



Optimization of Red Dragon Fruit, Red Beet and Black Rice Extract Concentrations in Goat Milk Synbiotic Kefir: Effects on Organoleptic Quality, pH and Viscosity

Indah Nuraeni¹, Rifda Naufalin², Juni Sumarmono³, Condro Wibowo²

10.18805/ajdfr.DRF-597

ABSTRACT

Background: Goat milk kefir is a probiotic-rich functional food with potential health benefits, yet its strong goaty aroma reduces consumer acceptance. Incorporating natural extracts rich in bioactive compounds, such as red dragon fruit (*Hylocereus polyrhizus*), red beet (*Beta vulgaris* L.) and black rice [*Oryza sativa* (L.) *indica*], may improve sensory quality and enhance functional properties.

Methods: Synbiotic kefir was prepared from goat milk with the addition of dragon fruit, beet and black rice extracts at concentrations of 0.5%, 1.0%, 1.5% and 2.0%. Sensory evaluation (hedonic and hedonic quality tests) was performed by 55 semi-trained panelists. pH and viscosity were analyzed instrumentally. Data were analyzed using Friedman and Kruskal-Wallis non-parametric tests.

Result: Extract type and concentration significantly affected color, texture, taste and overall acceptability ($p < 0.05$), but not aroma ($p > 0.05$). The best treatment was beet extract at 1.5% (E2K3), which scored highest in overall acceptability (3.51). Dragon fruit extract at 2% produced the most preferred aroma (3.53). pH values ranged from 3.80-3.93, remaining stable across treatments. Viscosity ranged from 210.88-363.63 cP, with beet extract producing the highest viscosity, while higher extract concentrations tended to reduce viscosity. Addition of beet extract at 1.5% provided the optimal balance of sensory attributes, pH stability and viscosity in goat milk synbiotic kefir. These findings highlight the potential of combining goat milk with plant-based extracts to enhance the acceptability and functionality of fermented dairy products.

Key words: Functional food, Goat milk, Kefir, pH, Sensory evaluation, Synbiotic, Viscosity.

INTRODUCTION

Obesity remains one of the most pressing global health challenges, contributing to a heightened risk of metabolic syndrome, type 2 diabetes, cardiovascular diseases and systemic inflammation. Functional foods enriched with probiotics and bioactive compounds have been increasingly explored as cost-effective strategies to help modulate gut microbiota and improve metabolic health outcomes. Fermented dairy products, particularly kefir, are of special interest due to their rich microbial diversity, production of bioactive metabolites and well-documented health-promoting effects. Recent studies have emphasized kefir's potential to ameliorate dysbiosis, reduce systemic inflammation and improve metabolic balance, making it a candidate functional beverage for obesity management (Peluzio *et al.*, 2021).

Goat milk offers unique nutritional and functional characteristics compared to cow milk, such as smaller fat globules, higher digestibility and specific casein and whey proteins that can yield bioactive peptides during fermentation. Goat milk kefir also contains microbial-derived exopolysaccharides with potential anti-obesity and anti-inflammatory activities. Integrating synbiotic principles by combining goat milk kefir with selected plant extracts provides a pathway to enhance its functionality and palatability. Although kefir's functional potential is well documented, there is still limited understanding of how varying concentrations of plant-based extracts influence

¹Department of Nutrition Science, Faculty of Health Science, Jenderal Soedirman University, Grendeng, Purwokerto Utara, Banyumas, Jawa Tengah-53122, Indonesia.

²Department of Food Technology, Faculty of Agriculture, Jenderal Soedirman University, Grendeng, Purwokerto Utara, Banyumas, Jawa Tengah-53122, Indonesia.

³Department of Animal Science, Faculty of Animal Science, Jenderal Soedirman University, Grendeng, Purwokerto Utara, Banyumas, Jawa Tengah-53122, Indonesia.

Corresponding Author: Rifda Naufalin, Department of Food Technology, Faculty of Agriculture, Jenderal Soedirman University, Grendeng, Purwokerto Utara, Banyumas, Jawa Tengah-53122, Indonesia. Email: rifda.naufalin@unsoed.ac.id

How to cite this article: Nuraeni, I., Naufalin, R., Sumarmono, J. and Wibowo, C. (2026). Optimization of Red Dragon Fruit, Red Beet and Black Rice Extract Concentrations in Goat Milk Synbiotic Kefir: Effects on Organoleptic Quality, pH and Viscosity. *Asian Journal of Dairy and Food Research*. **45(4)**: 570-576. doi: 10.18805/ajdfr.DRF-597.

