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# Studies on the physicochemical and sensory characteristics of goat's milk dadih incorporated with tropical- fruit purees

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**Abstract**

This study was carried out to improve the nutritional value of goat's milk dadih by the addition of tropical- fruit purees, namely, jackfruit (*Artocarpus heterophyllus*, Lam.), pineapple (*Ananas comosus*) and papaya (*Carica papaya*). Dadih with added fruits were compared with the control (without fruit puree) for physical, chemical and sensory attributes. The texture properties of the tropical- fruit dadih were significantly different ($p< 0.05$) from the control. Control dadih showed highest values for lightness and hue ($p< 0.05$) as compared to tropical- fruit dadih. The addition of tropical- fruit purees significantly increased ($p< 0.05$) the moisture, protein, ash and vitamin C contents of the fruit added dadih. There were no significant differences ($p> 0.05$) in the fat, carbohydrate, energy and total soluble solid contents. Sensory evaluations using a hedonic test showed that all dadih were acceptable. Overall, syneresis of the dadih increased with decreasing pH throughout storage at 4 °C.



## Introduction

Dadih is a unique traditional Malay dairy dessert popular in Malaysia and Indonesia. In Malaysia, dadih refers to a dairy product which is sweet in taste and has a soft and smooth texture. However, the Indonesian dadih is more like yoghurt and is sour in taste. In Malaysia, the dadih can commonly be found in restaurants, traditional stalls and food markets. Dadih is made from milk to which whey (obtained by fermenting milk overnight with asam gelugur (*Garcinia atroviridis*) has been added to acidify it to a pH just above the isoelectric point of casein, prior to the addition of sugar and salt. The milk mixture is then steamed to induce coagulation and gel formation. The induction of milk gel formation could be achieved with modified methods, such as the addition of enzyme or acid, or a combination of both, to induce the gel formation for the dadih production (Hamzah, 1983).

In this study, goat's milk was used as an alternative to cow's milk to produce dadih. Goat's milk differs from cow's milk and human milk. Goat's milk has smaller casein micelles and fat globules, less lactose, higher vitamin A and B contents, a higher content of free amino acid taurine, and a higher proportion of short- to- medium- chain fatty acids (Park *et al.*, 2007). Goat's milk, with its low lactose content, is more suitable for those who suffer from lactose intolerance (often caused by cow's milk).

Citric acid solution was added to acidify the goat's milk to a pH value near the isoelectric point of milk casein. Milk gel formation was further induced by heat during steaming. van Vliet and Keetels (1995) have reported the distinct effect of heat on the properties of the milk gel. The heat treatment of milk above 70 °C would cause denaturation of the whey proteins. It was then associated with k-casein via hydrophobic interactions and formed intermolecular disulphide bonds (Haque and Kinsella, 1988). The cross-linkages between whey protein and casein result in the milk gel structure of the dadih.

Tropical- fruit purees were incorporated into the dadih to mask the odour of goat's milk and improve the nutrition quality of the dadih. In this study, jackfruit, pineapple, and papaya purees were

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incorporated to make the dadih. Jackfruit (*Artocarpus heterophyllus*, Lam.) is a rich source of carbohydrate, minerals, fatty acids, dietary fibre, flavour volatiles, ascorbic acid and thiamine (Rahman *et al*., 1999). Pineapple (*Ananas comosus*) and papaya (*Carica papaya*) provide health benefits because they provide excellent sources of vitamin C, vitamin B1, vitamin B6, manganese, copper and dietary fiber (Cho *et al*., 2004). The nutrients contained in papaya fruit were found to have nutritional, medicinal, pharmacological and therapeutic effects on the body (Krishna *et al*., 2008).

Syneresis is one of the problems during storage of the dadih. The spoilage of dadih is indicated by the occurrence of syneresis and decrease in pH. The syneresis of dadih would become apparent as the storage continued. According to Toba *et al*. (1980), the darkened colour of milk is another signal of deterioration and is caused by the oxidation of tryptophan and tyrosine. The spoilage probably leads to the degradation of the nutrients and creates the unfavourable sensory characteristic which results in a shorter shelf life of the dadih.

