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Effect of gum arabic addition on physicochemical characteristics of goat milk yoghurt with mango puree

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ABSTRACT

Goat's milk has lower allergenic properties and higher digestibility compared to cow's milk. However, it possesses a distinct goaty aroma and a weak texture that is prone to syneresis. Efforts to improve the texture of goat milk yoghurt were made by adding gum arabic enriched with mango puree. This study aimed to determine the effect of gum arabic addition on the viscosity, syneresis, pH value, and water contact angle of yoghurt. The experimental design used was a completely randomized design (CRD) with four levels of gum arabic (0%, 0.25%, 0.5%, and 0.75%). The data were analyzed using Analysis of Variance (ANOVA) at a 0.05 significance level, followed by Duncan's Multiple Range Test (DMRT). The results showed that the addition of gum arabic treatment had a significant effect on viscosity and syneresis and tended to reduce the pH value of yoghurt. The addition of gum arabic as much as 0.75% was identified as the best treatment, yielding a viscosity of 11.8±0.84 dPas, a syneresis value of 15.98±1.18%, and a pH of 4.13±0.034. Water contact angle measurement results showed a tendency to increase the contact angle due to the addition of gum arabic.

Introduction

Goat milk production contributes to diversity of dairy products and supports nutritional needs in many regions. Goat milk presents lower allergenic potential and greater digestibility compared to cow milk. This is because goat milk does not contain β-lactoglobulin and has smaller fat globule sizes compared to cow's milk (Hendrawati and Isyunani, 2019).

However, the main drawback of goat milk is its distinct goaty aroma, which is attributed to presence of short-chain fatty acids such as caproic acid, caprylic acid, and capric acid (Yu *et al*., 2024). Efforts to reduce the goaty aroma can be made through milk fermentation and the addition of natural flavoring agents, such as mango fruit. The relatively low content of α-s1 casein in goat milk causes non-optimal coagulation, leading to a weak yoghurt texture and making it prone to syneresis (Hovjecki *et al*., 2023).

The incorporation of mango into goat milk yoghurt can increase the risk of syneresis due to its highwater content. To minimize this effect and improve product stability, the addition of hydrocolloids is recommended, such as gum arabic. Gum arabic is a polysaccharide derived from the exudates of acacia plant, known for its high solubility in water, increases viscosity, and good emulsifying properties due to the presence of amphiphilic polysaccharide-protein complexes (Liu *et al*., 2021). Gum arabic is composed of arabinose, galactose, rhamnose, and glucuronic acid. The carbohydrates present in gum arabic can serve as prebiotic dietary fiber, promoting the growth of *Lactobacillus* and *Bifidobacteria*, which ferment it into short-chain fatty acids (Leylak *et al*., 2021). The reduction of syneresis and increase in viscosity in yoghurt through the addition of gum arabic has been reported by Mugo *et al*. (2020).

The addition of Arumanis mango fruit (*Mangifera indica* L.) to goat milk yoghurt can provide additional nutrients for lactic acid bacteria, potentially affecting the pH of the resulting yoghurt product (Siriwardhana *et al*., 2024). Mango contains β-carotene, vitamin C, vitamin E, mangiferin, polyphenols, and dietary fiber. Pectin, a type of fiber found in mango, can contribute to yoghurt stability due to its ability to form a gel networks (Ke *et al*., 2022).

The addition of gum arabic to goat milk yoghurt is expected to influence its physicochemical characteristics when combined with mango puree. Therefore, this study aimed to investigate the effect of gum arabic addition on the physicochemical properties of goat milk yoghurt with mango puree.