Submitted: 30-09-2025 **Accepted:** 16-04-2026 **Online:** 28-04-2026

the physicochemical and sensory properties of goat milk kefir. Most previous studies have focused on single extract additions or cow milk matrices. Few investigations have systematically optimized the concentration levels of red dragon fruit, red beet and black rice extracts in goat milk kefir while simultaneously assessing organoleptic quality, pH and viscosity. Moreover, the interaction between extract

concentration, fermentation dynamics and sensory perception remains largely unexplored. Red dragon fruit (*Hylocereus polyrhizus*), red beet (*Beta vulgaris* L.) and black rice (*Oryza sativa* L.) are natural sources of anthocyanins, betalains, phenolics and nitrates, all of which exhibit antioxidant, anti-inflammatory and prebiotic-like properties. Incorporating these extracts into kefir formulations may support microbial growth, improve the sensory profile and enhance the beverage's functional qualities. Notably, these extracts are expected to influence key physicochemical parameters such as pH and viscosity while also affecting organoleptic acceptance, which are critical for consumer satisfaction and market viability.

Kefir is a fermented dairy product containing a complex consortium of lactic acid bacteria (LAB) and yeasts that contribute to its probiotic properties. Previous studies have shown that LAB isolated from goat milk kefir exhibit strong acid and bile tolerance, antimicrobial activity and the ability to metabolize prebiotic substrates, supporting their role in enhancing the functional value of fermented dairy products (Wulansari *et al.*, 2026). Goat milk, enriched in medium-chain fatty acids, is easier to digest compared to cow milk and provides potential functional benefits. However, the strong goaty flavor often limits consumer acceptance. Natural plant-based extracts may improve sensory quality while also providing additional bioactive compounds. The incorporation of plant-based bioactive compounds into kefir products has been reported to enhance their functional quality, particularly in terms of antioxidant activity and overall product performance. Optimization of extract concentration is crucial to achieve a balance between functional properties and product acceptability (Naufalin *et al.*, 2026). Red beet (*Beta vulgaris* L.) contains betalains (betacyanin and betaxanthin) with antioxidant and colorant properties. Red dragon fruit (*Hylocereus polyrhizus*) is rich in anthocyanins, which contribute to vivid coloration and antioxidant potential. Black rice [*Oryza sativa* (L.) *indica*] also contains anthocyanins, dietary fiber and phenolic compounds. Several studies in functional dairy systems have shown that the incorporation of plant-based or bioactive compounds can significantly influence physicochemical characteristics such as pH and viscosity, as well as improve sensory attributes and overall product quality (Subbalakshmi *et al.*, 2024). This study aims to optimize the concentrations of red dragon fruit, red beet and black rice extracts in goat milk synbiotic kefir and evaluate their effects on organoleptic quality, pH and viscosity. Specifically, the research will: (1) Determine the influence of different extract concentrations on kefir's sensory attributes (color, flavor, texture, overall acceptability). (2) Assess the effects of extract supplementation on pH and viscosity during and after fermentation, (3) Identify optimal concentration levels that balance sensory quality with physicochemical stability.

MATERIALS AND METHODS

The experiment was conducted using fresh goat milk, kefir grains (a consortium of Lactic Acid Bacteria and yeast) and extracts of red dragon fruit, red beetroot and black rice prepared by maceration. A completely randomized design (CRD) was applied with two factors: extract type (E1 = Black rice, E2 = Beet, E3 = Dragon fruit) and extract concentration (0.5%, 1%, 1.5% and 2%), resulting in twelve treatment combinations. For kefir preparation, fresh goat milk was pasteurized at 85°C for 30 minutes, cooled to 25-30°C and inoculated with 5% kefir grains. The extracts were then added according to the respective treatments and the mixture was fermented for 24 hours at room temperature (25-28°C). The study was carried out in 2025 at the Laboratory of Food Technology, Faculty of Agriculture and the Faculty of Animal Science, Jenderal Soedirman University, Indonesia. All experimental procedures and analyses were performed under laboratory controlled conditions.

Sensory evaluation was performed by 55 semi-trained panelists who assessed the products using two tests. First, a hedonic test was conducted where panelists rated color, aroma, texture, taste and overall acceptance on a 5-point hedonic scale. Second, a hedonic quality test was used to assess the intensity of these attributes. For physicochemical analysis, the pH of the samples was measured using a digital pH meter and viscosity was measured using a Brookfield viscometer. The collected data were tested for normality. As the data were not normally distributed, non-parametric analysis using the Friedman test and the Kruskal-Wallis test was performed, with the significance level set at $p < 0.05$.

