INTRODUCTION

Low pH milk beverages (by fermentation and acidification) are refreshing drinks that are currently getting more attention by consumers. The number of fermented milk beverages launched in Malaysia are increasing each year, while acidified milk beverage is now starting to show its potential. In Malaysian market, numerous commercial

PHYSICOCHEMICAL PROPERTIES AND SENSORY EVALUATION OF FERMENTED AND ACIDIFIED MILK BEVERAGES IN MALAYSIAN MARKET-REFERENCE FOR PALM-BASED ACIDIFIED MILK BEVERAGE

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ABSTRACT

In this study, 11 commercial samples in Malaysian market consisted of 10 fermented milk beverage and 1 acidified milk beverage were analysed for their proximate analysis, pH, titratable acidity (TA), brix, viscosity, colour, particle size and sensory evaluation. This study was conducted to get an overview on the physicochemical properties and sensory evaluation of the fermented and acidified milk beverages in order to produce palm-based acidified milk beverage. Energy content of these samples were ranged between 33.50-73.00 kcal/100 g. Fat, carbohydrate and protein contents were ranged between 0.00-2.54 g/100 g, 7.52-15.75 g/100 g and 1.98-2.10 g/100 g, respectively. All of the commercial samples were observed to be insignificant in sugar and ash content. pH, TA and brix of the samples varied from 3.50%-4.20%, 0.27%-0.72% and 9.40-18.90°B, accordingly. Colour (L*, a* and b*) varied significantly among the commercial samples. Viscosity and particle size were ranged between 0.022-0.063 Pa.s and 0.45-20.11 μm, respectively. Preferred sample based on sensory evaluation was commercial sample D (fermented). The characteristics of commercial samples B, D and E can be used as guidelines in formulating palm-based acidified milk beverage.

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INTRODUCTION

fermented milk beverages can be found at the hypermarket compared to only minor commercial acidified milk beverage.

Fermentation is one of the oldest methods to preserve milk while acidification method evolves through time. First commercial scale with direct acidification for dairy product started in 1962 (Little, 1967; Hingmire et al., 2008). Fermented milk beverages are produced by fermentation process of lactic acid bacteria (microorganism) while acidified milk beverages are prepared by adding mild acid to the emulsions. Both fermented and acidified techniques alter physicochemical and organoleptic properties of the beverages. They are
usually characterised as products having low pH and viscosity which may have stability issue due to sedimentation of aggregated milk protein (Amiceto et al., 1995) and wheying-off which is clear whey developed on the beverage’s surface (Lucey et al., 1999). In this context, Malaysian Food Act 1983 (Act 281) and Regulations (2003) defined fermented milk as product developed from pasteurised, sterilised, skimmed or recombined milk that went through culturing process of lactic acid bacteria producing acidity of more than 0.5% lactic acid. Permitted colour, flavour, food conditioner, sweetener, milk solid, salt and fruit are allowed to be added in fermented milk. However, no definition is specified for acidified milk in the Malaysian Food Act 1983 (Act 281) and Regulations (2003).

Fermented milk beverages are known to have health-promoting attributes especially for human digestive system as compared to acidified milk apart from having good taste. However, fermented milk beverages have compelling manufacturing drawback, i.e. high manufacturing cost and longer fermentation process compared to acidified milk beverages (Hingmire et al., 2008). Direct acidification on the other hand, does not require starter culture and any cost related to them (Nair and Thompkinson, 2008). Notwithstanding this, both methods are an oil in water emulsions. In general, almost all beverage emulsions have water content of between 60%-70% and depending on formulation it can go up to 80% (Tan, 2004).

To our knowledge, there is limited information available or reviewed on the physicochemical properties of commercial fermented and acidified milk beverages with regards to nutritional composition, pH, titratable acidity (TA), brix, viscosity, colour, particle size and sensory evaluation in Malaysian market. This information is important in developing future innovative fermented or acidified milk beverages. The main objective of this survey is to provide references in formulating future palm-based acidified milk beverage. Palm oil is a suitable alternative fat as it contains balanced fatty acid, rich in tocotrienol and other vitamin E, bland in taste as well as a source of cheaper raw material. Palm-based acidified milk beverage might have better shelf-life and low cholesterol level. To the author’s knowledge, there is no paper published yet with regard to milk-based beverage from palm oil.

