of goat's milk are higher in calcium, phosphorus, potassium, magnesium but lower in sodium and sulphur than cow's milk (Chandan et al., 1992). In fact, other minerals such as iron, zinc, and copper are related with the casein content in ruminant milk. In addition, the mineral composition of goat's milk may be affected depending on the diet, breed, state of lactation and animal health (Park and Chukwu, 1988). The minerals content in goat's milk is basically adequate for human requirement except it is deficient in folate and vitamin B12 which may cause anemia in infants (Park et al., 1986). The infant formula is fortified with iron, folic acid, vitamin A and vitamin D to nourish the milk appropriate for infant consumption.

Goat's milk contains high amount of vitamin A, niacin, thiamine, riboflavin and pantothenate (Ford et al., 1972). The colourless form of vitamin A was converted from beta-carotene in goat's milk, causing it to be less yellowish caprine milk than bovine milk. Apart from that, goat's milk is a source of considerable interest since it contains high nutritional value, anti-oxidative, and lower allergenic properties with the important role in human nutrition (Desobry et al., 1999; Medina and Nunez, 2004). Goat's milk has therapeutic properties in which it is beneficial for individuals with malabsorption syndrome whereby they can have better utilization of fat and mineral salts (Alferez et al., 2001).

Table 2.1 Comparative Compositions of Cow's Milk and Goat's Milk

Compositions	**Cow's milk**	**Goat's milk**
[c]Fat (%)	3.67	3.80
[c]Lactose (%)	4.78	4.08
[b]Protein (%)	3.30	4.60
[c]Energy (cal/100 ml)	69.00	70.00
[c]Total ash (%)	0.73	0.79
[a]Ca (mg/100 ml)	122	134
[a]P (mg/100 ml)	119	121
[a]Mg (mg/100 ml)	12	16
[a]K (mg/100 ml)	152	181
[a]Na (mg/100 ml)	58	41
[a]Cl (mg/100 ml)	100	150
[a]Vitamin A (IU/100 ml)	126	185
[a]Vitamin D (IU/100 ml)	2.0	2.3
[a]Vitamin B6 (mg/100 ml)	0.04	0.05
[a]Vitamin B12 (µg/100 ml)	0.36	0.07
[a]Vitamin C (mg/100 ml)	0.94	1.29

(Source: [a]Gebhardt and Matthews, 1991; [b]Park et al., 2007; [c]Posati and Orr, 1976; [c]Saini and Gill, 1991)

2.1.2 Milk-Based Products

Milk as primary source of nutrients has been processed extensively into dairy products in a variety of infant food, whole milk products, non-fat milk, fermented milks, yoghurt, ice cream, butter, cheese, ingredients for confectionary and baking industry, are the function of milk in industrial applications. Among the numerous types of dairy products, the dairy products which are in semisolid form resemble dadih are described in the literature study.

Custard is a semisolid dessert made from the addition of water with sugar, hydrocolloids such as modified starch and carrageenan, colorants, and aromas. The dairy custard was prepared by using normally skim milk powder mixed with water. The skim milk powder used is the milk left after extraction of fat. The mixture was left overnight in refrigerator before further heating with ingredients to form custard at cooling storage (Keršienė et al., 2008). Custards are most popularly flavoured with vanilla, strawberry and apple to provide an attractive feature for consumers. Therefore, it becomes a useful model system for studying diverse sensorial related properties in research areas, such as the influence of fat on the volatility of aroma, interaction between starch and milk fat on flavour and textural properties, and effects of aroma on food intake aspects.

Yoghurt is made by heating homogenised milk with continuous stirring to improve the total solid of milk. The pasteurised milk is inoculated with starter cultures for fermentation to occur. The starter cultures, mainly lactic acid bacteria and bifidobacteria species utilise lactose as the main carbon substrate for producing lactic acid throughout the incubation period. The physical actions such as homogenisation and heat treatment of the milk together with the biological metabolism of starter culture have contributed to the coagulation of milk liquid to form the viscous yoghurt (Robinson and Tamime, 2000).

Kefir is a fermented dairy beverage with acidic and alcoholic features which originated in Balkans, Eastern Europe, and the Caucasus (Fontán et al., 2006). The name "Kefir" has meaning of good feeling, stimulating and encouraging by self in Turkey language (Yaygin, 1999). Kefir is manufactured by fermenting milk with solid grains or commercial freeze-dried starter cultures. The grain culture contains either lactose fermenting yeast or non-lactose fermenting yeast to produce ethanol and carbon dioxide. The most popular type of kefir is made from goat's milk which is generally produced in traditional and industrial scales.

2.1.3 Outlook on Dairy Market

In Southeast Asian countries, the demand for dairy products has increased tremendously due to the modernisation of marketing infrastructures, economic growth and increase in population. Moreover, the expansion of dairy market is mostly related to the shift in dietary preferences to the process of Westernization with the rapid growth of fast food restaurants and aggressive sales promotion (Feng, 2005). It was noticed that the high consumption of dairy products are virtually according to Western style involving products such as sterilized milk, ice cream, yoghurt, full cream and milk powder, butter, and cheese.