RESULTS AND DISCUSSION

Sensory attributes and acceptance

The data recorded and analyzed for sensory attributes of the goat milk kefir showed that the type and concentration of the added extract had a significant effect on color, texture, taste and overall acceptability ($p < 0.05$). Among the different treatments, the highest overall acceptability score was observed under treatment E2K3 (1.5% beet extract), which received a mean score of 3.51 (Table S1). This indicates that the addition of beet extract at this concentration contributes favorable sensory properties that enhance consumer acceptance.

Data in Table S1 show that color scores were significantly improved with extract supplementation, particularly with beet and dragon fruit. The highest score for color (4.25) was recorded in treatment E2K4 (2% beet extract). This enhancement is consistent with the role of betalain pigments as natural colorants, which are known to be stable in the acidic pH typical of fermented dairy products (Pratiwi *et al.*, 2018). Although aroma variation was not statistically significant, the highest mean score for aroma (3.53) was observed under treatment E3K4 (2% dragon fruit extract), suggesting its volatile profile effectively

Table S1: Hedonic scores per treatment (mean).

Treatment	Color	Aroma	Texture	Taste	Overall
E1K1	3.55	3.07	3.38	2.95	3.09
E1K2	3.33	2.93	3.4	3.0	3.13
E1K3	3.56	2.95	3.29	2.82	2.93
E1K4	3.56	3.35	3.27	2.96	3.09
E2K1	2.35	2.96	3.25	2.51	2.44
E2K2	2.76	3.05	3.24	2.73	2.85
E2K3	3.89	3.47	3.45	3.35	3.51
E2K4	4.25	3.33	3.51	3.11	3.4
E3K1	2.4	2.85	2.76	2.07	2.31
E3K2	2.64	3.07	2.84	2.25	2.56
E3K3	3.44	3.09	3.13	2.82	3.07
E3K4	4.11	3.53	3.45	3.09	3.36

Table S2: Descriptive hedonic.

Treatment	Color	Aroma	Texture	Taste
E1K1	1.2	1.78	1.71	2.82
E1K2	1.2	1.75	1.96	2.85
E1K3	1.09	1.85	1.89	3.11
E1K4	1.05	1.89	1.75	2.82
E2K1	1.36	2.07	2.51	3.35
E2K2	2.27	1.84	2.6	3.25
E2K3	3.0	1.76	2.02	2.64
E2K4	4.02	1.89	2.69	2.53
E3K1	1.22	2.18	1.47	3.37
E3K2	2.16	2.04	1.38	3.45
E3K3	2.87	1.98	2.22	2.95
E3K4	3.55	1.84	2.09	2.84

Table S3: pH summary by extract (Reported summary values).

Extract	pH
Black rice (E1)	3.8
Beet (E2)	3.85
Dragon fruit (E3)	3.93
Overall mean	3.88

Table S4: Viscosity summary by extract (Reported summary values).

Category	Viscosity_cP
Beet (E2)-highest	363.63
Dragon fruit (E3)-lowest	210.88
Overall mean	272.96

masked the 'goaty' aroma of the milk (Table S1). This masking effect aligns with literature reporting that fruit volatiles can alter the perception of dairy off-notes (Setyawardani *et al.*, 2017).

Texture scores also showed significant differences among treatments ($p < 0.01$). Treatments with beet extract tended to increase perceived viscosity and body, which may be attributed to soluble solids and fiber from the extract

interacting with the milk's protein network (Isty *et al.*, 2023). For taste, the highest acceptance among beet treatments was recorded for E2K3 with a mean score of 3.35 (Table S1). The natural sugars in the fruit extracts can blunt sourness by increasing sweetness, but at higher concentrations (2%), the beet extract introduced earthy notes that lowered acceptability.

In addition to hedonic preference, the descriptive (hedonic quality) evaluation results are presented in Table S2. The data show that extract type and concentration influenced the intensity of sensory attributes. Color intensity increased notably with higher concentrations of beet extract, which is associated with betalain pigments. Aroma intensity varied among treatments, with dragon fruit contributing a more pronounced fruity aroma, while beet extract exhibited characteristic earthy notes. Texture intensity remained relatively stable across treatments, indicating that extract addition did not significantly alter mouthfeel perception. These findings are consistent with the hedonic results, confirming that both preference and intensity of sensory attributes are affected by extract incorporation.

