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Local Wild Honey on Goat Milk Yogurt

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The objective of this study is to discover how wild honey and sugar ratios used in goat milk yogurt formulations affect physical, lactic acid bacteria (LAB) growth and sensory analysis. Four distinct goat milk yogurt formulations were developed: goat milk yogurt with additions of 8% honey (HH), 6% honey and 2% sugar (LS), 4% honey and 4% sugar (MH), and 2% honey and 6% sugar (LH). 8% sugar was added to goat milk yogurt sample to create a control sample (HS). The goat milk yogurt's pH, color, moisture content, acidity, and lactic acid bacteria count were determined. A total of 40 untrained panelists performed a sensory assessment to gauge consumer acceptance of the goat milk yogurt with different honey composition. For all of the formulations, the physical examination of moisture content, pH, and titratable acidity revealed values between 70.61% and 79.90%, 4.36 and 4.53, and 0.60% and 0.95%, respectively. The L*, a*, and b* values for all of the formulations were between 56.24 and 63.40, (-1.62) and (-2.40), and 4.56 and 5.76, respectively, for the color analysis. The lactic acid bacteria count ranged from 3.06 to 5.49 log cfu/ml, with HS recorded the highest number. LH yogurt was found to be most preferred by the panelist than other yogurt compositions. It can be concluded that the incorporation of honey at 2% improved the goat milk yogurt characteristics and has potential to be developed into new goat milk based products.

Keywords: goat milk yogurt, honey, sensory assessment

INTRODUCTION

The Codex Alimentarius of 1992 defines yogurt as a coagulated milk product produced by the fermentation of lactic acid in milk by *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Bourlioux & Pochart, 1988). Yogurt is a good source of various essential nutrients, such as calcium, protein, phosphorus, potassium, vitamin B_2 and vitamin B_{12} (Carmuega & Weill, 2014). During the culturing process, ingredients such as concentrated skim milk, non-fat dry milk, buttermilk, whey, modified whey, lactalbumins, lactose and lactoglobulins may be added into the yogurt to increase the non-fat solid content in the yogurt (Trachoo, 2002).

On average, the composition of goat milk includes total solids of 13.2% which consists of 4.5% fat, 3.6% protein, 4.3% lactose and 0.8% minerals. Goat milk contains lower lactose levels compared to cow's milk and has higher total solid, fat, protein, casein and minerals than cow's milk (Turkmen, 2017). The structure and content of their milk lipids are the main differences between goat milk and cow milk. The fat globule range in both goat milk and cow milk is 1 to 10 µm. However, the ratio of fat globules smaller than 5

µm in cow milk is roughly 60%, but it is 80% in goat milk, which is greater than cow milk. This means that the fat globules in goat milk are smaller than those in cow milk (Silanikove, 2010).

In general, honey contains high sugar content but both its water content and its pH are low, these properties help inhibit the microbial growth in honey (Ahmat Azemi,et al., 2021). Honey is produced by about 500 species from 32 genera all over the world (Michener, 2013). Naturally, honey contains a few amounts of antioxidants which includes phenolics, flavonoids and carotenoids, organic acids, amino acids and Maillard reaction products in its composition (Lachman, 2010). Stingless bee honey has particular sweetness to it, as well as a sour and acidic flavor and their honey are more fluid compared to other bees' honey, moreover, their honey also contributes to slow crystallization (Abd Jalil et al., 2017; Biluca et al., 2016).

In recent years, the research into the development of yogurt-based products had increased since there were major demands from the customers which is their demand for healthier foods. Therefore, this has led to development of novel functional dairy products with potential health benefits such as probiotic yogurts. Besides, the customers are also interested in dairy products such as probiotic yogurts with new flavors (Dimitrellou et al., 2019). There are only a few studies which used honey as one of the ingredients in the yogurt production (Machado et al., 2017). The popularity of the honey is low resulting from the lack of understanding of this honey, making it being less known in terms of industrial production, quality standard and shelf life (Abd Jalil et al., 2017).

The addition of honey into goat milk yogurt may increase their nutritional value and affect the physical properties of the yogurt itself. However, the impact on the starter cultures also must be evaluated (Machado et al., 2017). The aims of this study include determination of the physical, LAB and sensory properties on goat milk yogurt.

