

Microbiological, chemical and sensory characteristics of yoghurt prepared from blended cow and goat milk

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Abstract

Chemical composition, microbiological and sensory properties of five different yoghurt prepared from blended cow and goat milk were analyzed. The result of the chemical analysis indicated that, the water percentage, pH of the yoghurt samples were not significantly different ($P>0.05$). The total acidity of yoghurt samples, however, were significantly different ($P<0.05$). Microbiological analysis showed that, yoghurt prepared from 75% goat milk had the highest bacterial population of $\log 8.8692$ cfu/g, while yoghurt made of 100% cow milk showed the lowest bacterial load of $\log 8.3979$ cfu/g. The result of sensory analysis showed that, yoghurt made from 100% goat milk obtained the highest score in colour and aroma of 6.9 and 7.0 respectively, though they were not significantly different ($P>0.05$). Analysis of texture showed that, yoghurt made of blended cow and goat milk were significantly preferable ($P<0.05$). Taste and overall acceptability of yoghurt made from blended 75% cow and 25% goat milk showed the highest score and were significantly different ($P<0.05$), compared to yoghurt made from 100% cow milk.

Keywords: microbiological, chemical, sensory, yoghurt, cow milk, goat milk

1. Introduction

Milk consumption in Indonesia is low (about 12 litres/capita/year), due to low milk production and high price. Only 32 % of that milk, obtained through domestic production, and 68% were imported. Mostly domestic milk production was obtained from cow, though there was some milk obtained from buffalo and goat rising. In Bali, Indonesia, goat population is about 79.817 in 2014 (Ditjennak keswan, 2014), predominated by “Peranakan Etawah (PE)” goat. The PE goat was dual purpose, yield meat and milk. So far, much of the milk obtained from goat rising is not yet consumed due to its unpleasant “goaty” odour. On the other side, goat milk has many benefits to human health, even more than that of cow milk. Goat milk has higher digestibility due to its small fat globule, less allergic reaction (low α_s -casein content), higher calcium and sodium content, more bioavailability of copper, zinc, selenium and iron (Alvarez *et al.*, 2003; Campos *et al.*, 2001; Haenlein, 2004).

Processing the milk is an alternative to diversify fresh milk into milk products with better sensory properties, so that increase milk consumption. So far fermented milk product such as yakult and yoghurt are widely marketed in Indonesia and also in Bali. Yoghurt is a fermented milk product which has an acid refreshing taste. Yoghurt obtained from milk or milk product, which undergone lactic acid fermentation by *Streptococcus thermophilus* and *Lactobacillus delbrueckii* sbsp. *bulgaricus*. *Streptococcus thermophilus* is gram positive, not motile, coccus. These bacteria are homofermentative, facultatively anaerobe, grow optimally at 40-45°C and pH 6.8. *Lactobacillus delbrueckii* sbsp. *bulgaricus* is gram positive, rod, non spore, homofermentative and facultatively anaerobe. This *lactobacillus* grow optimally at 45-50°C and pH 6.0 (Pederson, 1971). As starter culture for yoghurt production these bacteria occurred in 1:1 ratio (Vedamuthu, 1982)

Reddy *et al.*(1970) stated that lactic acid bacteria usually used to increase milk quality and to lengthen their shelf life. Furthermore they stated that, lactic acid production by lactic acid bacteria will decrease the pH, so that inhibit growth of spoilage bacteria such as : *Clostridium*, *Staphylococcus*, *Enterobacteria* and psychrophillic *Pseudomonas*.