Malaysia produces about 56 million litres per year and to meet the dairy demand, other sources of milk are supplied from New Zealand, Australia and

European Union (Heiner and Kum, 2010). Despite this, Malaysian government has attempted to increase domestic milk production through direct investment in farms, school milk programs, educational campaigns, and restrictions on entry of imported dairy products (Zhang et al., 2003). Assistants from government have driven to establish and operate the Milk Collection Centres (MCC) or Dairy Industry Service Centres whereby the milk produced is collected and wholesale to the large dairy processing plants or domestic dairy manufacturers (Heiner and Kum, 2010). The efforts on milk production will be continued and the dairy market in Malaysia is expected to be bright for the prospective of years.

2.2 Dadih

2.2.1 History and Properties of Dadih

In Malaysia, dadih refers to dairy product with a sweet taste, a soft, and smooth like custard texture. Dadih is most consumed by the people in the northern region of Peninsular Malaysia (Hamzah, 1983). Dadih with acceptable quality tends to be physically soft, smooth, and firm with little or no whey-off appearance. Dadih is available in restaurants, traditional stalls, and food markets, and it is commonly supplied from small scale producers or homemade production with differences in physical, chemical, and sensory properties.

In Indonesia, dadih which is making up of buffalo's milk is a most popular dairy dessert in West Sumatera (Surono et al., 1984). Dadih was traditionally made from buffalo's milk placed in bamboo tubes and covered with banana leaves that have been dried on the fire and incubated at temperature 27 to 33 °C for 2 days (Sughita, 1985). The fermented microorganisms are originated from buffalo's milk, surface of bamboo tube, and banana leaves that play a role to convert the buffalo's milk to curd dadih. This Indonesian dadih has the appearance like yoghurt and is sour in taste. Dadih is generally served during breakfast and it can be eaten as side dishes with hot rice.

The scarcity of buffalo's milk nowadays has resulted in the limited production and this has increased the price of dadih (Sirait et al., 1995). Currently, buffalo milk has been substituted by cow's milk because cow's milk is cheaper and more easily available in the market for preparing dadih (Manan et al., 1999). According to Taufik (2004), dadih produced from cow's milk was incorporated with the probiotic and starter cultures which cultured originally from the buffalo's milk. Modification on the production of dadih such as replacement of bamboo tube with propylene tube or container has applied to give a more hygiene and better quality of dadih.

Previous studies on dadih are typically scarce and many improvements can still be done. Some investigations have added enzyme β-galactosidase (E.C. 3.2.1.23) to lower the lactose content of the dadih produced from cow's milk (Manan et al., 1999). Likewise, previous study by Ruzaina et al. (2006) has claimed that the supplementation of inulin and coagulation with kesinai (*Streblus asper*) leaf extract has positively influenced the physical and sensory properties of the dadih.

2.2.2 Methods of Dadih Preparation

Nowadays, the preparation of dadih has drawn more attentions for amending the physical appearance and stability in addition to the improvement in the nutritional profiles. In Malaysia, the principal for preparation of dadih includes inoculum, acidic, and enzymatic methods. Preparation of inoculum is carried out by the incubation of milk with small pieces of dried asam gelugur (*Garcinia atroviridis*) at room temperature. The mixture is filtered to obtain whey formed. Dadih is made from pasteurising fresh cow's milk, added with sugar and salt then whey is added to acidify the milk. The acidified milk is then subjected to steam for curd formation and cooled. Whey provides acidic condition to solublise the colloidal calcium phosphate, disturb the micelle structure and reduce the charge on the proteins causing denaturation and aggregation of the whey protein and caseins (Ennis and Mulvihill, 2000). The heat treatment via steaming at lower pH resulted in increases of denatured whey proteins and interacts with casein micelles to form a complex network that contributes to milk gel formation (Oldfield et al., 2000).

Dadih preparation later evolved and focused on the milk gel formation with some modified methods such as the additions of acid (citric acid) or enzyme (rennet), or a combination of both, to alter the natural properties of milk protein for inducing milk gel formation (Hamzah, 1983). The methods of acid and enzyme-induced gel showed the similar mechanism to create the disruption of casein micelles and cross linking that affect the gel strength of milk protein (Vliet et al., 2004). Utilisation of acid and enzyme in dairy products are common particularly in production of cheese to precipitate the casein and milk fat from whey liquid. In the production of dadih, acid-induced gel method with pH adjustment above isoelectric point of casein was significant to prevent the destabilisation and separation of casein micelles from milk. Subsequently, the steaming process provided heat to further induce the gel formation of dadih.

According to an article reported by the Rural Transformation Centre (2011), Malaysian dadih can be prepared by the addition of pasteurised fresh mik with food hydrocolloid, sugar, corn flour, or/and permitted flavouring. This method is efficient to provide strong gel structure due to the stable junction zones being formed through crosslinking interaction between hydrocolloid and milk protein at coil-helix transition temperature. Meanwhile, sugar and flavouring used are primarily to enhance the organoleptic properties of dadih. Addition of hydrocolloid directly increases total solid and gel strength of milk; therefore steaming process is not required in this method to induce milk gelation in dadih. Hydrocolloid has advantages in reducing processing time of dadih in addition to improving texture consistency and decreasing the occurrence of syneresis.