**MATERIALS AND METHODS**

**Materials**

Eleven commercially available fermented and acidified milk samples were purchased from several hypermarkets in Selangor, Malaysia. These samples were kept at 4°C until further use for analyses. The commercial samples were abbreviated as A to K.

**Nutritional Analyses**

Fat and protein contents were determined according to AOAC 989.05 and 991.20 respectively (AOAC, 1995). Energy and carbohydrate were determined according to Sullivan and Carpenter (1993). Ash content and total sugars were carried out according to Pearson and Cox (1976). Equations used for fat, protein, energy, carbohydrate, ash and total sugars analyses are as follows:

**Fat:**

\[
\text{Fat (kcal/100 g) = \frac{[(\text{Weight dish + fat empty dish}) - \text{Blank}] \times 100}{\text{Sample size}}}
\]

**Protein:**

\[
\text{Protein (g/100 g) = \frac{(\text{TV-Blk}) \times 1.4007 \times F \times N}{W}}
\]

where,

- TV = Titration end point (ml)
- Blk = Titration value for blank (ml)
- F = Conversion factor for general food is 6.25
- N = Normality of HCl
- W = Sample weight (g)

**Energy:**

\[
\text{Energy (kcal/100 g) = (Fat x 9) + (Protein x 4) + (Carbohydrate x 4) + (Total Dietary Fibre x 2)}
\]

**Carbohydrate:**

\[
\text{Carbohydrate (g/100 g) = 100 - (Fat + Protein + Moisture + Ash + Total Dietary Fibre)}
\]

**Ash:**

\[
\text{Ash (g/100 g) = \frac{\text{weight of Ash} \times 100}{\text{Sample weight}}}
\]

**Total sugars:**

\[
\text{Total sugars (g/100 g) = \frac{\text{mg sucrose x volume of dilution x 100%}}{100 \text{ ml x 1000 x sample size (g)}}}
\]

**pH and Titratable Acidity**

pH of the commercial samples was determined using Milwaukee MW100 digital pH meter.
(Romania, Europe). Titratable acidity (TA) of the commercial sample was determined using direct titration method described in IS:SP 18 Part XI (ISI, 2013). Approximately, 10 g of commercial sample was diluted in 10 ml of distilled water and titrated against 0.1N of sodium hydroxide using phenolphthalein as an indicator to end point of solution which turned it to pale and light pink. The titratable acidity was calculated using the equation below:

$$\text{TA} (%) = \frac{9 \times N \times V}{W}$$

where,

- $V$ = Volume (ml) of standard sodium hydroxide solution
- $W$ = Weight (g) of sample
- $N$ = Normality of standard sodium hydroxide solution

**Colour Analysis**

Colour of the commercial samples was measured using chromameter CR-400 (Konica Minolta Sensing, Tokyo, Japan). The lightness ($L^*$) value indicates the lightness and the reflection or transmission of light on a scale of 0 to 100. The higher the value of $L^*$ indicates that the sample has a lighter colour (Paz et al., 2017). A positive redness ($a^*$) represents the redness, while negative $a^*$ represents greenness and yellowness ($b^*$) measures yellow component, while negative $b^*$ measures blueness (El-Nimr et al., 2010).

**Viscosity Analysis**

Viscosity of the commercial samples was measured using a rotational Brookfield RVTD viscometer (Stoughton, USA). The RV2 spindle was used for this analysis. The sample was analysed at 4°C at 100 rpm. Results are reported in Pascal-second (Pa.s).

**Brix Analysis**

Sugar concentration was measured at 20°C using a digital refractometer RFM 110 (Bellingham and Stanley, United Kingdom) according to the method by Zárate-Rodríguez et al. (2000). Results are reported in °B.

**Particle Size**

Particle size of the samples was analysed by light scattering Malvern Mastersizer 2000S (Malvern, Worcester, United Kingdom) according to the method by Mirhosseini et al. (2008). The samples were diluted with reverse osmosis (RO) water prior to analysis. Samples were stirred during the measurement to prevent sedimentation.

**Sensory Evaluation**

30 panellists were recruited from Malaysian Palm Oil Board (MPOB) staff and students. Each panellist was given samples in a cup of 30 ml that were served straight from 4°C incubator. Each panellist was requested to evaluate for sweetness, sourness, viscosity and overall acceptance of the commercial samples using hedonic seven-point scale. Scale 1 indicates least acceptable sample while scale 7 indicates the most acceptable sample.

