Proximate Analysis of Goat Milk Yogurt Powder Produced by Freeze Drying and Vacuum-Oven Drying and in Comparing with Freeze-Dried Yogurt Powder Prepared with *Tualang* Honey

Siti Norhannani Ahmat Azemi, Norshafiqah Zainul, Asmaliza Abd. Ghani* and John Tang Yew Huat

School of Food Industry, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, 22200 Besut, Terengganu, Malaysia

*Corresponding author: asmaliza@unisza.edu.my

**ABSTRACT**

This study was carried out to produce powdered yogurt from goat milk with longer shelf life. Two methods of drying process of yogurt were used which are vacuum-oven drying (VD) and freeze-drying (FD). Goat milk yogurt powder prepared with added *Tualang* honey (TH) was produced by freeze-drying method. In this study, four formulations of yogurt were prepared with the addition of commercial yogurt containing as starter culture. Granulated sugar was added about 8% into the yogurt as control sample. While other three yogurts were prepared with 8% of *Tualang* honey, 6% of *Tualang* honey with 2% of sugar and 4% of *Tualang* honey with 4% of sugar. The proximate analysis was used in order to identify the proximate composition and pH value of the yogurt. The moisture content of goat milk yogurt, VD goat yogurt powder and FD goat yogurt powder were 79.20%, 8.22% and 9.66% respectively. While, the moisture content for FD goat yogurt powder with addition of 4%, 6% and 8% *Tualang* honey were 15.12%, 15.92% and 13.53% respectively. While the value of ash content for FD goat milk yogurt powder with addition of 4%, 6% and 8% *Tualang* honey were 0.37%, 0.35% and 0.50% respectively. The total protein content for goat milk yogurt was 4.61% while in VD goat yogurt powder and FD goat yogurt powder were 15.04% and 15.07% respectively. The value of protein content for FD goat milk yogurt powder with addition of 8% of *Tualang* honey was 15.38%. The pH value of goat milk sample and fresh yogurt goat milk were 6.52 and 3.82. The pH values for fresh yogurt with addition of 4%, 6% and 8% of *Tualang* honey were 4.64, 4.68 and 4.73. Vacuum-oven drying method and freeze-drying method did not show any significant different in moisture, ash and protein content but showed significant different in pH value.

**Keywords:** Goat milk, freeze-drying, vacuumoven-drying, *Tualang* honey, yogurt powder

**INTRODUCTION**

Yogurt is a popular fermented milk product that can be taken as a diet or refreshing beverage (Olugbuyiro & Oseh, 2011). Yogurt is made by fermenting milk with bacterial cultures which are *Streptococcus* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (Lee & Lucey, 2010). The real “live” yogurt in milk or milk product fermented by the true yogurt cultures and the cultures are still active at the time of consumption. Yogurt is also high in protein, vitamins, fatty acids and minerals, especially calcium and phosphorus. Another important value is that the bacteria partially digested the lactose during fermentation making the final product...
more digestible for lactose intolerant individuals (Santos et al., 2018a). Goat milk yogurt has lower mass of coagulated matter compared with cow milk yogurt (Bruzantin et al., 2016). Besides, smooth body and sharp flavour of goat yogurt can easily be compared from cow milk yogurt by the consumer. Goat yogurt also did not show any whey-offs well. Also, goat milk yogurt has faster development of lactic acid than cow yogurt (Loewenstein et al., 1980). However, Gomes et al., (2013) claimed that the flavour of goat’s milk is more intense than cow’s milk, which can restrict the acceptance of its derive by consumers.

Two types of drying methods were used in this study: freeze-drying and vacuum-oven drying. Freeze-drying also considered one of the most advanced methods for drying high value products sensitive to heat such as yogurt. It prevents undesirable shrinkage and products materials with high porosity, unchanged nutrition quality, taste, aroma, flavour and colour retention (Oikonomopoulou et al., 2011). The food will be frozen, then the surrounding pressure will be decreased, allowing the frozen water in the substance to directly sublime from the solid to the gas phase (Ahmed et al., 2013). While vacuum-oven drying is utilized at decreased pressure, empowering food to be dried at lower temperatures. By this drying technique, less oxidation occurs because of the absence of air, while the sensorial properties of the dried foods are maintained (Suna, 2019). Vacuum drying is conceptually the ideal method for drying materials sensitive to heat or oxygen (such as microorganisms and enzymes) due to the advantage of removing moisture at low temperature and minimizing the possibility of oxidation reaction (Ghandi et al., 2013). The primary goal of producing yogurt powder is to ensure that the quality of product is shelf stable. Furthermore, yogurt powder has a distinct flavour and nutrients that make it suited for a wide range of food applications, including replacing fresh yoghurt in beverages and dips, as well as being used in confectionery as a coating material for fruit, nut, and cereal coating (Krásaekoopt & Bhatia, 2012). Sunitha et al., (2016) reported that, the reduced weight and bulk water of this dehydrated product decrease packaging, handling, and transportation cost. Moreover, the water reduction in yogurt contributes to greater preservation and facilitates transport and packaging due to the reduced weight of the product (Santos et al., 2018a).