Fermentation of milk by *Streptococcus thermophilus* and *Lactobacillus bulgaricus* will yield yoghurt with good flavor and a refreshing acid taste, semi solid in texture, compact, contain high enough acid and no alcohol. Usually yoghurt is made from cow milk, but milk from other ruminants such as goat, sheep, camel, were also can be used. Costa *et al.*(2014) stated that yoghurt from goat milk is an excellent source of fatty acids, mineral, protein, however, consumer acceptance was low due to its “goaty” flavour. Moreover, they stated that goat milk fat contain higher caproic, caprilic and capric fatty acids compared to other ruminant species. These volatile fatty acids will absorb smell from the milking environment, which contribute to unpleasant “goaty”

aroma of the milk (Haenlein and Caccese, 2014), as well as the milk products.

This study was intended to find out the physico-chemical, microbiological and sensory properties of yoghurt made of goat and cow milk blended. The result could be relevant to growing goat milk industry that intended to gain more consumers for their products as well as to increase milk consumption.

2. Materials and Methods

2.1 Materials

Yoghurt was made of cow milk which was bought from Margo Utomo, Denpasar, Bali, Indonesia; and goat milk was obtained from Farmer at Singaraja District, Province of Bali, Indonesia.

For chemical analysis alcohol 70%, distilled water, NaOH 0.1 N, NaCl, and phenolphthaleine 1% were obtained from laboratory of Dairy Technology, Faculty of Animal Husbandry, Udayana University. For microbiological analysis, The Mann Rogosa and Sharp Agar (MRSA) (Oxoid CM361) was obtained from Laboratory of Animal product Technology, Faculty of Animal Husbandry, Udayana University, Denpasar.

Equipment Used in this study were: oven, stove, plastic cup, incubator, pH metre, balance, buret, measuring glass, beaker glass, thermometer, wood stirrer, refrigerator, autoclave, test-tube, petri plates.

2.2 Research Design

A Randomized Block Design, with 5 type of yoghurt samples and 3 replications were adopted in this study. The five yoghurt samples were made from: 100% cow milk (A1); 75% cow milk blended with 25% goat milk (A2); 50% cow milk and 50% goat milk (A3); 25% cow milk and 75% goat milk (A4) and 100% goat milk (A5).

2.3 Yoghurt Preparation

Cow and goat milk were blended according to type of yoghurt samples. Blended milk was pasteurized at 90°C for 15 minutes, and cooled to 43°C. Cooled milk for any yoghurt type were then inoculated with 2% starter cultures, homogenized and then placed into glass jar. The inoculated milk were then incubated at 43°C for 5 hours. Yoghurts were then Analyzes for chemical, microbiological and sensory quality.

2.4 Titratable Acidity

Total titratable acidity was determined by the methods described by AOAC (1990).. Weigh accurately 10 g of sample in a beaker glass. Add 30 ml of distilled water and mixed thoroughly. 1 ml of phenolphthalein 1% indicator was introduced to 10 ml of the filtrate solution and shake well. It was titrated against standard 0.1 N NaOH solution, until a pink colour persisted for about 20 seconds for complete neutralization. The titratable acidity as lactic acid was calculated as:

$$\% \text{titratable acidity} = \frac{\text{ml NaOH} \times \text{N NaOH} \times 90}{\text{sample weight (mg)}} \times 100\%$$

N = normality of standard NaOH

90 = molecular weight of lactic acid

2.5 pH determination

pH was determined using a pH- meter (HANNA-pH210, Germany). 10 g of yoghurt sample were dissolved in 100 ml of distilled water. Shake well and allowed to equilibrate for about 3 minutes at room temperature. The electrode of the pH meter was then inserted into the sample mixture and the result was displayed on the pH meter.