**Statistical analysis**

Two replicates were applied for nutritional analyses samples while three replicates were used for all other analyses and the results were demonstrated as mean value ± standard deviation. Data were statistically analysed using Tukey’s one-way analysis of variance (ANOVA) with 95% confident level. Pearson correlation was used to assess linear correlation between two continuous variables. All statistical analyses were done using Minitab (Version 17).

**RESULTS AND DISCUSSIONS**

**Nutritional Analysis**

The nutritional composition of the commercial samples is shown in Table 1. Energy content of the commercial samples varied from 33.50±0.71 kcal to 73.00±5.66 kcal. These samples were significantly different among each other (p<0.05). Sample C had the highest energy content while sample H possessed the lowest energy content. The energy content has positive correlation with the composition of fat, carbohydrate, total sugars and protein. The highest and most significant Pearson correlation coefficient was found between energy and carbohydrate with coefficient of 0.805 (p<0.05) compared to fat with coefficient of 0.595. Although energy and protein are resulted in positive correlation, their correlation however, is insignificant (p>0.05).

The average fat content of the commercial samples ranged from 0.00±0.00 g to 2.54±0.43 g. Bhoir et al. (2012) reported that lassi in Akola market, India has fat content of 2.88 g to 3.26 g. In this regard, average fat content of the commercial fermented and acidified milk samples in Selangor, Malaysia was slightly lower compared to the lassi in Akola market. As the average fat content has p<0.05, the results were significantly different among the commercial samples. Samples F, G, H, I and J on the other hand, did not have any fat content while
sample C had the highest fat content. According to Codex Alimentarius International Food Standard (2013), beverages having fat content of less than 0.5 g and 1.5 g per 100 ml of samples can be described as fat-free and low fat, respectively. In this regard, samples B, D, E, F, G, H, I and J were fat free while sample A and K were low in fat. Sample C was high in fat.

Statistical analysis revealed that carbohydrate content varied between these samples ranging from 7.52±0.18 g to 15.75±4.88 g. These values are close to the range demonstrated by Zohra et al. (2016) in which her lassi contained carbohydrate of between 9.43±0.02 g to 12.93±0.03 g. Total sugars content of the samples was statistically similar (p>0.05) having values between 4.68±1.76 g to 10.77±4.29 g. These total sugars contents are close to the finding by Chawla and Sivakumar (2017) having total sugars content of 12-14 g/100 g samples if compared with the higher total sugars side of the commercial samples.

Protein content of the commercial samples, on the other hand, did show significant different (p<0.05). Sample C had the highest protein content of 2.40±0.01 g while sample K showed the lowest protein content of 0.51±0.01 g. Protein content of between 1.98 g to 2.10 g was reported by Shuwu et al. (2016) during the development of value added lassi using honey. Ash content of the samples was statistically similar (p>0.05) having values between 0.27±0.00% to 0.72±0.01%. The pH value indicates the strength of acid in the emulsion. The pH of the commercial samples indicates that the fermented and acidified beverages have mild acidity. It is observed that sample G had the highest amount of acid compared to other commercial samples while sample K showed the lowest amount of acid. The pH shows a negative correlation with TA (Pearson correlation = -0.377; p-value = 0.031). This indicates that when TA increases, pH will decrease.

In fermented milk, pH and acidity are controlled by lactic acid that is produced by lactic acid bacteria through lactose fermentation (Lee and Lucey, 2010). In a market survey of commercial Lassi (fermented milk beverage) in Akola, India, Bhoir et al. (2012) found that the range of the Lassi’s pH values was between 4.18-4.26 which is relatively close to commercial samples A, C, D, E and I in the present study. Tabassum et al. (2017) produced freeze dried probiotic pineapple fermented milk powder and found that pH of the product lessened from 4.7 to 4.1 when stored at 25°C±2°C for 12 months compared to storage condition of -18°C±2°C when the reading

### Physicochemical Properties

Results of pH and TA evaluation for the commercial fermented and acidified milk are presented in Table 2. There were significant differences of pH and TA between all of the commercial samples regardless of either fermented or acidified milk. The pH values ranged between 3.50±0.00 to 4.20±0.00 while TA values ranged between 0.27±0.00% to 0.72±0.01%. The pH value indicates the strength of acid in the emulsion while TA measures acid amount in the emulsion. The pH of the commercial samples indicates that the fermented and acidified beverages have mild acidity. It is observed that sample G had the highest amount of acid compared to other commercial samples while sample K showed the lowest amount of acid. The pH shows a negative correlation with TA (Pearson correlation = -0.377; p-value = 0.031). This indicates that when TA increases, pH will decrease.