MATERIALS AND METHODS

The pasteurized goat milk was obtained frozen from the local supplier from Jerteh, Besut while the wild honey from nearby supplier from Jerteh uses local wild honey bees. The frozen goat milk was stored in the freezer at 0 °C while the local wild honey was stored in the chiller at 4 °C immediately. Commercial yogurt was used as the starter culture. The commercial yogurt used is from Lactel brand with original flavor without any addition of artificial flavorings and colorings.

Preparation of yogurt

The frozen goat milk was thawed in the running tap water until the frozen goat milk fully melted. The weight of gelatin and starter culture were constant for all formulations while the weight of local wild honey and granulated sugar added were dependent on the ratio of the formulation. The fully thawed goat milk was pre-heated at a temperature of 90 °C for 10 minutes. This is to eliminate undesired microbes which may contain in the goat milk. Granulated sugar was added into the heated milk at a rate of weight of 8%. The mixture was stirred to make sure that sugar mixed well with the goat milk. The honey also was added according to its weight over weight (w/w) based on the formulations in Table 1. The stabilizer or the gelatin was added at a rate of weight of 0.4% into the mixture and stirred well again. After the mixture has mixed well, the goat milk mixture is cooled immediately in the ice bath until its temperature reaches 43 °C or below. This immediate cooling step is to prevent bacterial contamination from occurring during the cooling process.

After the goat milk mixture has cooled, the commercial yogurt was added, which acts as starter culture at the rate of weight of 5% into the mixture. The mixture was mixed well and was incubated at a temperature of 40 °C for five hours. After being incubated, the goat milk yogurt was produced and stored in the chiller at 4 °C.

pH

The physical analysis was done on all of the samples (HS, LS, MH, LH and HH) samples which includes the pH determination, color determination, moisture content determination and acidity determination. The pH values were determined using the pH meter (Mettler Toledo, Germany). The pH meter was calibrated using the buffer solution with pH of 4, 7 and 10 to standardize the device before the analysis was conducted. The ratio dilution of the sample used was 1:10, which 1 g sample was diluted in 10 ml distilled water. The mixture was stirred and mixed well. The pH reading was recorded and the steps were repeated to take at least 3 readings of pH values thus to obtain the average value (Ahmat Azemi, et al., 2021).

Table 1. Formulations of Goat Milk Yogurt.

Samples	Goat milk	Stabilizer	Starter culture	Sugar	Honey

HS	86.6%	0.4%	5%	8%	-
LS	86.6%	0.4%	5%	2%	6%
MH	86.6%	0.4%	5%	4%	4%
LH	86.6%	0.4%	5%	6%	2%
HH	86.6%	0.4%	5%	-	8%

Source: (Ahmat Azemi,et al., 2021).

Moisture content

The oven drying method was used for the determination of the moisture content for goat milk yogurt. The crucibles were dried in the oven for 4 hours at temperature of 105 °C. The crucibles were cooled in the desiccator until it finally reached room temperature. The cooled crucibles were weighed and recorded as (W1). Approximately 5 g of goat milk yogurt control samples (HS) was weighed. The 5 g sample placed into the crucible was weighed and its weight was recorded as (W2). Next, the crucibles containing the sample were transferred into the oven and dried at a temperature of 105 °C overnight. After drying, the crucibles were removed from the oven and cooled in the desiccator until it reached room temperature. After the crucible has cooled, the crucibles were weighed and recorded as (W3). The steps were repeated for the other formulation samples (LS, MH, LH and HH). The percentage of the moisture content for the sample were calculated after all of the W1, W2 and W3 values were obtained using the equation below:

$$\%\,moisture = \frac{W2 - W3}{W2 - W1} \times 100\%$$

Where;
W1: weight of empty crucible (g)
W2: weight of crucible + weight of wet sample (g)
W3: weight of crucible + weight of dried sample (g)

Color

The color of goat milk yogurt samples of all formulations was determined using CR-400 colorimeter (Minolta Co. Osaka, Japan). According to International Commission on Illumination, the color will be determined using the L*, a* and b* parameters (C.I.E, 1986). The L*, a* and b* values each represent different meanings, for L* which mean luminosity represents light and dark, while for a* value represents will give either of 2 values which are +a means red and -a means green. For b* value also will give either of 2 values which are +b means yellow and -b means blue.