2.2.3 Nutritional Profiles of Dadih

Some previous researches have carried out to study the nutritional profiles of dadih. Dadih conventionally made from buffalo's milk composed of fat 7.05%, protein 4.79% and total sugars 17.2% (Hamzah, 1983). Nowadays, the utilization of cow's milk as raw material is more common for preparing dadih. In the study by Taufik (2004), dadih made from a combination of cow's milk and starter bacteria was evaluated for nutritional compositions. The author further reported that dadih with 3% concentration of starter *Lactobacillus sp.* contained 13.95% of fat, 4.13% of protein, 80.52% of moisture, 0.87% of ash, and 2.21% of titratable acidity. Another study was done to investigate the effect of inulin on dadih prepared by enzyme coagulation method (Ruzaina et al., 2006). According to the authors, the supplementation of inulin might lead to changes in bioavailability of nutrients besides improving hardness, fracturability, cohesiveness and decrease undesirable syneresis. In addition, the dadih also showed improvement in the mouth feel quality during sensorial assessment.

2.3 Jackfruit

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the Moraceae family which is widely distributed in many tropical countries with optimal growing temperature ranging from 16 to 28 °C. According to Rajendran (1992), the name "jack" originated from Portuguese "Jaca" but it was then named natively as jacquier (French), jangli (Bangladesh), nangka (Java and Malay), langka (Philippine), khnaor (Cambodia), makmi, khanum, banum (Thailand), or mit (Vietnamese) in different countries.

Jackfruit plant is an evergreen tree with all its parts containing sticky white latex. The tree has an average age of 70 years while the jackfruit yield varies depending on management and climatic factors. Jackfruit takes about 95 days for maturation and can be harvested when the leaves start to fade and fruit colour change from green to yellowish green. Interestingly, jackfruit becomes an alternative staple food when grains foods are meagre in India and Bangladesh during summer and thus it was described as "poor man food" in India (Ahmed et al., 1986). There are various cultivars of jackfruit types in different regions of countries. In Malaysia, the common registered cultivars of jackfruit are clones J29, J31, J33, "Tekam yellow", and "Mantin" (Anem, 2011).

2.3.1 Jackfruit Pulp

2.3.1.1 Characteristics of Jackfruit Pulp

A jackfruit has a mass of 20 to 49 kg and the edible portion occupies about 30% to 35% of the total fruit weight (Alok et al., 2009). The fruit consists mainly of three regions which are outer spikes skin, edible fruit and seed of the fruit. Jackfruit with outer spikes skin composed of inner sticky latex layer (flesh), dicotyledonous edible fruit (bulb/pulp), and brownish core of the fruit (seed). Each jackfruit has a length approaching 40 cm and it is oblong round in shape containing 100 to 500 bulbs. The colour of ripe edible bulb varies from cream to deep saffron depending on the variety (Plate 2.1).

Plate 2.1 Jackfruit Pulps.
(Source: SCUC, 2006)

2.3.1.2 Physiochemical Properties of Jackfruit Pulp

Jackfruit is considered as a nutritious fruit due to the relatively high compositional values of the jackfruit pulp. The jackfruit pulp has a pH of 5.1 which containing carbohydrate 18.9 g, protein 1.9 g, fat 0.1 g, moisture 77%, crude fiber 1.1 g, ash content 0.8 g, and caloric value 84 for every hundred gram of the ripen edible pulp (Bose, 1985). A recent study by Michelle et al. (2009) has demonstrated that an increase of moisture content and temperature above 30 °C can positively influence the thermal diffusivity and thermal conductivity of the jackfruit pulp. These thermo-physical properties are interestingly important factors essential for manufacturing fresh jackfruit into processed products.

Jackfruit is also a rich source of free sugar, fatty acids, minerals, and vitamins like calcium, phosphorus, iron, ascorbic acid, riboflavin, and niacin (Jagadeesh et al., 2007; Rahman et al., 1999). The soluble solid and total sugars increased upon ripening where the water soluble fructose, glucose and sucrose are the dominant sugars in the pulp. Jackfruit pulp contains major non-volatile organic acids including citric acid, malic acid, and succinic acid, which are decreased during the ripening stage, probably due to the respiration process and involved in the synthesis of other metabolites (Kays, 1991).

Besides, fatty acids such as capric, myristic, lauric, palmitic, oleic, stearic, linoleic and arachidic acids were abundantly found in pulp and other different parts of the jackfruit (Chowdhury et al., 1997). The fatty acids and lipids are generally regarded as important precursors being oxidized to generate the aroma substances in tropical fruits. Wong et al. (1992) state that the jackfruit grown in Malaysia contains forty five volatile components of which thirty two have been reported for the first time. In addition, the major aroma volatiles identified from two varieties of jackfruit were butyl isovalerate, isopentyl isovalerate, ethyl isovalerate, butyl acetate and 2-methylbutyl acetate (Maia et al., 2004). These volatile compounds and esters increased during fruit maturation which imparts the distinct flavour of jackfruit. The