2.6 Water Percentage determination

Water percentage was determined by drying methods (AOAC, 1990). 2 g of yoghurt sample was dried in hot air oven at 102°C for 24 hour. The lost in weight was determined and recorded as the water percentage and calculated as :

$$\% \text{ water percentage} = \frac{W_1 - W_2}{W_1} \times 100$$

W_1 = initial weight of the sample

W_2 = Weight of the dried sample

2.7 Microbiological Analysis

Analysis of total lactic acid bacteria was done according to Buckle *et al.* (1982). Ten grams of yogurt sample from any type of yoghurt were placed in glass flask containing 90 ml sterile 0.85 % saline solution and shaken to prepare 10^{-1} dilution. Then a decimal dilution series was prepared in 0.85% saline solution to get 10^{-6} and 10^{-7} dilution. 0.1 ml of this dilution was transferred on to plates containing sterile solid MRS agar and spread evenly. The inoculated plates were then incubated upside down at 37°C for 48 hours in an anaerobic jar. Total lactic acid bacteria were counted from plates containing 30 – 300 colonies.

2.8 Sensory Analysis

Sensory profiling of the yogurt samples was conducted using conventional profiling, by a trained panel. Ten judges were selected among the faculty staff, and students of Faculty of Animal Husbandry, Udayana University, who successfully passed standardized tests for olfactory and taste sensitivities as well as verbal abilities and creativity. The panellists were given a hedonic questionnaire to test taste, texture, colour, flavour and overall acceptability of coded samples of cow milk yogurt as control, as well as the other four type of yoghurt. They were scored on a scale of 1–7 (1 = dislike very much, 2 = dislike, 3 = rather dislike, 4 = fair, 5 = rather like, 6 = like, 7 = like very much). Each attribute was evaluated in triplicate and the values were then averaged.

2.9 Statistical Analysis

Data obtained were analyzed using analysis of variance (ANOVA) according to Steel and Torrie (1980), if there were any significant differences between mean for each variable, least significant difference (LSD) test was used.

3. Result and Discussion

3.1 Chemical Analysis

3.1.1 Water Percentage

Water content of yoghurt made of cow and goat milk blended were not significantly different ($P > 0.05$). The water percentage of yoghurt A2, A3, and A4 (yoghurt of blended cow and goat milk) were respectively 2.25%, 1.97% and 1.13% higher than that of yoghurt A5 (yoghurt of 100% goat milk), and respectively 0.45%, 0.73% and 1.48% lower than that of yoghurt A1 (yoghurt of 100% cow milk). Figure 1. showed that, water percentage of yoghurt prepared from blended milk containing more goat milk were lower than that of yoghurt made of blended milk containing more cow milk.

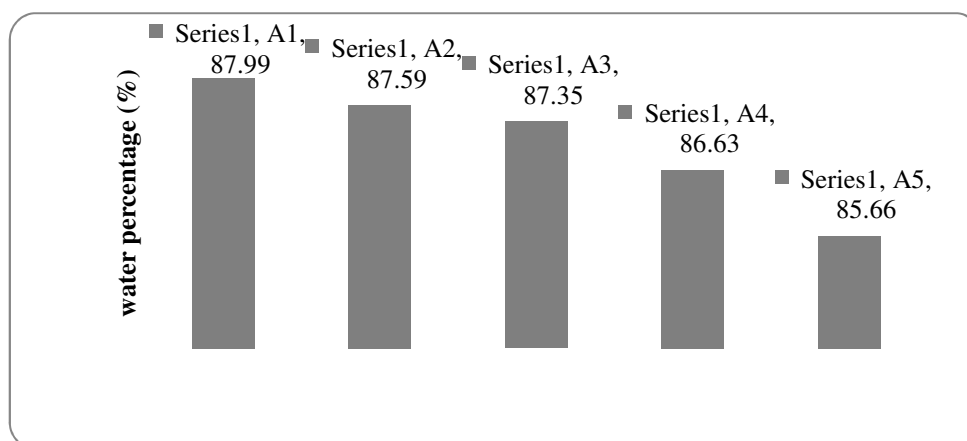


Figure 1. Water percentage of yoghurt prepared from blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk;

A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

The more goat milk in the blended milk, the lower the water percentage of yoghurt obtained. This is in line with Ehirim and Onyeneke (2013) who found that, yoghurt made of goat milk has lower water percentage than yoghurt made of cow milk. This is because goat milk (PE goat milk) has higher percentage of total solid of about 14.02% - 16.33% (Sutama, 2009; Widodo *et al.*, 2012; Setiawan *et al.*, 2013) compared to cow milk of 11.82% (Widodo *et al.*, 2013). The chemical composition of yoghurt was largely depended on the raw milk used to make it. Yoghurt made of milk with lower total solids has higher water percentage (Ehirim and Onyeneke, 2013).