Dadih is gradually being forgotten, especially by the younger generation, due to a lack of product promotion and innovation. The objectives of the present work were to develop goat's milk dadih added with tropical fruits and to study the physiochemical and sensory properties as a function of the storage time.

## Materials and Methods

*Sample preparation*

Fresh goat's milk was supplied by a local farm in Sungai Nibong, Penang. Food- grade ingredients including sugar, salt, citric acid, and tropical fruits were purchased from a grocery shop in Sungai Dua, Penang. The chemicals used for all analyses were of analytical grade.

Jackfruit, pineapple and papaya were first washed and chopped into small pieces. Only the jackfruit pulp was added with water in a ratio of 5:8. The respective fruit pulps were then individually pureed and strained using clean muslin cloth. The fruit purees were then heated to 85°C for 2 min and cooled prior to use.

The dadih preparation method was adapted from Hamzah (1983). 200 ml of goat's milk was pasteurised at 90°C for 5 min. The heated milk was slowly added with 10% sugar and 1% salt, and then cooled to 40°C. 10% fruit puree and 10% citric acid were later added to achieve a constant pH of 5.8 (above the isoelectric point of casein protein to avoid milk protein precipitation). The respective mixtures were then poured into several plastic cups and steamed for 10 min. The dadih was then cooled to room temperature, covered and stored at 4°C for 14 days.

*Physical analysis*

A texture profile analysis was performed with a texture analyser, TA-XT2 model using an Expert Software version 1.05 (Stable Micro Systems, Surrey, UK). The analytical method was modified from Kumar and Mishra (2004). An aluminium cylinder probe P36R with a diameter of 35 mm was used. A compression strain of 60% was used with a 5 kg load cell at a speed of 5 $mms^{-1}$. The hardness, cohesiveness, springiness and gumminess of the dadih samples were measured in triplicates.

Colour measurement (Hunter Lab, CIE L*a*b*) was performed using a colourimeter (Minolta Spectrophotometer CM-3500d, Osaka, Japan) with Spectramagic software. The required calibration was performed with a zero calibration plate (CM-100) and a white calibration plate (CM-120) with a large target mask (CM-126).

*Chemical analysis*

The dadih samples were analysed for moisture by oven- drying method (AOAC 990.20, 2005), crude fat using the Mojonnier method (AOAC 989.05, 2005), crude protein using Kjeldahl method (AOAC 991.20, 2005), and for ash by furnace- drying (AOAC 945.46, 2005). The total soluble solid content was determined with a refractometer (Hanna H1 96801, USA). The carbohydrate and calorie values were obtained by calculation.

The vitamin C content of the dadih samples was determined using the DCPIP titrimetric method (AOAC 967.21, 2005). The standard used was a solution of 100 mg ascorbic acid diluted with 3% HPO3: HOAC to 100 ml in a volumetric flask. The dye solution was prepared by dissolving 50 mg 2, 6-dichloroindophenol in hot water containing 42 mg sodium carbonate. A total of 10 g of the sample was then added to 3% $HPO_3$: HOAC and filtered with no. 42 Whatman filter paper. The sample extract was titrated against the dye solution to a pink colour endpoint lasting for 15 sec. The titer obtained was used to calculate the ascorbic acid content. All of the analyses were run in triplicate.

*Sensory evaluation*

Twenty-five panellists (13 males and 12 females from Universiti Sains Malaysia) were randomly selected for sensory evaluation. A hedonic form with a 7-point scale was given to each panel. The dadih samples were served in randomised order in small

cups coded with three random digits. The hedonic form scales ranged from 1, representing 'dislike very much', to 7, representing 'like very much'. The sensory parameters used were aroma, taste, texture, colour, and overall acceptability.

*Storage study*

All types of dadih (control, jackfruit, papaya, and pineapple) were stored at 4°C. The samples were taken out and left at room temperature prior to analyses. The samples were then homogenized to obtain a uniform mixture for further analysis. At different storage intervals (1, 4, 7, 11 and 14 days), the samples were measured for pH and syneresis. Measurement of pH was done for each sample with a pH meter (Mettler Toledo S20).