Honey is a frequent natural sweetener that can replace sugars in foods and have many health benefits when it is consumed. One of the commonly honey in Malaysia is called Tualang honey. Honey, in general, has a high sugar content but low water content and acidity, which inhibits microbial growth. *Apis dorsata* bees or known as Asian rock bees harvested the Tualang honey from the combs where they build their hives up in tualang tree (*Koompassia excelsa*) (Tan et al., 2009). This type of honey has high level of phenolic acid and flavonoids content and it has been reported for being particularly anti-inflammatory, anti-microbial, anti-oxidant and anti-ageing (Ranneh et al., 2018). Moreover, Tualang honey also has the best antioxidant potential, ferric reduction capability, and colour intensity (Moniruzzaman et al., 2013). The aim of this study is to prepare goat milk yogurt powder produced by different drying methods which are freeze-drying with addition of different percentage of Tualang honey and vacuum-oven drying. Besides that, to determine the physicochemical properties of goat milk yogurt powder.

**MATERIALS AND METHODS**

**Materials and Chemicals**

Fresh goat milk yogurt was purchased from a supplier of local milk farm at Kampung Lubok Kawah, Jerteh, Terengganu. Ground sugar, Tualang honey, gelatine and Farm Fresh plain yogurt which act as starter culture were purchased from supermarket in Jerteh, Terengganu. Chemicals used in this study including Kjeltabs Cu (Fishier Scientific), concentrated sulphuric acid (R&M chemicals), boric acid (EMSURE®) and hydrochloric acid (J.T.Baker®).
Sample Preparation

Yogurt Preparation

Fresh goat milk was pre-heated to 90ºC for 10 minutes. Sugar was added at a rate of weight at 8% and stirred well. Then, the heated milk is mixed with stabilizer, which is gelatine at rate of weight at 0.4% and cooled to 43ºC. After that, 5% of commercial yogurt, which was act as starter culture was added into the mixture. The sample then was incubated in incubator (Memmert, Germany) at 40°C for nearly five hours and stored in the refrigerator at 4 °C. Four formulations were used in this research: which are one for control and the other formulations were added with different percentages of Tualang honey (4%, 6% and 8%) and sugar (2% and 4%) for freeze-drying, while for vacuum drying, the yogurt with 8% of sugar was prepared.

Freeze-Drying

The yogurt samples were placed in stainless steel trays and stored in a freezer at -25 ± 2°C for 24 hours prior to freeze drying. Then, the samples were placed in the freeze dryer (SP Virtis, Genesis Pilot Lyophilizer, USA) operating at -40°C in the condensation chamber under vacuum, at a minimum pressure for about 31 hours. The freeze-dried samples were ground in a dry mill blender for about 30 seconds to obtain a homogeneous product, which was stored in polyethylene terephthalate plastic jar.

Vacuum Oven-Drying

150 g yogurt was spread in a stainless-steel tray with thickness 3mm. Then, it was placed inside the vacuum oven (Memmert VO400, Germany, 49 L volume) at 70 °C and 33.3 kPa for 24 hours.

Figure 1 and Figure 2 below shows the sample of fresh yogurt and yogurt powder with addition of 8% TH, 6% TH - 2% sugar, 4% TH - 4% sugar and 8% sugar prepared by freeze drying (FD) method, while Figure 3 shows a yogurt powder prepared by vacuum-oven drying (VD) method. Fresh yogurt with 8% TH, 6% TH – 2% sugar and 4% TH – 4% sugar were yellowish than the fresh yogurt with sugar. This is affected by the colour of TH added into the yogurt.