3.1.2 pH

The pH of yoghurt samples were not significantly affected by blended of cow and goat milk ($P > 0.05$). The pH of yoghurt obtained from blended cow and goat milk (A2, A3 and A4) were respectively 0.49 %, 0.73% and 1.71% higher than that of cow milk yoghurt (A1), but respectively 1.91%, 1.67% and 0.71% lower than that

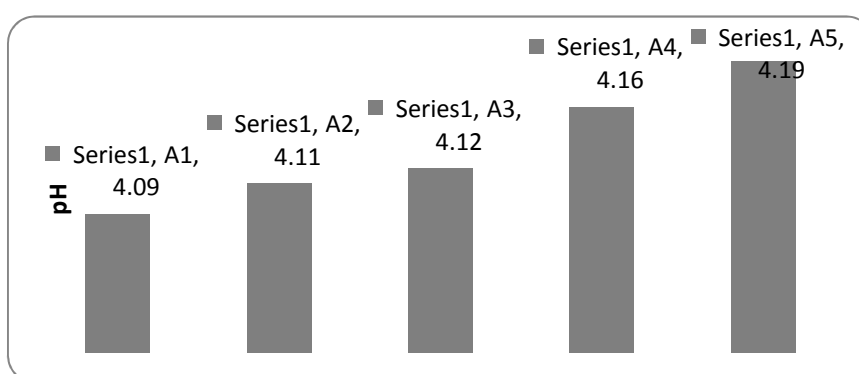


Figure 2. pH of yphgurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

of goat milk yoghurt (A5) (Figure 2.). This is in line with Eissa *et al.* (2011) who found that, Sundanese yoghurt made of cow milk has lower pH than that of yoghurt made of goat milk, they also reported that, goat milk used for yoghurt preparation contained lower lactose than that of cow milk. The pH of yoghurt was largely affected by carbohydrate content of raw milk use to make the yoghurt, since bacterial starter culture in yoghurt making will convert carbohydrate (lactose) present in milk to lactic acid, result in reduction of pH. Cow milk contains higher lactose than that of goat milk (Haenlein and Caccese, 2014; Arora *et al.*, 2013) respectively of 4.7% and 4.1%. Yoghurt A2, A3 and A4 contained 75%, 50% and 25% cow milk, which mean more lactose available for lactic acid production by lactic acid bacteria compared to yoghurt A5 or inversely compared to yoghurt A1. Therefore yoghurt A4 showed higher pH than that of yoghurt A3, A2 and A1 (100% cow milk). Inversely they had lower pH than that of yoghurt A5 (100% goat milk).

3.1.3 Total Titratable Acidity

Total acidity of yoghurt were significantly affected by blended of cow and goat milk ($P < 0.05$). Total acidity of yoghurt made of cow and goat milk blended : A2, A3 and A4 were respectively 8.75%, 6.25% and 3.74% higher than that of A5 (yoghurt made of 100% goat milk), but these total titratable acidity were respectively 3.33%, 5.55% and 7.77% lower than that of A1 (yoghurt made of 100% cow milk) (Figure 3.). This is in agreement with Nahar *et al.* (2007) and Moneim *et al.* (2011) who found yoghurt made from goat milk showed significantly lower percentage of acidity than that of yoghurt made from cow milk.