Syneresis of the homogenised dadih was determined by placing the no. 1 Whatman filter paper in a Buchner funnel. The funnel was then placed in an Erlenmeyer flask and attached to a vacuum pump (Fisher Scientific, FB 70155). A total of 20 g of the dadih samples was then spread evenly on the filter paper and vacuum-filtered for 10 min. The collected residue was weighed and percent syneresis was calculated by dividing the weight of the residue by the initial sample weight multiplied by 100 (Hongyu *et al*., 2000).

*Statistical analysis*

All data were analysed using SPSS version 17.0 for Windows (SPSS Inc., Chicago, IL, USA) with a one-way analysis of variance (ANOVA). A Duncan's multiple range test was used to analyse the differences between the individual means at a 5% significance level.

## Results and Discussion

*Physical analysis*

***Texture analysis***

Significant differences ($p< 0.05$) were found in hardness, gumminess, cohesiveness and elasticity (Table 1). The values for hardness and gumminess were highest for the papaya dadih and lowest for the pineapple dadih. The papaya dadih was significantly more elastic than the control. The papaya puree had the most influence on the textural quality of the dadih. This result could be due to the pectin component of the papaya puree, which tended to produce resistance to the structural deformation of the dadih. According to Dennapa *et al*. (2006), a combination of pectin and sugar in the presence of acid contributed to the gelling properties of milk and subsequently affected its texture. An appropriate thermal process was applied during the sample preparation to denature the enzymes papain and bromelain found in papaya and pineapple respectively to avoid the hydrolytic digestion of milk protein. Proteolytic enzymes would have interfered with the interaction between milk casein and whey protein to form the milk-clotting structure (Lopes *et al*., 1998).

Table 1. Texture profile analysis of tropical- fruit dadih

| Texture Profile Analysis | Control | Jackfruit | Pineapple | Papaya |
|---|---|---|---|---|
| Hardness (g) | $70.31 \pm 5.40^{b}$ | $89.01 \pm 1.58^{c}$ | $57.99 \pm 0.58^{a}$ | $92.06 \pm 3.42^{c}$ |
| Gumminess (g) | $34.95 \pm 0.91^{b}$ | $42.10 \pm 3.93^{c}$ | $30.48 \pm 0.97^{a}$ | $45.34 \pm 1.87^{c}$ |
| Cohesiveness | $0.50 \pm 0.04^{a}$ | $0.47 \pm 0.02^{a}$ | $0.53 \pm 0.02^{a}$ | $0.49 \pm 0.01^{a}$ |
| Elasticity | $0.94 \pm 0.01^{a}$ | $0.96 \pm 0.00^{ab}$ | $0.96 \pm 0.00^{ab}$ | $0.97 \pm 0.02^{b}$ |

Mean values in the same row with different letters are significantly different ($p< 0.05$).

Table 2. Colour analysis of tropical- fruit dadih

| Colour | Control | Jackfruit | Pineapple | Papaya |
|---|---|---|---|---|
| Lightness | $7.03 \pm 0.12^{d}$ | $3.96 \pm 0.16^{b}$ | $6.54 \pm 0.47^{c}$ | $1.41 \pm 0.03^{a}$ |
| Redness | $2.04 \pm 0.78^{a}$ | $6.38 \pm 0.22^{c}$ | $4.65 \pm 0.17^{b}$ | $6.61 \pm 0.28^{c}$ |
| Yellowness | $11.46 \pm 0.17^{c}$ | $6.59 \pm 0.33^{b}$ | $11.42 \pm 0.10^{c}$ | $2.27 \pm 0.04^{a}$ |
| hue | $79.90 \pm 0.53^{d}$ | $44.88 \pm 0.33^{b}$ | $67.86 \pm 0.56^{c}$ | $19.60 \pm 0.30^{a}$ |

Mean values in the same row with different letters are significantly different ($p< 0.05$).