Titratable acidity

Titratable acidity was used to determine the acidity of the samples. Ten grams of goat milk yogurt sample was weighed and the sample was dissolved in 30 ml of distilled water. The solution was mixed thoroughly to make sure the sample totally dissolved. The solution was transferred into a conical flask. The burette was filled with 0.1M NaOH solution. The first reading of the volume of NaOH solution before titration was recorded. 8 drops of phenolphthalein indicator were dropped into the solution. The mixed solution was titrated against NaOH solution until the solution turns into pale pink color. The reading of NaOH solution in the burette was recorded after the titration was completed. Titratable acidity for each formulations of goat milk yogurt samples were calculated using the equations below (Matela et al., 2019):

$$titratable\ acidity\ (\%) = \frac{vol.\,NaOH\ used\ (ml) \times 0.1M\ NaOH\ \times\ milliequivalent\ factor}{mass\ of\ sample\ (g)} \times 100\%$$

Where;
V1: Volume of 0.1M NaOH solution before titration (ml)
V2: Volume of 0.1M NaOH solution after titration (ml)
Milliequivalent factor of lactic acid: 0.090

Lactic Acid Bacteria (LAB) enumeration

For the microbial analysis, the purpose is to count the LAB in the goat milk yogurt samples using the spread plate method on the MRS agar plate. The bacteria from the starter culture are *Streptococcus thermophilus* and *Lactobacillus bulgaricus* as stated in the Lactel yogurt ingredients list. The agar used for this starter bacteria group was the MRS Agar. The serial dilutions of each sample were done up to 10^{-8} in saline. A volume of 0.1ml was spread on MRS agar plates. The plates were incubated at 37°C for 24 hours (Hasan et al., 2016). The numbers of LAB were expressed as in (log cfu/ml) which is log of the colony forming units per ml of goat milk yogurt sample.

Sensory evaluation

As for the sensory evaluation, the attributes to be evaluated includes the appearance, aroma, texture, sweetness, sourness and overall acceptability of the goat milk yogurt. The sensory for goat milk yogurt samples were evaluated by 40 untrained panelists which were undergraduate students and postgraduate students of Universiti Sultan Zainal Abidin (UniSZA), Besut Campus. The seven-point hedonic scale was used to evaluate all of the goat milk yogurt samples. The score was shown in Table 2. (Matela et al., 2019).

Table 2. The 7-point scale hedonic test

Score	Details
1	Dislike very much
2	Dislike moderately
3	Dislike slightly
4	Neither like nor dislike
5	Like slightly
6	Like moderately
7	Like very much

Source: (Matela et al., 2019)

All of the analysis including physical and microbial analysis were taken in three readings and the results were expressed as means. ANOVA or one-way analysis of variance were used to compare means at the significant level $p<0.05$. SPSS software was used to perform the data from the analysis.

RESULTS

Moisture content

The moisture content for the HH sample is 79.90% which is a significant difference ($p<0.05$) compared to LS sample which is 70.61%. The 8% amount of honey added in the HH sample may affect the moisture content of the HH goat milk yogurt. The HS goat milk yogurt formulation with addition of sugar is 8% in its formulation and without addition of honey, the moisture content obtained is 74.39.

pH

The pH from goat milk yogurt formulations LS, MH, LH and HH with addition of honey at different levels of 6%, 4%, 2% and 8% respectively shows significant statistical difference ($p<0.05$) with values obtained 4.40, 4.45, 4.49 and 4.36 respectively. The HS goat milk yogurt without addition of sugar shows the highest pH value which is significantly different ($p<0.05$) to other formulations which is 4.53. According to FDA guidelines, all of the yogurt samples should have pH levels with a maximum of 4.5 (Weerathilake et al., 2014). Therefore, from Table 3., the pH values obtained for all of the goat milk formulations are within the FDA guidelines.

Titratable acidity

From Table 3., the percentage of titratable acidity for HS, LH and HH formulation are significantly statistical difference ($p<0.05$) with each other which are 0.60%, 0.77% and 0.95% respectively where the amount of titratable acidity for HH goat milk yogurt is the highest and the amount of titratable acidity for HS goat milk yogurt is the lowest. According to the FDA specification, only HH goat milk yogurt formulation is compiled since it has 0.95% which is above its minimum requirement.