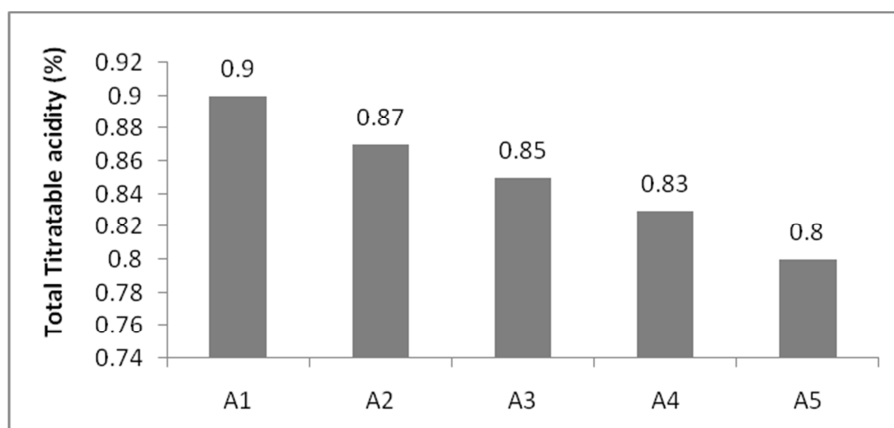


Figure 3. Total Titratable acidity of yoghurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

Total titratable acidity of yoghurt samples were mostly resulted from degradation of lactose present in raw milk used to make the yoghurt which is mostly lactic acid. The more lactose content of the raw milk, the higher lactic acid produced by lactic acid bacteria used to make the yoghurt. Yoghurts A2, A3, and A4 in this study, contained respectively 75%, 50% and 25% cow milk respectively, which mean the lactose content of raw milk for making yoghurt A2, A3 and A4 were higher than that of A5 (100% goat milk) or lower than that of A1 (100% cow's milk). These are because goat milk has lower lactose percentage than that of cow milk (Haenlein and Caccese, 2014; Arora *et al.*, 2013). Therefore the more goat milk included in blended raw milk, the lower the total acidity of the yoghurt obtained.

3.2 Microbiological Analysis

3.2.1 Total Lactic acid Bacteria

Blended of cow and goat milk for yoghurt making did not significantly affect total lactic acid bacteria of yoghurt obtained. Total lactic acid bacteria of yoghurt samples from yoghurt A3 and A4 were respectively 2.68% and 5.61% higher than that of A1; 0.12% and 2.98% higher than that of A5. Lactic acid bacteria need nutrients for their growth. Goat milk has higher mineral and vitamin content, and higher digestibility than that of cow milk (Haenlein and Caccese, 2014), so that lactic acid bacteria used to ferment the raw goat milk get enough nutrients to grow in yoghurt A2, A3, A4 and A5. Therefore total lactic acid bacteria of yoghurt A2, A3, A4 and A5 were higher than that of A1. Total lactic acid bacteria of yoghurt A5 was lower than that of yoghurt A3 and A4. Lactic acid bacteria, in addition to nutrients need for their growth, water availability was also determinants for their growth. Goat milk has lower water percentage than that of cow milk. Therefore growth of lactic acid bacteria in yoghurt A5 (100% goat milk) were slower than that of yoghurt A3 and A4, which result in lower total lactic acid bacteria. Jay (1992) stated that nutrients and water available in a food is necessary for microbial growth. Water is necessary for transport of nutrients, to carry out enzymatic reactions, to synthesized cellular materials and other biochemical reactions during microbial growth. When the water available for growth is lower, then the lag phase and generation time were progressively lengthened, which means, the growth of lactic acid bacteria were slowed.