Fig.1 Fresh yogurt with addition of (i) 8% TH, (ii) 6%TH - 2% sugar, (iii) 4% TH - 4% sugar and (iv) 8% sugar
Moisture Content Analysis

Moisture analysis of the sample was determined by using the oven drying method which have been approved by the AOAC international as the standardized method in determining the amount of moisture in food sample. Crucible was dried in an oven at 105 °C for 4 hours and it was let to be cooled in a desiccator until it reached room temperature. After reaching room temperature, the weight of the crucible was recorded as (W1). Then about 5 g of sample was added into the crucible and weighed as (W2). The crucible was transferred into the oven and dried overnight at 105 °C. Next, the crucible was removed from the oven and let to be cooled in a desiccator and weigh soon after reaching room temperature (W3). The percentage of moisture was calculated using the formula below:
**Ash Analysis**

Ash content of yogurt samples was determined according to the method by AOAC (1990). The crucible was dried in an oven at 105 °C for 4 hours. Then it was let cooled in a desiccator and until reaching room temperature, it was weighed as (W1). Then about 5 g of homogenized sample was weighed and added into the crucible as (W2). The crucible with sample was burned in muffle furnace at 550°C for overnight. Lastly, the crucible was removed and cooled inside the desiccator until reaching room temperature, it was then weighed as (W3). The percentage of total ash was calculated using formula below.

\[
\% \text{Ash} = \frac{W_3 - W_1}{W_2} \times 100
\]

Where;
- W1 = Weight of crucible (g)
- W2 = Weight of sample (g)
- W3 = Weight of crucible + ash (g)

**Protein Analysis**

Protein content of yogurt samples was determined according to the method by AOAC (1990). By using Kjedahl method, the crude protein was determined from the nitrogen content in the food. There are three stages involved which are digestion, distillation and titration. 1 g of sample was weighed and then two Kjeltabs catalyst was added into the digestion tube. Next, 12 ml of concentrated H₂SO₄ was carefully added. About 60-90 minutes, the samples were digested until a clear green or blue solution is formed. The tubes were removed and cooled in the stand for 10-20 minutes. In the distillation process, 25 ml of receiver solution (25 ml of 2% boric acid with 5 drops of indicator solution) was added into the conical flask. Then, the conical flask was placed into the distillation unit and close where the distillate outlet was submerged in the receiver solution. Next, distilled water was dispensed into the tube and followed by 50 ml of 32% NaOH. About 4 minutes, the receiver solution will be green which indicates the presence of alkali substances. The final step is titration. The distillate with standardized hydrochloric acid 0.1N until the colour turns to pink. The volume of HCL used for the sample and blank was recorded. The crude protein was calculated using the formula below.

\[
\% \text{Nitrogen} = \frac{0.1 \times (A - B) \times 14.007 \times 100}{\text{Weight of sample (g) \times 100}} \times 10
\]

Where;
- 0.1 = Molarity of HCL
- A = Volume of HCL for sample (ml)
- F = Protein Factor (6.38)
**Determination of pH**

1 g of the yogurt sample was dissolved with 10 ml distilled water in a beaker. Then, the pH was measured by immersing the electrodes of pH meter (Mettler Toledo, Germany) in the samples solution and the pH readings were recorded. The pH meter was calibrated with buffer solution at pH 4.0, 7.0 and 10.0 prior to analysis.

**Statistical Analysis**

Data analysis was conducted by using SPSS software. The analysis of variance (ANOVA) tests has been used to evaluate the difference between the data. The means were separated by Tukey’s post hoc test with significant differences were determined at (p≤0.05).

**RESULTS AND DISCUSSION**

Samples were compared for the proximate analysis of moisture content, ash content and protein analysis.

**Moisture Content Analysis**

Table 1 and Table 2 below presented the mean values for different formulation of fresh goat yogurt, goat yogurt powder prepared by FD and VD method. Moisture content of fresh goat yogurt added with 8% *Tualang* honey is higher than fresh goat yogurt added with sugar which is 82.02% and 79.20% respectively with significance statistical difference (p≤0.05). Moniruzzaman et al., (2013) reported that *Tualang* honey had the highest moisture content (17.53%). Hence, the addition of *Tualang* honey increased the moisture content of the goat yogurt. The moisture content present in honey is important as it contributes to its ability to resist fermentation and granulation during storage (Moniruzzaman et al., 2013).

Moisture content of FD goat yogurt powder decreased sharply compared to fresh goat yogurt indicates that freeze-drying method was able to reduce the moisture content of the yogurt. As shown in Table 2, there is significant statistical difference (p≤0.05) between FD goat yogurt powder added with 8% of *Tualang* honey (13.53%) and FD goat yogurt powder added with sugar (9.66%). As stated by Ibrahim et al., (2020), freeze-drying was able to reduce water activity of foods while retain the nutritional and sensory qualities. Plus, yogurt powder which is a dehydrated product producing by freeze-drying can increase its shelf life.