Color

The color was measured based on L*, a* and b* values. L* which stands for luminosity is for the brightness, where as a* value is for redness, +a means the redder the color of the food, -a means the greener the color of the food. b* value indicates the yellowness, +b means the yellower the color of the food while -b means the increase in blue color of the food (Anupama et al., 2003). From Figure 1, of comparison of color between the different goat milk yogurt formulations, the highest L* value obtained is 63.40 for HH formulations where the lowest L* value obtained is LS goat milk yogurt formulations. This shows that HH goat milk yogurt with full addition of honey has lighter color compared to HS goat milk yogurt without addition of honey. There is no significant statistical difference ($p<0.05$) among the L* values of all goat milk yogurt formula.

Table 3. Physical analysis of moisture content, pH and titratable acidity for different goat milk yogurt formulations.

Parameter	HS	LS	MH	LH	HH
Moisture content (%)	74.39±1.50[ab]	70.61±2.75[a]	74.39±4.37[ab]	76.51±0.38[ab]	79.90±0.38[b]
pH	4.53±0.01[e]	4.40±0.02[b]	4.45±0.01[c]	4.49±0.01[d]	4.36±0.01[a]
Acidity (%)	0.60±0.04[a]	0.88±0.03[cd]	0.79±0.04[bc]	0.77±0.04[b]	0.95±0.03[d]

HS – goat milk yogurt with 8% sugar; LS – goat milk yogurt with 2% sugar and 6% honey; MH – goat milk yogurt with 4% sugar and 4% honey; LH – goat milk yogurt with 6% sugar and 2% honey; HH – goat milk yogurt with 8% honey. [a – e] values indicated different superscripts letters are statistically significant difference ($p<0.05$) from each other, based on Tukey's test. Presented data are mean values of triplicate value with ± standard deviation shown in error bar.

According to Figure 1, the lowest a* value obtained is -2.40 for HS goat milk yogurt formulation is significantly different ($p<0.05$) to the HH goat milk yogurt which has the highest a* value of -1.62. Figure 1. also shows that there is increasing pattern of a* values as the percentage of addition of honey increases. From HS goat milk yogurt without addition of honey, LH goat milk yogurt with 2% honey, MH goat milk yogurt with 4% honey, LS goat milk yogurt with 6% honey and HH goat milk yogurt with 8% honey shows a* values of -2.40, -2.20, -1.95, -1.83 and -1.62 respectively. This indicates that as the amount of addition of honey increases, the a* values also increase means the redder the color of the goat milk yogurts.

Figure 1. shows that there are also increasing pattern for b* values for all goat milk yogurt formulations with addition of honey. As for the control sample which is HS goat milk yogurt without addition of honey, the b* value obtained is 4.49 which is significantly different ($p<0.05$) to the HH goat milk yogurt which is 5.76. From LH formulation with 2% honey, MH goat milk yogurt with 4% honey, LS goat milk yogurt with 6% honey and HH goat milk yogurt with 8% honey shows the b* values of 4.56, 5.06, 5.31 and 5.76 respectively. As b* value increases means the yellower the color of the goat milk yogurt.

LAB enumeration

Table 4. shows the number of LAB in goat milk yogurt samples. The highest number of LAB obtained was 5.49 log cfu/ml for HS goat milk yogurt formulations with 8% sugar and without addition of honey. There were no significant differences ($p>0.05$) for the LAB count in all goat milk yogurt formulations.

Sensory evaluation

40 untrained panelists from UniSZA students participated in this goat milk yogurt sensory evaluation. Each panel was presented with 5 samples at once and they evaluated each of the yogurt samples according to attributes provided which are the appearance, aroma, sweetness, sourness, texture and overall acceptance. This study has been assigned with a study protocol code (UniSZA/UHREC/2021/338) which should be used for all communications with UHREC related to this study.

A 7-point hedonic scale was used to determine the degree to which one or more goat milk yogurt are acceptable. This is a categorical scale with seven-point categories ranging from scale 1 as "dislike extremely", scale 4 as "neither like or dislike" and scale 7 as "like extremely". Based on their responses, the panelists will rank the product

on the scale (Zoecklein, 1991).