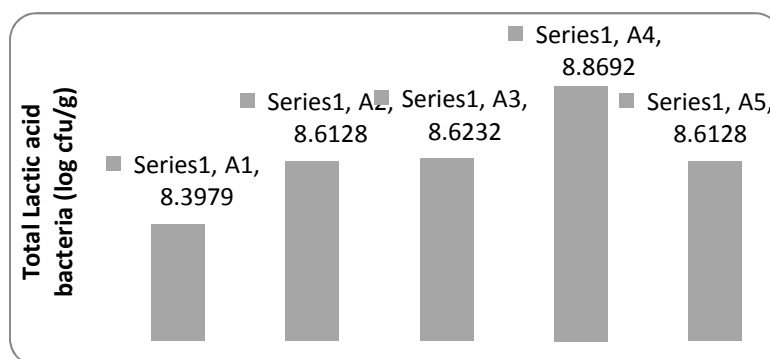


Figure 4. Total lactic acid bacteria of yoghurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

3.3 Sensory quality

3.3.1. Colour

Rating of colour preference of yoghurt obtained from fermented cow and goat milk blended did not significantly different ($P>0.05$). Colour preference to yoghurt A2, A3 and A4 were respectively 10.34%, 1.72% and 15.52% higher than that of yoghurt A1. The colour preferences were ranging from a bit like (score : 6) to like (score :7). However they were respectively 7.25%, 72.76% and 1.45% lower than that of yoghurt in treatment A5.

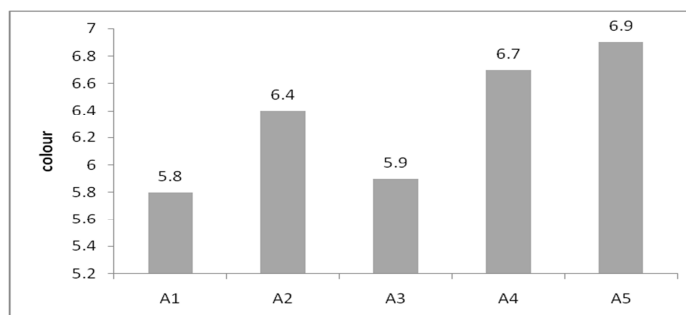


Figure 5. Colour of yoghurt

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

In term of the colour preference, data on Figure 5. showed that, preference to colour of yoghurt samples were improved as the incorporation of goat milk increase. In fact yoghurt samples containing higher goat milk, looked cleaner and whiter, while yoghurt samples contained more cow milk looked yellowish due to carotene content of the milk. This is in line with Abdel Moneim *et al.* (2011) who evaluated yoghurt from cow and goat milk, and reported that panelists mostly preferred white yoghurt colour.

3.3.1 Aroma

Score of preferences to aroma of yoghurt samples obtained from blended cow and goat milk showed in Figure 6. were not significantly different ($P>0.05$).The rate of preferences to aroma of yoghurts A2, A3 and A4 were respectively 1.49%, 1.49% and 4.48% lower than that of yoghurt A1 and were respectively 5.71%, 5.71% and 34.29% lower than that of yoghurt A5. The rate of preferences to aroma of all of the yoghurt samples, were ranging from like (6) to like very much (7). Figure 6. showed that, increasing the incorporation of goat milk to 75% (A4), decrease the preference to aroma of yoghurt obtained, but yoghurt made of 100% goat's milk was more preferred than that of 100% cow milk.

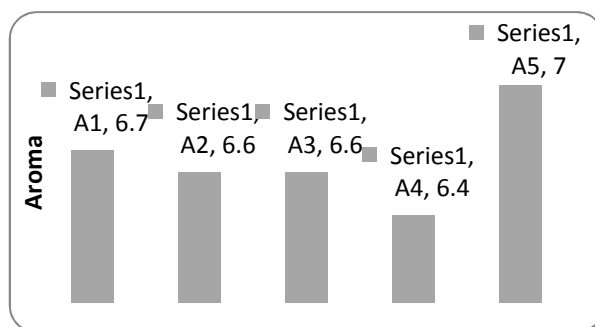


Figure 6. Aroma of yoghurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk;
 A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