Materials and methods

Material

The research was conducted from February to May 2025 at the Food Engineering and Agricultural Products Laboratory and the Food Technology Laboratory, Center of Research, Diponegoro University. The equipment utilized in this study comprised glass jars, a waterbath, a laminar air flow, an incubator, a thermometer, an analytical balance, a Bunsen burner, a funnel, a blender, a mixer, measuring cups, an iron spatula, a Brookfield viscometer, centrifuge tubes, a centrifuge, a digital scale, a pH meter, a dehydrator, baking paper, and an optical contact angle device (OCA 25). The materials used included fresh goat milk, YUMMY natural plain yoghurt (containing *Lactobacillus acidophilus*, *L. bulgaricus*, *Bifidobacterium*, and *Streptococcus thermophilus*), gum arabic, frozen Arumanis mango fruit, powdered sugar, ethanol, and distilled water.

Methods

This research was conducted using a completely randomized design (CRD). The treatments in this study were applied by the addition of gum arabic at concentrations of 0, 0.25, 0.5, and 0.75% (w/v). The research stages were carried out by making mango puree and making yoghurt

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samples with the addition of gum arabic and mango puree. Furthermore, viscosity, syneresis, and pH value were measured. The best treatment results were further analyzed for water contact angle.

Preparation of mango puree

The preparation of mango puree referred to Hasyim *et al.* (2023) with modifications. The preparation was initiated by thawing the frozen Arumanis mango fruit. The mango fruit was blended to obtain a smooth puree using a blender. The mango puree was pasteurized at 80°C for 10 minutes, then cooled to room temperature before being used as a mixture in yoghurt.

Processing of goat milk yogurt

The preparation of goat milk yoghurt referred to Mugo *et al.* (2020) with modifications. The process of making yoghurt was initiated by pasteurization of 500 ml goat milk at 80°C for 15 minutes. In the last 5 minutes of pasteurization, gum arabic was dissolved into goat milk according to the treatment levels of 0, 0.25, 0.50, and 0.75% (w/v). After pasteurization was completed, 6% (w/v) powdered sugar and 15% (w/v) mango puree were added and stirred until homogeneous. The milk was cooled to 37°C, followed by inoculation 5% (w/v) yoghurt starter. Then, incubation was conducted at 37°C for 12 hours using an incubator. After that, the yoghurt was stored in the refrigerator at 4°C.

Viscosity Testing

Viscosity testing was carried out referring to Damayanti *et al.* (2020). Yoghurt viscosity was tested using a Brookfield viscometer with LV spindle number 4. The spindle was mounted on the tool and then lowered into the tested sample until the designated part of the spindle was covered. A speed of 30 rpm was used. The viscometer was turned on until the needle was stabilized. The viscosity of yoghurt was recorded in units of dPas.

Syneresis Testing

Syneresis was measured using the centrifugation method according to Rahmawati *et al.* (2024). A total of 15 g of yoghurt sample was placed into a centrifuge tube. Then, the tube was inserted into a centrifuge and was centrifuged at 1540 rpm for 20 minutes. The formed precipitate was weighed. Syneresis was determined using the following equation:
Syneresis= (The initial weight (g) - sediment weight (g))/(The initial weight (g))×100%

Measurement of pH Value

The pH was measured according to Adrianto *et al.* (2020). A pH meter, calibrated with pH 4 and pH 7 buffer standards, was used for the measurement. The pH meter was turned on and the probe was inserted into the test sample. Next, the value on the pH meter was waited until it stabilized and the measurement results were recorded.

Water Contact Angle Testing

The preparation of yoghurt leather was conducted by referring to Azeem *et al.* (2021) with modifications. Yoghurt with a thickness of 0.8 cm was placed in a container lined with baking paper. Next, drying was carried out using a dehydrator at a temperature of 55°C for 8 hours. The formed yoghurt leather was then cut into pieces measuring 2x2 cm. The water contact angle was measured on the yoghurt leather using an optical contact angle device (OCA 25) according to Bahiyyah *et al.* (2023). Distilled water was dropped onto the surface of the yoghurt leather and contact angle images were captured. Subsequently, the contact angle was determined based on the obtained image.