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<table>
<thead>
<tr>
<th>Commercial sample</th>
<th>Energy (kcal)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Total sugars (g)</th>
<th>Protein (g)</th>
<th>Ash (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>63.50±4.95&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.13±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.90±1.27&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.51±3.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.51±0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.25±0.07&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>62.00±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.16±0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.30±0.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>9.86±3.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.11±0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.24±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>73.00±5.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.54±0.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.15±2.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.58±1.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.40±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.51±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>40.00±1.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.49±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>8.25±0.30&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>6.32±1.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.74±0.04&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>0.27±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>E</td>
<td>55.00±2.83&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.31±0.01&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>11.55±0.78&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.01±2.68&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.46±0.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.58±0.23&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>F</td>
<td>54.50±2.12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.00±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>11.85±0.07&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.31±3.10&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.32±0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.21±0.23&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>G</td>
<td>66.00±15.56&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.00±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>15.75±4.88&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>9.10±1.41&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.31±0.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.37±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>H</td>
<td>33.50±0.71&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.00±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>7.52±0.18&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.89±1.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.79±0.09&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>0.33±0.04&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>I</td>
<td>39.50±2.71&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.00±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>8.39±0.22&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.82±1.44&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.43±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.45±0.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>J</td>
<td>36.00±1.41&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.00±0.00&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>7.61±0.33&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.68±1.76&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.28±0.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.33±0.13&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>K</td>
<td>62.00±5.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.76±0.18&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>13.80±0.28&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>10.77±4.29&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.51±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.17±0.04&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>


Samples with similar superscript in the same column are insignificantly different (p ≥ 0.05).
Table 2. pH value, titratable acidity (TA) and Brix of fermented and acidified milk beverages

<table>
<thead>
<tr>
<th>Commercial sample</th>
<th>pH</th>
<th>TA (%)</th>
<th>Brix (°B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.10±0.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.38±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.97±0.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>3.50±0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.53±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>14.67±0.06&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>4.00±0.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.70±0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>16.70±0.10&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>4.03±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.31±0.01&lt;sup&gt;d&lt;/sup&gt;</td>
<td>9.87±0.06&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>E</td>
<td>4.10±0.00&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.39±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
<td>13.70±0.10&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>F</td>
<td>3.90±0.00&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.56±0.01&lt;sup&gt;f&lt;/sup&gt;</td>
<td>13.87±0.06&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>G</td>
<td>3.50±0.00&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.72±0.01&lt;sup&gt;g&lt;/sup&gt;</td>
<td>18.90±0.10&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>H</td>
<td>3.80±0.00&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.54±0.01&lt;sup&gt;h&lt;/sup&gt;</td>
<td>9.73±0.06&lt;sup&gt;h&lt;/sup&gt;</td>
</tr>
<tr>
<td>I</td>
<td>4.20±0.00&lt;sup&gt;i&lt;/sup&gt;</td>
<td>0.49±0.01&lt;sup&gt;i&lt;/sup&gt;</td>
<td>10.30±0.00&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>J</td>
<td>3.50±0.00&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.59±0.00&lt;sup&gt;j&lt;/sup&gt;</td>
<td>9.40±0.00&lt;sup&gt;j&lt;/sup&gt;</td>
</tr>
<tr>
<td>K</td>
<td>3.70±0.00&lt;sup&gt;k&lt;/sup&gt;</td>
<td>0.27±0.00&lt;sup&gt;k&lt;/sup&gt;</td>
<td>14.00±0.00&lt;sup&gt;k&lt;/sup&gt;</td>
</tr>
</tbody>
</table>


Samples with similar superscript in the same column are insignificantly different (p≥0.05).