Aroma of yoghurt was attributed to the release of free fatty acids occurred in the product, which come from goat milk used to make the yoghurt. Compared to cow milk, goat milk contained higher volatile fatty acids such as caproic, caprylic and capric acids (Haenlein, 2012), and 4-methyloctanoic acid (Young *et al.*, 2012), which absorbed “goaty” smell surrounding the barn where milking conducted. In addition, goat milk has smaller globule of fat than that of cow milk, which means wider surface of releasing free fatty acids, so that the release of free fatty acids in goat milk was higher than that of cow milk. Therefore yoghurt made from higher incorporation of goat milk gave lower score in aroma due to unpleasant “goaty” odour of goat milk. This is in line with Obi and Maduagwu (2009) who stated that, smell of yoghurt was attributed to the free fatty acids release from the product. Yoghurt of treatment A5, however, gave higher score of aroma. The higher score of aroma of yoghurt A5 was also attributed to the release of free fatty acids of the product. Yoghurt A5 has the lowest water content compared to the other product (A1, A2, A3 and A4), which result in more compact product, and contribute to less surface area of fat globule available for release of free fatty acids. Free fatty acids were the component of milk carrying the aroma. So that the higher free fatty acids release the sharper the smell obtained from the product.

3.3.2 Texture

Texture of yoghurt obtained from goat and cow milk blended were significantly different ($P < 0.05$). Incorporation of goat milk up to 75% improved the texture of the yoghurt obtained, even yoghurt made of 100% goat milk gave the highest score of yoghurt texture.

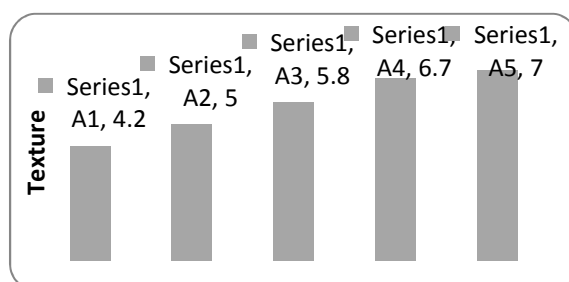


Figure 7. Texture of yoghurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk;
 A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

Score of texture preferences of yoghurt A2, A3 and A4 were ranging from rather like (5) to like very much (7). Preferences of texture of yoghurt A2, A3 and A4 were respectively 19.05%, 38.09 and 69.05% higher than that of yoghurt A1 (100% cow milk), but they were respectively 28.57%, 17.14% and 4.28% lower than that of yoghurt A5 (100% goat milk). The increase in texture score of yoghurt made of more addition of goat milk was due to lower water content of goat milk, which contributes to firmer gel formation. In addition the smaller fat globule of goat milk result in finer gel of the yoghurt made of higher level of goat milk incorporation. This is in

line with Bano *et al.* (2011) who stated that the increase in texture score of yoghurt made of goat milk was due to formation of firm gel. Furthermore, they stated that, less water content of yoghurt result in more viscous product which leads to better texture.

3.3.3 Taste

Taste of yoghurt obtained from cow's and goat's milk blended (A2, A3 and A4), were scored higher than that of cow milk yoghurt (A1) and goat milk yoghurt (A5). Yoghurt from 75% goat milk (A4) scored the highest for taste and significantly different ($P < 0.05$) from A1, A2 and A5.

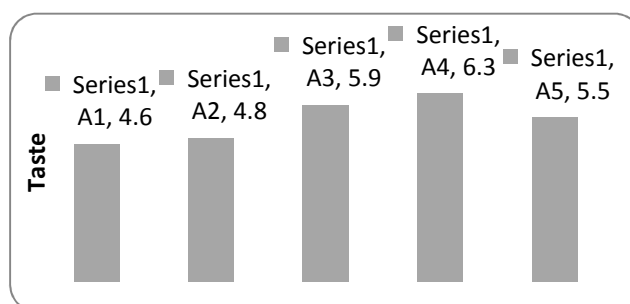


Figure 8. Taste of yoghurt made of blended goat and cow milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