Statistical analysis

The results of viscosity, syneresis, and pH value were analyzed by the Analysis of Variance (ANOVA) method at 0.05 significance level and were followed by Duncan's Multiple Range Test (DMRT) at 0.05 significance level if significant differences were found.

Results

The results of the study in Table 1 showed that the application of gum arabic up to 0.75% increased the viscosity of yoghurt significantly. It is also shown that the addition of gum arabic decreased the syneresis of yoghurt significantly. This effect is presumably attributed to its capacity to bind water and enhance the structural integrity of the gel network. Meanwhile, the addition of gum arabic up to 0.75% did not decrease the pH value significantly. The pH range of yoghurt is around 4.11 - 4.14. This is in accordance with SNI 2981:2009 regarding the quality requirements of yoghurt, a good yoghurt pH value range from 3.80 – 4.50.

Table 1. Physicochemical properties of yoghurt stabilized with gum arabic.

Treatment	Viscosity (dPas)	Syneresis (%)	pH Value
Control	7.4±0.89^{a}	21.79±2.46^{a}	4.16±0.030^{a}
0.25%	9.2±0.45^{b}	20.68±0.77^{ab}	4.15±0.027^{a}
0.50%	10.4±1.30^{b}	18.80±0.84^{b}	4.14±0.031^{a}
0.75%	11.8±0.84^{c}	15.98±1.18^{c}	4.13±0.034^{a}

The data is displayed as mean±standard deviation. Different superscript letters in the same column showed a marked difference ($p<0.05$) in the post-hoc test of Duncan's Multiple Range Test (DMRT). The same superscript letters are not significantly different according to DMRT.

In addition, the results of the measurement of the water contact angle on the surface of the yoghurt layer in Fig. 1 shows a tendency to increase the water contact angle due to the increase in the concentration of gum arabic. Yoghurt without gum arabic addition is likely more hydrophilic than yoghurt with 0.75% gum arabic addition, although both contact angles are less than 90° which indicates that both are hydrophilic.

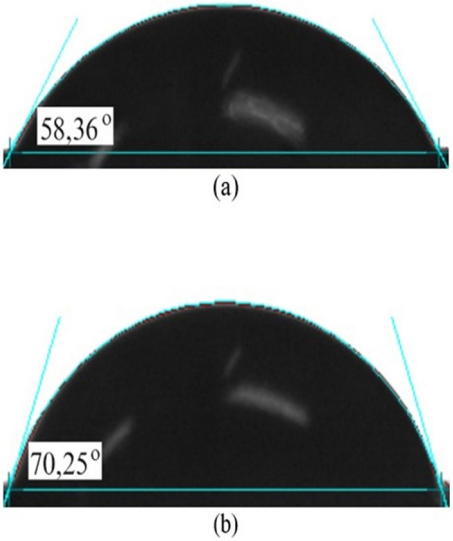

Fig 1. Illustrates the result of water contact angle (a) without gum arabic addition and (b) with 0.75% gum arabic addition.

Discussion

The viscosity of yoghurt reflects its resistance to flow and indicates the relative resistance to movement (Hiola *et al.*, 2024). The addition of gum arabic as a hydrocolloid plays an important role in increasing the

viscosity of yoghurt. Prasad *et al.* (2022) stated that the increase in viscosity caused by gum arabic is due to the enhancement of intermolecular tensile forces and an increase in the number of molecules per unit volume, thereby reducing the mobility of water in the mixture. Jumansyah *et al*. (2017) reported that gum arabic possesses hydrophilic properties and contains many hydroxyls (-OH) groups. These characteristics allow gum arabic to bind water, resulting in water entrapment and the formation of a more viscous yoghurt.