Brix values for the commercial fermented and acidified milk samples are demonstrated in Table 2. These samples had inconsistent Brix values with a huge range of 9.40±0.00°B to 18.90±0.10°B and were analysed to be significantly different (p<0.05). The results indicated that sample G had the highest soluble solids in the solution while sample J had the lowest value. Based on the results of Brix (Table 2) and total sugars (Table 1) of the commercial samples, positive and significant (p<0.05) Pearson correlation was found between Brix and total sugars with coefficient of 0.690. Acidified milk beverage was observed to possess quite a high brix value of 14.00±0.00°B compared to other commercial drinks. Sourness of beverages from fermentation and acidification is balanced or reduced with the addition of sugar or other sweeteners (Béal and Helinck, 2014). The amount of sugar incorporated in beverages is typically based on sensory evaluation which is the translation of consumer’s acceptance. Brix value can be tailored by adjusting the total soluble solid especially the amount of sugar incorporated in the beverage. Hingmire et al. (2008) reported that addition of 12% sugar in their acidified milk beverage was the most preferable amount compared to 8% and 10% sugar addition. In another study, Nair and Thompkinson (2008) also prepared their acidified milk beverage by adjusting the sugar level to 12%. Janhøj et al. (2008), on the other hand, formulated their fermented and acidified milk beverages with 8% of sugar to mimic commercial beverage. All of these studies reflect closely to the total sugars content in the commercial samples having majority of total sugars content of 10%.

Viscosity of fermented and acidified milk beverages are shown in Figure 1. Significant difference (p<0.05) in viscosity was observed for all of the commercial samples. The viscosity values of these commercial samples ranged from 0.022±0.000 Pa.s (sample G) to 0.063±0.001 Pa.s (sample A). Sample A with the highest viscosity provided indication of a viscous emulsion. Viscosity of the commercial samples could be associated with total solids and protein content (Gomes et al., 2013; Küçükçetin et al., 2011; Martin-Diana et al., 2003) as well as the type and amount of stabiliser used in the beverages. The present study indicated that there was positive correlation (Pearson correlation = 0.461) between viscosity and protein. However, it was found that viscosity had no correlation with total sugars. Guar gum, xanthan gum, high methoxyl pectin, carboxyl cellulose (CMC), gelatine and locust bean gum are examples of hydrocolloid stabiliser. The lowest viscosity was observed in sample G as it did not contain any stabiliser (based on the ingredients labelling) compared to other samples.

In the acidified milk beverages, citric or lactic acid or their combination are commonly used. The commercial acidified milk beverage was reported to have pH value of 3.70±0.00. The value is quite close with the pH value reported by Hingmire et al. (2008) whom prepared acidified milk drink with 50% (volume/volume) lactic acid with desired pH of 3.4, 3.6 and 3.8 and found that drink with pH 3.8 had no influence on colour, appearance and overall acceptability. The pH value of 3.95 was used by Janhøj et al. (2008) in formulating fermented and acidified milk drinks. This value is still close to the reported commercial pH value of 3.7. Malic, tartaric and acetic acids are rarely used to replace citric and lactic acids. The pH value of below 4.5 is preferable to hinder unnecessary bacterial growth that grows well at pH of 6.0-8.5 (Tan, 2004). Based on Table 1, pH value for acidified milk beverage (sample K) is below 4.5.

Only dropped to pH value of 4.3. In addition, it was also reported by Rojas-Castro et al. (2007) and Gomes et al. (2013) that during storage, acidification of dairy product may continue but with lesser effect at low temperature. pH and acidity towards the end of stabilisation period in fermented dairy products may also be associated with inhibition of enzymatic activity, lessened of bacteria population and probably lactose depletion in the beverage. Storage temperature of the commercial samples which was at 4°C might have effect on the evaluated pH. Notwithstanding this, samples A, D, E and I did not meet the requirement of the Malaysian Food Act 1983 (Act 281) and Regulations (2003) under cultured milk category as their TA value was less than 0.5%.
Lightness ($L^*$), redness ($a^*$) and yellowness ($b^*$) of the commercial samples are shown in Table 3. $L^*$, $a^*$ and $b^*$ of samples D and E were not determined as these brands did not produce natural fermented drink without flavour. A broad range of brightness value from $L^*$ of 88.09±0.01 (very light colour) to 56.69±0.36 (darker colour) was found for the commercial samples. Sample C was the lightest compared to other commercial samples. Sample K possessed the darkest and reddest colour among all commercial samples. Sample I had the highest $b^*$ value in terms of yellowness compared to other samples. Colour is influenced by the formulation which reflects the ingredient and amount used by manufacturers.