Vacuum drying principles are similar to freeze drying with the main exception of elevated temperatures and vacuum level, thus the material is kept in a non-frozen state during the whole process, this means that the removal of water during vacuum drying is more rapid than during ice sublimation (Domínguez, 2011). Vacuum oven-drying and freeze drying are utilized at decreased pressure and low temperature of drying process.

**Ash Content Analysis**

Table 1 below shows that there is no significant statistical difference (p≤0.05) between fresh goat yogurt with different percentage of *Tualang* honey (4%, 6% and 8%) and fresh goat yogurt with addition of sugar on ash content. Meanwhile, there are significant statistical difference (p≤0.05) of ash content values between goat FD yogurt powder with addition 8% of *Tualang* honey (0.50 ± 0.31) and FD goat yogurt powder with addition of sugar (0.26 ± 0.04). Moniruzzaman et al., (2013) reported that *Tualang* honey has mineral value with 0.75 mS/cm. Hence, mineral value of *Tualang* honey contributed to higher ash content in both fresh goat yogurt and FD goat yogurt powder with addition of *Tualang* honey compared to fresh goat yogurt and FD goat yogurt powder with addition of sugar.
The result of the average levels of total ash content of goat yogurt powder on these two drying methods meet the standard. SNI 2981:2009 state that the maximum total ash content is 1.0% (Nurwantoro et al., 2020). Likewise, as stated by Hassan et al., (2007), the removal of water and moisture by heat during drying procedure cause increasing in nutrients concentration and make the nutrients more available. Ash content is the measure of total amount of minerals present within a food. The specific characteristics of minerals have a low volatility and not destroy by heat can be as a description for the increasing of ash content of dried yogurt sample after drying (Siti Mahirah et al., 2018).

**Protein Content Analysis**

Table 1 below shows there is no significant statistical different (p>0.05) between fresh goat yogurt with 8% of Tualang honey and fresh goat yogurt with addition of sugar on the protein content. However, the result is incomparable with Moniruzzaman et al., (2013) which stated that Tualang honey contain high amount of protein (4.83 g/kg) which contributed to higher protein content in the yogurt production.

Meanwhile, from Table 2, there is significance statistical different (p≤0.05) between FD goat yogurt powder with 8% Tualang honey and FD goat yogurt powder with addition of sugar. However, according to Ibrahim et al., (2020), freeze-dried product has protein content within 33.0% to 36.0% due to destruction protein in yogurt as well as the destruction of hydrogen bonds and non-polar hydrophobic reaction. During the drying process, molecule bond will damage and denaturation and coagulation of milk protein occurred. The protein content in VD goat yogurt powder and FD goat yogurt powder were 15.04% and 15.38% respectively. High water content in food matrix can explained this result which it decreases the nutrient concentration.

**Determination of pH**

As represented pH value in Table 1 below, fresh goat yogurt with addition of different percentage of Tualang honey (4%, 6% and 8%) and fresh goat yogurt with addition of sugar were acidic which range from 3.82% to 4.73%. pH value between fresh goat yogurt with addition 8%, 6% and 4% of Tualang honey and fresh goat yogurt with addition of sugar shows significant statistical difference (p≤0.05) with values 4.73, 4.68, 4.64 and 3.82 respectively. The result of higher acidity of fresh goat yogurt with addition of sugar can be supported by Olugbuyiro & Oseh, (2011) which stated that plain yogurts were more acidic with mean pH range from 3.70 to 4.08.

Meanwhile, there is significance statistical difference (p≤0.05) in pH between fresh goat yogurt and FD goat yogurt powder with addition of Tualang honey where FD goat yogurt powder results in higher acidity than fresh goat yogurt. However, there were no significant statistical difference (p≤0.05) in pH between fresh goat yogurt and FD goat yogurt powder with addition of sugar.

From Table 3, the pH value of Tualang honey was acidic (2.67) while the pH of the fresh goat milk is near to neutral (6.52). The addition of Tualang honey with different percentage in yogurt has led to slight reduction of initial pH in yogurt formulation containing Tualang honey. The result in Table 1 shows that there only a slightly difference on pH value between fresh goat yogurt with addition of 8%, 6% and 4% of Tualang honey (4.73 ± 0.04, 4.68 ± 0.01 and 4.64 ± 0.03 respectively). The concentration of gluconic acid had an impact on the pH of honey. Gluconic acid is a by-product of glucose oxidation by glucose oxidase, hence a honey that has been kept for a long time will have a lower pH value (Roslan et al., 2015). Besides, Oliveira et al., (2001) and Lucas et al., (2004) stated that L.bulgaricus produce lactic acid during refrigerated storage known as post acidification. Furthermore, extending the storage time, there were steady decrease in pH value reaching the minimum value at the end of storage period due to the deliberate metabolic activity of the yogurt starter culture. Moreover, the addition of goat milk in the yogurt formulation also results in a lower pH. The acidification rate of lactic acid bacteria can be affected by use of different types of milk (Dimitrellou et al., 2019).
Table 1. Proximate analysis and pH value of fresh goat yogurt