The dadih with the tropical- fruit purees and the control dadih exhibited similar cohesiveness. It was speculated that the addition of the tropical- fruit purees to the dadih might not affect the strength of the internal bonds formed in the food. As explained by Hickson *et al*. (1982), the ability of a gel to exhibit viscosity, rigidity and elasticity will be affected by the types of protein, the temperature and time of heating, the protein concentration, and the ionic strength. Several studies of milk gel interaction and its rheological properties have previously been reported by McClements and Keogh (1995), O'Kennedy and Kelly (2000) and Oh *et al*. (2007). Lucey *et al*. (1997) noted that various polysaccharides such as xanthan gum, wheat starch, gelatin and locust bean gum can be used in yoghurt for higher shear consistency and viscosity.

***Colour analysis***

Table 2 shows the colour of the dadih. The colour analysis in this study was expressed in term of lightness (L), redness (a), yellowness (b), and hue (h). The control dadih had the lightest and yellowest colour, whereas the papaya dadih had the reddest colour. The control dadih showed a pale yellowish colour due to the milk casein micelles. The prominent red colour of the papaya dadih was due to carotenoids present in the papaya puree. According to Morales and Van Boekel (1998), the colour of a food is the result of natural products associated with raw material or of coloured compounds that are generated. The colour of a food determines the degree of consumer preference.

Table 3. Physicochemical characteristics of tropical- fruit dadih

| Composition | Control | Jackfruit | Pineapple | Papaya |
|---|---|---|---|---|
| Moisture (%) | 76.76 ± 0.08$^{a}$ | 78.31 ± 0.26$^{b}$ | 77.79 ± 0.14$^{b}$ | 78.20 ± 0.46$^{b}$ |
| Fat (%) | 4.62 ± 0.01$^{a}$ | 4.21 ± 0.40$^{a}$ | 4.48 ± 2.32$^{a}$ | 3.21 ± 0.34$^{a}$ |
| Protein (%) | 4.29 ± 0.12$^{a}$ | 4.65 ± 0.12$^{b}$ | 4.26 ± 0.23$^{a}$ | 5.52 ± 0.09$^{c}$ |
| Ash (%) | 0.78 ± 0.04$^{a}$ | 0.79 ± 0.15$^{a}$ | 0.90 ± 0.02$^{ab}$ | 1.04 ± 0.18$^{b}$ |
| Carbohydrate (%) | 13.54 ± 0.09$^{a}$ | 12.05 ± 0.33$^{a}$ | 13.71 ± 2.43$^{a}$ | 12.04 ± 0.71$^{a}$ |
| Energy (kcal) | 112.94 ± 0.46$^{b}$ | 104.66 ± 2.61$^{a}$ | 107.64 ± 9.28$^{a}$ | 99.10 ± 0.64$^{a}$ |
| TSS (°Brix) | 18.23 ± 0.72$^{b}$ | 17.30 ± 0.26$^{a}$ | 17.30 ± 0.36$^{a}$ | 17.40 ± 0.35$^{ab}$ |
| Vit-C (mg/100g) | 1.24 ± 0.41$^{a}$ | 3.93 ± 0.45$^{c}$ | 4.00 ± 0.30$^{c}$ | 2.88 ± 0.20$^{b}$ |

TSS= Total soluble solid; Vit-C= Vitamin C
Mean values in the same row with different letters are significantly different ($p< 0.05$).

Table 4. Sensory attributes of tropical- fruit dadih

| Attributes | Control | Jackfruit | Pineapple | Papaya |
|---|---|---|---|---|
| Colour | 4.80 ± 0.91$^{a}$ | 4.60 ± 1.15$^{a}$ | 4.76 ± 0.97$^{a}$ | 4.12 ± 1.42$^{a}$ |
| Aroma | 4.40 ± 1.04$^{a}$ | 4.16 ± 1.49$^{a}$ | 4.48 ± 1.76$^{a}$ | 4.08 ± 1.44$^{a}$ |
| Taste | 4.48 ± 1.45$^{a}$ | 4.64 ± 1.47$^{a}$ | 4.88 ± 1.33$^{a}$ | 4.48 ± 1.56$^{a}$ |
| Texture | 4.20 ± 1.63$^{a}$ | 4.12 ± 1.48$^{a}$ | 4.32 ± 1.41$^{a}$ | 3.60 ± 1.44$^{a}$ |
| Overall acceptability | 4.36 ± 1.11$^{a}$ | 4.64 ± 0.99$^{a}$ | 4.52 ± 1.00$^{a}$ | 4.20 ± 1.44$^{a}$ |

Mean values in the same row with different letters are significantly different ($p< 0.05$).