Table 4 shows that average particle size of the commercial fermented and acidified milk beverages ranged between 0.45±0.01 µm (sample J) to 20.11±1.09 µm (sample I). The results were significantly different from each other (p<0.05). Small average particle size is needed in beverage for it to be stable with no creaming or separation. Stokes’ law points out that smaller particle size (≤100 nm) prolongs the shelf life up to nine months (Chen and Wegner, 2004). All commercial samples have particle size of less than 10 µm except for sample I which gave moderate particle size. Homogenisation is an important step to obtain low particle size reading (Chen and Wegner, 2004). The number of homogenisation cycle and its pressure contribute to particle size reading. Higher number of homogenisation cycle and higher pressure result to lower particle size reading and uniform particle size distribution. In general, Tan (2004) suggested that in order for beverage emulsions to have better uniformity distribution of particle size, a two-cycle homogenisation is needed. Apart from this, the author also emphasised the necessity of conducting pre-homogenisation which could be achieved through high-speed mixer or colloid mill. Pre-homogenisation, in general, produces particle size of less than 20 µm. However, pre-homogenisation particle size of less than 10 µm is preferred. Sample I which possessed bigger particle size (20.11±1.09 µm) might face instability issue.

<table>
<thead>
<tr>
<th>Commercial sample</th>
<th>$L^*$</th>
<th>$a^*$</th>
<th>$b^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>81.56±0.18$^b$</td>
<td>-6.70±0.09$^d$</td>
<td>10.43±0.13$^d$</td>
</tr>
<tr>
<td>B</td>
<td>65.23±0.13$^f$</td>
<td>-5.71±0.14$^g$</td>
<td>1.85±0.34$^e$</td>
</tr>
<tr>
<td>C</td>
<td>88.09±0.01$^e$</td>
<td>-7.69±0.02$^g$</td>
<td>12.35±0.08$^g$</td>
</tr>
<tr>
<td>D</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>E</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>F</td>
<td>75.41±0.11$^d$</td>
<td>-7.38±0.02$^g$</td>
<td>7.06±0.11$^g$</td>
</tr>
<tr>
<td>G</td>
<td>64.71±0.27$^f$</td>
<td>-6.24±0.01$^e$</td>
<td>25.87±0.09$^g$</td>
</tr>
<tr>
<td>H</td>
<td>71.84±0.02$^c$</td>
<td>-6.77±0.01$^d$</td>
<td>4.18±0.02$^d$</td>
</tr>
<tr>
<td>I</td>
<td>68.13±0.03$^e$</td>
<td>-7.19±0.01$^h$</td>
<td>27.44±0.06$^e$</td>
</tr>
<tr>
<td>J</td>
<td>67.76±0.06$^e$</td>
<td>-7.40±0.02$^h$</td>
<td>-0.81±0.07$^h$</td>
</tr>
<tr>
<td>K</td>
<td>56.69±0.36$^b$</td>
<td>-4.79±0.05$^b$</td>
<td>-0.78±0.07$^b$</td>
</tr>
</tbody>
</table>

Note: A-J: Fermented milk; K: acidified milk. Samples with similar superscript in the same column are insignificantly different (p≥0.05).

In addition, milk protein aggregation (sedimentation of casein) can be prevented or
reduced using high methoxy pectin in order to stabilise the acidified milk drink. Pectin adsorbs onto the surface of casein particles through electrostatic interactions that subsequently contribute to steric stabilisation by molecule of pectin (Parker et al., 1994; Kravtchenko et al. 1995; Lucey et al., 1999; Tuinier and de Kruif, 2002). Tromp et al. (2004) reported that homogenisation pressure of beyond 100 bar has positive effect on adsorption of pectin in their fermented milk beverage.