The taste of all samples was ranging from fair (4) to like very much (7). Routray and Mishra (2011) stated that odor and taste of sour milk products are determined by numerous volatile bacterial metabolite, and lactic acid is suggested as one of the major compounds significantly contribute to yoghurt flavor (taste and odor). Fermented milk products such as yoghurt are preferred due to its acid refreshing taste, and yoghurt from 75% (A4) contain higher lactic acid than that of yoghurt A1 (100% cow milk), A2 and A3 (25% and 50% goat milk), but lower than that of A5 (100% goat milk). The highest scored of taste obtained from yoghurt A4 was due to its high lactic acid concentration and the lower scored for taste obtained from yoghurt A5 was due to its fairly “goaty” taste, which is less accepted by consumers. This is not in line with Ehirim and Onyeneke (2013) who stated that yoghurt made of 100% goat milk give the highest score for taste due to its “goaty” taste, since the panelists like goat meat or “goaty” flavour. In addition yoghurt from 75% goat milk has enough acidity which gave a refreshing taste to panelists

3.3.4 Overall Acceptability

In term of overall acceptability of yoghurt manufactured from cow and goat milk blended, yoghurt from 75% goat milk (A4) has the highest scored which is significantly different from yoghurt A3, A2 and A1 ($P < 0.05$), but not significantly different from yoghurt A5 ($P > 0.05$). The overall acceptability of yoghurt A4 was like very much and 18.64% higher than that of yoghurt A3 (like :6), 34.61% higher than that of yoghurt A2 (rather like 5) (Figure 9.). It appears that yoghurt from 75% goat milk (A4) was accepted very much due to its highest score in taste, higher score in color, aroma and texture compared to yoghurt A3, A2 and A1, and less “goaty” odor compared to yoghurt A5. This is in accordance to Routray and Mishra (2011) who stated that taste and aroma are properties of foods that control consumer acceptance, feeling and well being. It seems that yoghurt from 75% of goat's milk (A4) was very well accepted by the panelists.

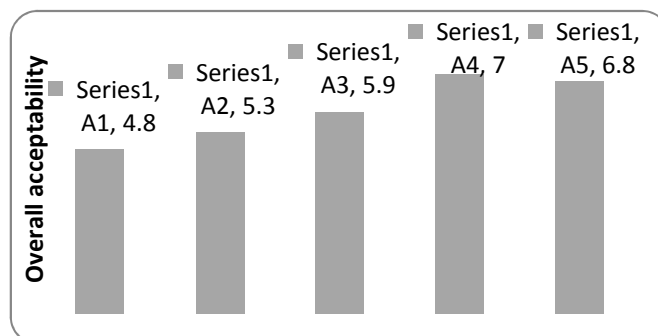


Figure 9. Overall acceptability of yoghurt made of blended cow and goat milk

Description: A1 = 100% cow milk; A2 = 25% goat milk, 75% cow milk; A3= 50% goat milk, 50% cow milk; A4 = 75% goat milk, 25% cow milk; A5 = 100% goat milk

4. Conclusion

Yoghurt prepared from blended cow and goat milk as well as from goat milk had higher nutrient content than that of yoghurt made of cow milk. The nutrient content reduced as the incorporation of goat milk lower. Yoghurt made from blended cow and goat milk has higher water contents. Acidity of yoghurt prepared from blended cow and goat milk increase as the incorporation of goat milk increase. Scores of sensory attribute showed that, the higher incorporation of goat milk, the more preferable yoghurt obtained, except for the aroma attribute, yoghurt made of blended cow and goat milk less preferable than that of both yoghurt made of cow milk and goat milk only. The highest acceptability was obtained from yoghurt made from blended 75% goat milk, 25% cow milk. Therefore, it can be concluded that blended cow and goat milk may make Indonesian people to consume goat milk product and finally stimulate goat milk consumption.

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