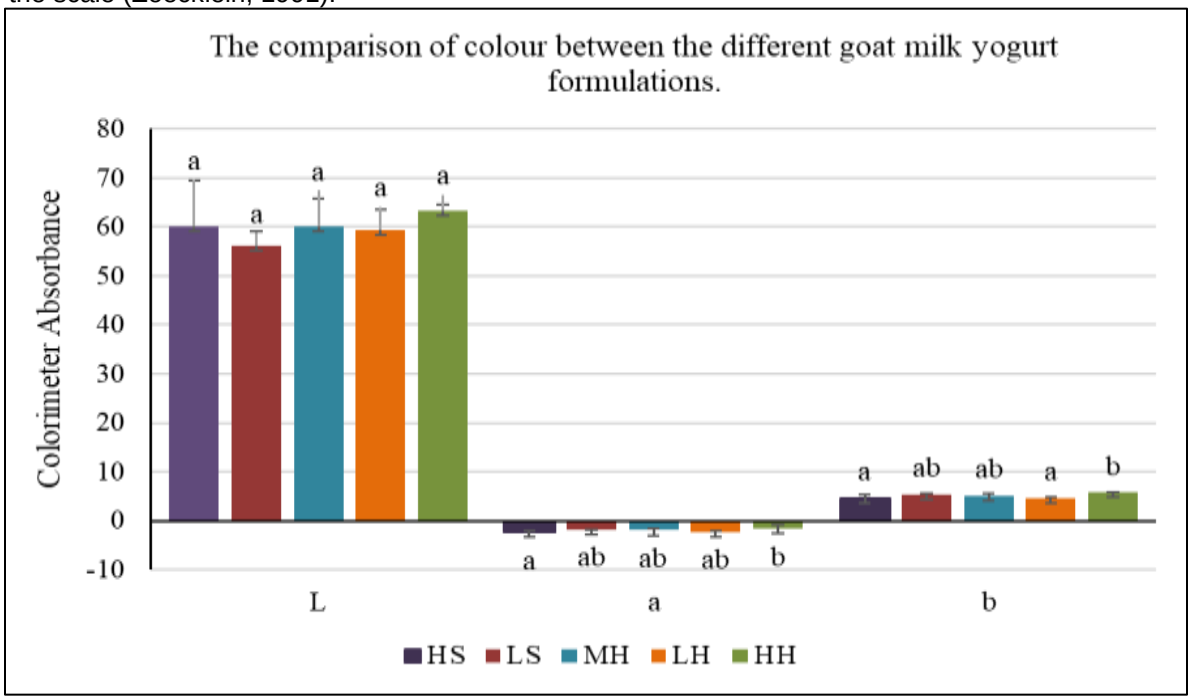

Figure 1. The comparison between the color of L*, a* and b* of goat milk yogurt with different formulations.

HS – goat milk yogurt with 8% sugar; LS – goat milk yogurt with 2% sugar and 6% honey; MH – goat milk yogurt with 4% sugar and 4% honey; LH – goat milk yogurt with 6% sugar and 2% honey; HH – goat milk yogurt with 8% honey. $^{a-b}$ values indicated different superscripts letters are statistically significant difference ($p<0.05$) from each other, based on Tukey's test. Presented data are mean values of triplicate value with ± standard deviation shown in the error bar.

Table 4. Lactic acid bacteria (LAB) count in goat milk yogurts.

Parameter	HS	LS	MH	LH	HH
LAB (log cfu/ml)	5.49±2.60^{a}	4.81±1.34^{a}	3.74±0.17^{a}	4.70±3.23^{a}	3.06±1.08^{a}

HS – goat milk yogurt with 8% sugar; LS – goat milk yogurt with 2% sugar and 6% honey; MH – goat milk yogurt with 4% sugar and 4% honey; LH – goat milk yogurt with 6% sugar and 2% honey; HH – goat milk yogurt with 8% honey. ^{a} value indicated different superscripts letters are statistically significant difference ($p<0.05$) from each other, based on Tukey's test. Presented data are mean values of triplicate value with standard deviation shown in the error bar.

From Figure 2, the most preferred goat milk yogurt formulation is the LH goat milk yogurt with 2% honey and 6% sugar, in contrast, the least preferred goat milk yogurt is HH goat milk yogurt with 8% honey and without addition of sugar.