### *Chemical analysis*

Higher moisture contents were observed in the tropical- fruit dadih than in the control dadih (Table 3). Water contained in the fruit purees contributed to the final moisture content of the dadih. A certain amount of the moisture in the milk and the fruit purees was lost during the steaming process. As reported by Johnson (1974), a small amount of the water in the milk was evaporated. Bonding between the water and the milk protein occurred to a certain extent and resulted in lower amounts of moisture, compared with the actual water content.

No significant differences in crude fat content was observed among the dadih samples. The tropical fruits used for making dadih contained very low levels of fats. The fat content of the dadih was contributed primarily by the fat present in the goat's milk. The fat content in goat's milk (3.8%) is generally similar with cow's milk (3.6%) (Saini and Gill, 1991). The fat of goat's milk is more digestible than that of cow's milk because the smaller and greater surface area of fat globules of goat's milk is able to be digested by the lipases in the gut more rapidly (Jandal, 1996).

The protein content was highest in the papaya dadih, followed by the jackfruit, control, and pineapple dadih. The goat's milk was a primary source of protein. Additional protein content was provided by the added fruit purees. According to Galindo *et al*. (2009), a high amount of protein (10.7%) was found in the fruit of *Carica papaya* L. cv. Maradol. Varnam and Sutherland (1994) reported that a Maillard reaction might be initiated and could have caused the loss of available protein lysine of milk, decreasing the protein content to 1% to 2%. The ash content of the control dadih was lower than that of the tropical-fruit dadih (Table 3). The ash content is the amount of non-combustible matter and total minerals present in a food (Johnson, 1974). Therefore, addition of the jackfruit, pineapple and papaya purees to the dadih had increased the ash and thus the mineral contents of the tropical- fruit dadih than in the control dadih (Table 3).

The carbohydrate content of the dadih samples did not differ significantly. However, the energy content of the control dadih was slightly higher than that of the tropical- fruit dadih. The estimated energy content is based on carbohydrate, protein and fat. The higher fat content of the control dadih led to its higher energy content compared to the tropical- fruit dadih samples (Table 3). Meanwhile, the higher value of total soluble solids in the control dadih is probably due to the higher amount of lactose presence the control.

The DCPIP titrimetric method was used to determine the vitamin C content of each of the dadih samples. Table 2 shows noticeable variation in vitamin C content among the dadih samples. The tropical-fruit purees were particularly added to the dadih to increase its vitamin C content because vitamin C is normally low in dairy product. However, a certain amount of vitamin C was degraded during the dadih processing, cooking and storage because vitamin C is easily oxidised by exposure to air, high temperature and water (Morris *et al*., 2004).

### *Sensory evaluation*

The results of the sensory tests of the colour, aroma, taste, texture and overall acceptability of the dadih are shown in Table 4. The tropical- fruit dadih and the control dadih gained similar acceptance by the panels although the control were less colourful. The panels were not able to distinguish any differences in aroma and taste, although the tropical fruits were added to the dadih with the intention to provide more flavour variations. The textures of all the dadih were soft and smooth. The same trend was seen in the results for overall acceptability with average hedonic scores of 4 out of 7. Preference assessments are dependent on the psychological or functional components of pleasure of eating as complexity of neuron system determined the liking extent unconsciously (Berridge, 1996).

### *Storage study*

### ***pH analysis***

The dadih samples were initially adjusted to a pH above the isoelectric point of casein to destabilise the casein complex without clot formation. The destabilised milk complex was later steamed to induce gel formation. Significant differences in the pH changes were observed during the storage period.