### TABLE 4. PARTICLE SIZE OF FERMENTED AND ACIDIFIED MILK BEVERAGES

<table>
<thead>
<tr>
<th>Commercial sample</th>
<th>Average particle size (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6.21±0.34&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>1.05±0.03&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>1.31±0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>D</td>
<td>2.10±0.01&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>E</td>
<td>1.21±0.06&lt;sup&gt;de&lt;/sup&gt;</td>
</tr>
<tr>
<td>F</td>
<td>0.58±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>G</td>
<td>6.25±0.35&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>H</td>
<td>0.71±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>I</td>
<td>20.11±1.6&lt;sup&gt;ef&lt;/sup&gt;</td>
</tr>
<tr>
<td>J</td>
<td>0.45±0.01&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>K</td>
<td>3.11±0.00&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Note: A-J: Fermented milk; K: acidified milk. Samples with similar superscript in the same column are insignificantly different (p≥0.05).

### Sensory Evaluation

The values of chemical analyses and physicochemical properties are of no importance if sensory evaluation is not conducted as it summarises all properties obtained earlier. Table 5 shows the score for four sensory characteristics (sweetness, sourness, viscosity and overall acceptance) that was evaluated by 30 panellists. The highest number of panellists (25 panellists) gave scores of 5 and above for sweetness to sample B. However, the average score showed that sample D was the most preferred beverage in terms of sweetness with a score of 5.70±1.21. Again, the highest number of panellists (26 panellists), gave scores of 5 and above for the sourness to sample B. However, when all of the scores for sourness were averaged, samples B and D shared similar score value of 5.50. Sample E received the highest number of panellists (25 panellists) that gave score of 5 and above for viscosity. This result is aligned with the average viscosity score received by sample E (5.63±1.09) in which sample E was the most preferred viscosity. In terms of the overall preference, the highest number of panellists (25 panellists), gave score of 5 and above for sample D. On average, sample D still received the highest score of 5.77±1.10 for the overall preference. Sample D (fermented) possessed energy content of 40.00 kcal/100 g, fat content of 0.49 g/100 g, carbohydrate content of 8.25 g/100 g, total sugars content of 6.32 g/100 g, protein content of 0.74 g/100 g, ash content of 0.27 g/100 g, pH value of 4.03, TA value of 0.31%, brix of 9.87°B, viscosity of 0.038 Pa.s and particle size of 2.10 µm. On the other hand, sample A received the lowest average score for overall acceptance. Sample E possessed energy content of 63.50 kcal/100 g, fat content of 1.13 g/100 g, carbohydrate content of 11.90 g/100 g, total sugars content of 9.51 g/100 g, protein content of 1.51 g/100 g, ash content of 0.25 g/100 g, pH value of 4.10, TA value of 0.38%, brix of 12.97°B, viscosity of 0.063 Pa.s and particle size of 6.21 µm.

### CONCLUSION

All commercial samples analysed varied in chemical and physical characteristics except for total sugars and ash content. These chemical and physical properties were summarised using sensory evaluation. Sensory evaluation demonstrated that sample D (fermented) having energy content of 40.00 kcal/100 g, fat content of 0.49 g/100 g, carbohydrate content of 8.25 g/100 g, total sugars content of 6.32 g/100 g, protein content of 0.74 g/100 g, ash content of 0.27 g/100 g, pH value of 4.03, TA value of 0.31%, brix of 9.87°B, viscosity of 0.038 Pa.s and particle size of 2.10 µm was the most favoured beverage. Sample A (fermented) having energy content of 63.50 kcal/100 g, fat content of 1.13 g/100 g, carbohydrate content of 11.90 g/100 g, total sugars content of 9.51 g/100 g, protein content of 1.51 g/100 g, ash content of 0.25 g/100 g, pH value of 4.10, TA value of 0.38%, brix of 12.97°B, viscosity of 0.063 Pa.s and particle size of 6.21 µm was the least favoured beverage. Sample K (acidified) having energy content of 62.00 kcal/100 g, fat content of 0.76 g/100 g, carbohydrate content of 13.80 g/100 g, total sugars content of 10.77 g/100 g, protein content of 0.51 g/100 g, ash content of 0.17 g/100 g, pH of 3.70, TA value of 0.27%, brix of 14°B, viscosity of 0.038 Pa.s and average particle size of 3.11 µm, received moderate sensory response. Samples A, B, C, D, E and K can be manipulated by replacing existing milk fat with palm oil. However, in order to formulate palm-based acidified milk, samples B, D and E will be served as reference as they contain milk fat (although considered as fat free) and received high score in sensory evaluation.
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