Figure 2. shows that the scores obtained for attributes appearance, aroma, sweetness, sourness, texture and overall acceptance. As for the sourness and sweetness attributes for LH goat milk yogurt, most of the panelists preferred this formulation for its sourness and sweetness. Compared to the pH and acidity level of LH

formulations in Table 3., it shows that LH goat milk yogurt may contain mild acidity as its titratable acidity (0.77%) is slightly higher than HS goat milk yogurt (control) (0.60%) and its pH value (4.49) is slightly lower than control sample (4.53) and higher than HH goat milk yogurt (4.36). As for HH formulation, its sourness and sweetness attributes are the least preferred with the score of 4.38 and 4.18 respectively.

According to Figure 2, for appearance attributes, the most preferred yogurt is LH goat milk yogurt with a score of 6.05. From Figure 4.2, the L* value which indicates the brightness of the yogurt of LH formulation is 59.34 which is lower than HH formulation with 8% honey (63.40). As for the texture attribute, the least preferred yogurt is MH goat milk yogurt with a score of 4.4 and the most preferred is LH goat milk yogurt with a score of 5.85. As for attribute overall acceptance, the most preferred yogurt is LH goat milk yogurt (2% honey) with a score of 5.83 and the least preferred yogurt is HH goat milk yogurt (8% honey) with a score of 4.4. Although the intention of using honey as natural sweeteners in the goat milk yogurt to substitute sweeteners such as sucrose, however, the results obtained are not satisfying as expected. Since HH yogurt is the least preferred yogurt, therefore, HH yogurt with 8% honey and without addition of sugar is not suitable in terms of consumer acceptance. Conversely, for LH goat milk yogurt with 2% honey and 6% sugar is the most preferred yogurt, this indicates that honey can be used as side sweetener rather than as main sweetener in the goat milk yogurt.

DISCUSSION

The moisture content obtained from HS is 74.39%. Since there was no addition of honey in HS formulation, the moisture content of HS goat milk yogurt formulation should be the lowest compared to other goat milk yogurt formulations with addition of honey. The probability for inaccuracy to happen is the time of yogurt production for all formulations. The HS goat milk yogurt formulation was produced earlier a few days compared to other goat milk yogurt formulations. The occurrence of syneresis for HS yogurt may influence the increase in its moisture content because as the time increases, the protein networks from the goat milk yogurt become denser, they lose their ability to attract the whey, therefore, they will be ejected and visible on the surface of the goat milk yogurt (Machado et al., 2017). Yogurt should have less than 84% moisture as the texture and mouthfeel are impacted by the existence of more moisture (Matela et al., 2019a). The moisture content of all the goat milk formulations were below 84%.

Honey is known as one of the acidic foods with a pH of approximately 4.48. Therefore, adding honey into the goat milk yogurt makes the yogurt more acidic thus, lowering the pH of the goat milk yogurt. In addition, the lowering pH value of goat milk yogurt with addition of honey may be related to the increased honey concentration which appears to boost lactic acid metabolism and as a result, increases the acidification of yogurt (Machado et al., 2017). Given the natural acidity of stingless bee honey, its incorporation may have somewhat lowered the initial pH of yoghurt compositions which contains honey (Machado et al., 2017). The organic acids that are naturally present in honey's makeup are what give it its acidity (Chuttong et al., 2016). Since stingless bee honey contains prebiotic oligosaccharides that may, in small quantities, encourage the development and/or metabolic activity of lactic acid bacteria, as was earlier reported for sesame honey's effect on lactobacilli and bifidobacteria, this elevated acidity in yoghurts incorporating honey may also be related to the presence of these compounds (Das et al., 2015). However, the effect was not significant as sucrose that was used in HS goat milk yogurt also promoted the growth of lactic acid bacteria. HH goat milk yogurt samples show a significantly higher titratable acidity than other goat milk yogurt formulations, which could be owing to more fermenting microorganisms being available (Matela et al., 2019). The increase of total acidity of HH formulation might be associated with addition of honey since honey also has high total acidity as it has a low pH. Yogurt samples with honey addition had a lower pH than yoghurt samples without honey (Machado et al., 2017; Coskun and Karabulut Dirican, 2019). Glušac et al. (2015) discovered that yoghurt samples containing acacia honey incorporated at various ratios at the start and end of storage (21 days) had lower pH values than samples without honey. According to a study by Ammar El-Tahra et al. (2015), the pH levels of yoghurt samples with honey and ABT culture (S. thermophilus, Lb. acidophilus, and B. bifidum) were lower at the start and end of storage (15 days) than those of samples with only ABT culture. This might be caused by honey's prebiotic effects (Coskun and Karabulut Dirican, 2019).