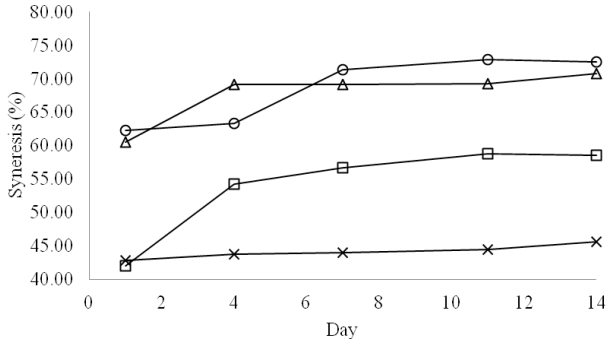


Figure 1. Syneresis of control dadih (□), jackfruit dadih (o), pineapple dadih (Δ) and papaya dadih (x).

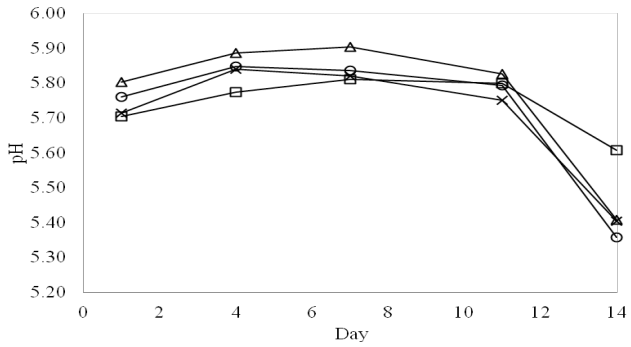


Figure 2. Change of pH of control dadih (□), jackfruit dadih (o), pineapple dadih (Δ) and papaya dadih (x during storage)

The rate of the pH changes for the tropical- fruit dadih was higher than that of the control dadih, as shown in Figure 2. The rich source of sugar provided by the fruit purees served as a suitable substrate for the growth of microbes. However, a low number of not harmful microorganisms still survived after heating and steaming process. These viable microorganisms still multiply and eventually dadih become acidic as the storage period continued. In addition, spoilage of pasteurized milk would likewise be caused by bacteria that contaminated the milk after the pasteurization process or from improper refrigeration (DFSN, 2007).

*Syneresis analysis*

Syneresis defined as the separation of liquid from a shrinkage gel. This condition affects the texture and quality of the dadih throughout the storage period. Syneresis was significantly higher ($p< 0.05$) in the dadih with jackfruit puree, followed by the pineapple, control, and papaya dadih (Figure 1). The jackfruit dadih was prepared by adding water to jackfruit pulp, whereas no water was added to the other types of tropical- fruit dadih during the preparation of the sample. The added water might contribute to higher syneresis value for jackfruit dadih at the end of the storage day. In contrast, the papaya dadih had a firm texture and the lowest syneresis. In a study on yoghurts prepared from the milk of goats, cows and sheeps, Jacek (2009) reported that the improvement of textural properties slowed down the occurrence of syneresis.

Syneresis increased progressively from day 1 until day 14 except in the papaya dadih which did not show any marked increase (Figure 1). Syneresis is an undesirable process. Syneresis increased markedly at lower pH, where the elastic deformation of the gel network occurred (Walstra *et al*., 1999). The gel interaction network was weakened and eventually ruptured which reduced the water holding capacity of dadih structure. The dadih was kept at a cool temperature (4 °C) to avoid bond relaxation at high temperature which might accelerate the syneresis (Castillo *et al*., 2005). The cooling would cause the protein casein to become more swollen. Moreover, moisture loss would occur at a low temperature and subsequently decreased the occurrence of syneresis.

## Conclusions

In place of conventional methods, this study used an approach to dadih production in which tropical-fruit purees of jackfruit, pineapple and papaya were added to goat's milk. The assessment results showed that incorporating the tropical- fruit purees to the dadih would significantly affect the physical characteristics of texture and colour. The tropical-fruit dadih were found to have higher contents of moisture, protein, and vitamin C than control dadih. Both the tropical- fruit dadih and the control dadih were found to be acceptable by the sensory panellists with the average scores of 4 out of 7. The change of acidity was inversely proportional to the syneresis throughout the storage study of dadih samples.

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