Syneresis is a parameter that indicates the separation of liquid (whey) from the solid matrix in yoghurt. This phenomenon occurs when the gel structure of yoghurt weakens and fails to retain the liquid phase, resulting in whey separation (Joon *et al*., 2017). Ismaiel *et al*. (2022) reported that gum arabic is effective in reducing syneresis in yoghurt. Soewangsa and Darmoatmodjo (2024) explained that syneresis can be reduced because gum arabic acts as a stabilizer that effectively binds water. As a stabilizer, gum arabic influences water-binding capacity. Prabowo and Radiati (2018) explained that stabilizing agents added to yoghurt can enhance the hydrophilic properties of the protein, thereby increasing their ability to bind water. The higher water-binding capacity of yoghurt reduces syneresis, improves viscosity, and enhances textural quality. Although gum arabic cannot interact electrostatically with casein, since it is classified as a non-ionic polysaccharide, Zang *et al.* (2024) noted that gum arabic can still influence the stability of casein micelles by increasing yoghurt viscosity.

The addition of mango puree to yoghurt also contributes to increased viscosity and water-binding ability due to its pectin content. This is consistent with the findings of Miranti (2021), who stated that pectin can bind water, sugar, and dissolved solids, thereby increasing the total acidity of yoghurt as the sugars in mango are hydrolyzed into acids. An increase in total acid promotes casein coagulation, leading to gel formation. Jonathan *et al.* (2022) explained that the formed gel results in a semi-solid yoghurt texture, thus increasing its viscosity.

The pH value indicates the degree of acidity in yoghurt. According to Rukmi *et al*. (2020), the pH value reflects the concentration of hydrogen ions (H+) formed during milk fermentation process by microorganisms, which result in acid production. Acidity is one of the key parameters used to assess yoghurt quality. Sanusi *et al*. (2024) explained that this occurs because gum arabic contains organic acids, such as glucuronic acid, and arabinose. In addition, gum arabic can act as a prebiotic, providing nutrients for lactic acid bacteria during the fermentation.

The pH value of yoghurt is inversely proportional to its viscosity. Conversely, as the pH value decreases, the viscosity of yoghurt increases in proportion to the rising concentration of gum arabic. This finding aligns with the research conducted by Sanusi *et al*. (2024), which demonstrated that the incorporation of gum arabic enhances viscosity and reduces pH value. Emmawati *et al*. (2020) explained that a decrease in the pH value to below the isoelectric point (pH 4.6) precipitates the coagulation and gelation of milk. The addition of ingredients containing sugar to yoghurt has been shown to result in increased viscosity. Therefore, an increase in the concentration of gum arabic, which can act as a prebiotic, leads to a decrease in pH and an increase in the viscosity of yoghurt made from goat milk and mango puree.

The water contact angle describes the wettability of a surface. According to Zhang *et al*. (2025), the contact angle is defined as the geometric angle formed at the interface between a liquid droplet and a solid surface. This angle indicates the hydrophilic or hydrophobic nature of the surface being measured. The water contact angle of both samples was less than 90°, indicating that both surfaces were hydrophilic. This finding is consistent with Wiguna and Kelen (2018), who reported that a contact angle below 90° indicates hydrophilic properties or high surface wettability. The increased contact angle due to the addition of gum arabic suggests lower surface wettability in the yoghurt layer compared to the control treatment.

The increase in contact angle occurred due to the addition of gum arabic which was consistent with the increase in viscosity and the decrease in the syneresis value of yoghurt. Research conducted by Hou *et al.* (2023) showed a positive correlation between the water contact angle and the viscosity of yoghurt. The water contact angle increased as the viscosity of the yoghurt increased. Yoghurts with a higher water contact angle indicated a semi-hydrophobic surface yet still exhibited low syneresis. According to Susianti *et al*. (2020), the decrease in syneresis shows that gum arabic has a stronger water-binding capacity, thereby enhancing yoghurt stability. This is associated with the increased viscosity of yoghurt, which limits water mobility.

Conclusion

The addition of higher concentrations of gum arabic increased viscosity and reduced syneresis significantly, tended to lower the pH value and tended to increase the water contact angle on the surface of yoghurt. The best treatment was observed in yoghurt with the addition of 0.75% gum arabic.

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Conflict of interest

The authors have no conflict of interest to declare.

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