Color has a significant role in determining quality and can influence consumer acceptance

(Mohan et al., 2020). The fermentation process is also connected to the color shift (Bielska et al., 2021). The technological process parameters can be selected and optimized based on the color measurement. (Bierzuńska et al., 2019). From HS goat milk yogurt without addition of honey, LH goat milk yogurt with 2% honey, MH goat milk yogurt with 4% honey, LS goat milk yogurt with 6% honey and HH goat milk yogurt with 8% honey shows a* values of -2.40, -2.20, -1.95, -1.83 and -1.62 respectively. This indicates that as the amount of addition of honey increases, the a* values also increase means the redder the color of the goat milk yogurts. This color difference in yogurt could be due to the addition of honey, as well as the oxidation of fatty acids and protolithic activity which occurs naturally in yogurt (Farkye et al., 2001). As for the control sample which is HS goat milk yogurt without addition of honey, the b* value obtained is 4.49 which is significantly different ($p<0.05$) to the HH goat milk yogurt which is 5.76. From LH formulation with 2% honey, MH goat milk yogurt with 4% honey, LS goat milk yogurt with 6% honey and HH goat milk yogurt with 8% honey shows the b* values of 4.56, 5.06, 5.31 and 5.76 respectively. As b* value increases means the yellower the color of the goat milk yogurt. Addition of honey into the goat milk yogurt also contributes to the increasing b* values of the goat milk yogurt with addition of honey since the color characteristics of honey and also the possible reaction of Maillard reaction which may occur in the yogurt (Farkye et al., 2001). The a* and b* values of all goat milk formulations added with honey were higher than the control sample. In the study conducted by Machado et al. (2017), Coskun and Karabulut Dirican (2019) and Sohrabpour et al. (2021), stated a* and b* values shown an increment with the enhancement of honey addition ratio. 5% of honeydew honey added into the kefir reduced the L* value by 4.7% and 5.3% while L* and red color intensity was observed in the physicochemical, rheological, and sensory features of kefir after the post-fermentation addition of fir honey (Dimitreli et al., 2019; Bielska et al., 2021). Yogurts sweetened with manuka honey recorded higher b* values than the unsweetened yogurts (Mohan et al., 2020).

A dairy product serving size of 100 g should have at minimum 6-7 log cfu/g or mL of live probiotic bacteria at the time of consumption to encourage customer beneficial health effects (Vinderola et al., 2000). All of the goat milk formulations contain below 6 log cfu/ml LAB with the highest of 5.49 log cfu/ml for HS goat milk yogurt formulations with 8% sugar and without addition of honey. According to Machado et al. (2017), yogurts containing additional stingless bee honey proved to guarantee the maintenance of greater counts throughout time as opposed to yogurts without additional honey. This was opposite to the results obtained from the current study. This could be caused by the inadequate amount of sugar available in all of the formulations that was necessary to promote the growth of the bacteria (Machado et al., 2017). In the recent study by Mohan et al. (2020), all sweetened with manuka honey samples displayed higher LAB counts than the unsweetened control, however due to the non-digestible oligosaccharide components, only the yogurts with honey as the sweetener can be regarded as a possible prebiotic.

Since there was presence of small amounts of prebiotic oligosaccharides in honey, they may enhance the growth and metabolic activity of lactic acid bacteria which are Lactobacillus bulgaricus and Streptococcus thermophilus (Machado et al., 2017). However, the effect was not significant as sucrose that was used in HS goat milk yogurt also promoted the growth of lactic acid bacteria.