<table>
<thead>
<tr>
<th>Sample</th>
<th>Formulation</th>
<th>Moisture Content (%)</th>
<th>Ash Content (%)</th>
<th>Protein Content (%)</th>
<th>pH Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh goat yogurt</td>
<td>8% TH</td>
<td>82.02 ± 0.10a</td>
<td>0.07 ± 0.00b</td>
<td>3.91 ± 0.09c</td>
<td>4.73 ± 0.04c</td>
</tr>
<tr>
<td></td>
<td>6% TH – 2% sugar</td>
<td>80.85 ± 0.51ab</td>
<td>0.07 ± 0.00b</td>
<td>-</td>
<td>4.68 ± 0.01b</td>
</tr>
<tr>
<td></td>
<td>4% TH – 4% sugar</td>
<td>80.29 ± 0.09bc</td>
<td>0.07 ± 0.01b</td>
<td>-</td>
<td>4.64 ± 0.03b</td>
</tr>
<tr>
<td></td>
<td>8% sugar</td>
<td>79.20 ± 1.35c</td>
<td>0.06 ± 0.00b</td>
<td>4.71 ± 0.51c</td>
<td>3.82 ± 0.01c</td>
</tr>
</tbody>
</table>

Each value is expressed as mean ± standard deviation (SD). a–c Means with different lowercase superscripts differ significantly (P > 0.05) according to Tukey’s test.

Table 2. Proximate analysis and pH value of FD goat yogurt powder and VD goat yogurt powder

<table>
<thead>
<tr>
<th>Sample</th>
<th>Formulation</th>
<th>Moisture Content (%)</th>
<th>Ash Content (%)</th>
<th>Protein Content (%)</th>
<th>pH Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD Goat yogurt powder</td>
<td>8% TH</td>
<td>13.53 ± 0.11e</td>
<td>0.50 ± 0.31a</td>
<td>8.71 ± 0.60b</td>
<td>3.75 ± 0.09c</td>
</tr>
<tr>
<td></td>
<td>6% TH – 2% sugar</td>
<td>15.92 ± 0.11d</td>
<td>0.35 ± 0.06ab</td>
<td>15.38 ± 0.34a</td>
<td>3.96 ± 0.03b</td>
</tr>
<tr>
<td></td>
<td>4% TH – 4% sugar</td>
<td>15.12 ± 0.75ab</td>
<td>0.37 ± 0.07ab</td>
<td>8.71 ± 0.60b</td>
<td>3.94 ± 0.02b</td>
</tr>
<tr>
<td></td>
<td>8% sugar</td>
<td>9.66 ± 0.08c</td>
<td>0.26 ± 0.04b</td>
<td>15.38 ± 0.34a</td>
<td>3.72 ± 0.02c</td>
</tr>
<tr>
<td>VD Goat yogurt powder</td>
<td>8% sugar</td>
<td>8.22 ± 0.13b</td>
<td>0.27 ± 0.02a</td>
<td>15.04 ± 0.28a</td>
<td>3.83 ± 0.01b</td>
</tr>
</tbody>
</table>

Each value is expressed as mean ± standard deviation (SD). a–c Means with different lowercase superscripts differ significantly (P ≤ 0.05) according to Tukey’s test.

Table 3. pH value of fresh goat milk and Tualang honey

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Goat Milk</td>
<td>6.52 ± 0.01</td>
</tr>
<tr>
<td>Tualang honey</td>
<td>2.67 ± 0.02</td>
</tr>
</tbody>
</table>

CONCLUSION

From this study, it could be concluded that vacuum oven-drying (VD) method and freeze drying (FD) method does not show a significant different in moisture, ash and protein content but showed significant different in pH value on the goat milk yogurt powder. FD and VD method were the appropriate drying method for high value product like yogurt in retaining the chemical composition of the end product since the procedure utilization of low drying temperature and low pressure were applied. Besides, addition of Tualang honey slightly changes the pH value of the yogurt. In terms of proximate analysis, freeze drying and vacuum drying method were able to reduce the moisture content of goat yogurt. Meanwhile, goat yogurt with addition of Tualang honey resulted in higher percentage of ash content.

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