Honey is known as high viscosity fluid; therefore, it will also influence the viscosity of the food added with honey. Honey also raises the overall solids content and improves the consistency of the finished product (Machado et al., 2017). Păucean et al. (2011) claim that the addition of honey might make the samples appear to be viscous because it can encourage higher total solids contents. In contrast, firmness was favourably associated with the total solids according to Mohan et al. (2020) textural characteristics. Honey is one type of natural sweetener which is a better choice for food business and consumers rather than refined sweeteners since some of the natural sweeteners contain additional nutrients and biologically active phytochemicals (Edwards et al., 2016). Honey as a natural sweetener may affect the yogurt's sweetness attribute but it also affects other properties such as physical behavior, color and flavor of the yogurt itself (Balthazar, et al., 2015).

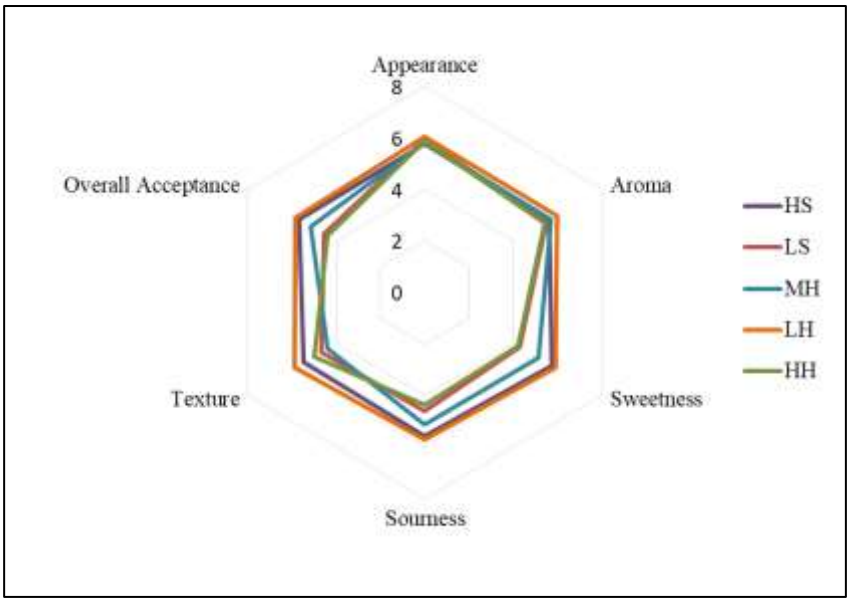

Figure 2. Sensory evaluation attributes' scores for different goat milk yogurt formulations.

HS – goat milk yogurt with 8% sugar; LS – goat milk yogurt with 2% sugar and 6% honey; MH – goat milk yogurt with 4% sugar and 4% honey; LH – goat milk yogurt with 6% sugar and 2% honey; HH – goat milk yogurt with 8% honey. Presented data are mean values of triplicate value with standard deviation shown in error bar.

Exopolysaccharide can be produced by probiotic bacteria and starter cultures (Coskun and Karabulut Dirican, 2019). Yogurt with a high exopolysaccharide content may have a finer consistency (Han et al., 2016). It is well recognised that microbial exopolysaccharides may enhance the body and consistency of fermented goods because they act as thickener, stabiliser, and emulsifier agents (Fazilah et al., 2018). The most preferred goat milk yogurt according to the sensory evaluation results is LH goat milk yogurt, which received the highest score for each of the qualities.

CONCLUSION

Honey is a natural sweetener which is suitable to be used as the side sweetener in goat milk yogurt, according to the findings from this study. Honey is unsuitable to be used to substitute commonly used sweeteners such as sucrose and glucose since honey can affect a variety of other properties besides the sweetness in the goat milk yogurt. From the physical analysis, which is the moisture content, it shows that honey may enhance the moisture content of the goat milk yogurt since honey itself has high moisture content. The findings of pH and titratable acidity show that as the amount of addition of honey increases, the pH value decreases and the titratable acidity rises, indicating that honey raises the acidity of goat milk yogurt. The color values of L*, a* and b* follow a proportionate pattern, with increasing values as the amount of honey increases. In terms of LAB count, it appears that honey has no effect on LAB growth. The most preferred goat milk yogurt according to the sensory evaluation results is LH goat milk yogurt, which received the highest score for each of the qualities.

CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

NAMA performed data analysis and wrote the manuscript. SNMM performed experiments and data analysis. AAG and JYHT designed experiments and reviewed the manuscript. All authors read and approved the final version.

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