Physicochemical properties

The pH values for all treatments remained within a narrow and stable range of 3.80-3.93 (Table S3). This indicates that the added extracts did not substantially alter the fermentation end-products or microbial activity in a way that would compromise product safety or stability. Comparable studies report similar pH ranges for fermented dairy beverages with fruit additions (Pratiwi *et al.*, 2018). A stable pH near 3.8-4.0 is typical for kefir and ensures microbial stability while providing the characteristic tang. Viscosity was significantly influenced by the treatments, with values ranging from 210.88 cP to 363.63 cP (Table S4). The highest viscosity was observed in kefir with beet extract, while the lowest was found in the dragon fruit treatment. It was also noted that increasing extract concentration tended to reduce viscosity. A plausible mechanism for this reduction is interference with protein gelation by low-molecular-weight solutes from the extracts, as small

phenolic compounds might destabilize protein-polysaccharide networks (Mulyadewi *et al.*, 2024). The higher viscosity for beet overall suggests that its matrix contributes more solid-like characteristics compared to dragon fruit or black rice extracts. The correlation between sensory texture scores and measured viscosity was moderate, indicating that treatments with higher viscosity tended to receive higher texture scores up to an optimal point, after which excessive thickness could decrease overall acceptance.

Color

Experimental results indicated that color scores increased with higher concentrations of beetroot and dragon fruit extracts, with beetroot at 2% (E2K4) yielding the highest mean score. This outcome aligns with known pigment chemistry, where betalains from beetroot and anthocyanins from dragon fruit contribute intense red-purple hues that are relatively stable under acidic conditions typical of kefir (Zhao *et al.*, 2021). Black rice anthocyanins produced darker and less vivid tones, which were less preferred by panelists, consistent with studies indicating that consumers generally favor brighter and more saturated beverage colors (Spence, 2015). The pH-dependence of anthocyanin color expression is critical, as structural transformations across pH gradients alter light absorbance and perceived color (Roy *et al.*, 2021). Given kefir's acidic pH (3.8-3.93), anthocyanins are expected to exhibit red-purple coloration, which is often associated with freshness and antioxidant-rich products (Spence, 2015). However, pigment stability may be compromised by oxidation and microbial metabolism during storage; therefore, stabilization strategies such as co-pigmentation, encapsulation, or reduced oxygen exposure are often required to maintain color quality over shelf life (Zhao *et al.*, 2021; Panche *et al.*, 2016).

Aroma

Aroma profiles were markedly influenced by extract type and concentration. Dragon fruit at 2% provided the most favorable aroma scores, suggesting effective masking of goat milk's characteristic 'goaty' notes. Goaty flavor arises from volatile medium-chain fatty acids and branched-chain compounds present in caprine milk; fruit-derived volatiles can mask or complement these notes (Setyawardani *et al.*, 2017). The reduction of undesirable fermentation volatiles (e.g., excessive ethanol, acetaldehyde) in dragon fruit treatments suggests interactions between phenolic compounds and microbial metabolism that modulate volatile production (Wang *et al.*, 2024). Beetroot contributed earthy, sometimes off-putting notes at higher concentrations due to volatiles such as geosmin; however, at mid-level concentrations ($\approx 1.5\%$), beetroot balanced acidity and contributed to overall acceptability (Lu *et al.*, 2003; Wibawanti, 2018). Microbial transformation of flavor precursors during fermentation—such as glycoside hydrolysis and esterification—also shifts aroma profiles over time (Hu *et al.*, 2022). Optimization must therefore consider

both immediate sensory effects and dynamic aroma evolution during storage.

Texture (mouthfeel and perceived viscosity) varied by extract and concentration. Beet extract increased viscosity and yielded the highest texture acceptance (1.5-2% ranges), likely due to additional solids, soluble fibers and interactions between plant polysaccharides and milk proteins that reinforce the gel matrix (Isty *et al.*, 2023; Yilmaz-Ersan *et al.*, 2020). Conversely, dragon fruit, rich in soluble sugars and lower in structural polysaccharides, tended to reduce viscosity at higher concentrations, possibly disrupting casein-casein interactions during gelation (Mulyadewi *et al.*, 2024). Fermentation kinetics (starter concentration and duration) substantially influence texture through acid-induced casein aggregation and exopolysaccharide (EPS) production by lactic acid bacteria; kefir-derived EPS (e.g., kefiran) can enhance creaminess and mouthfeel (Peluzio *et al.*, 2021). Plant extracts can modulate EPS production and proteolysis, thus indirectly affecting texture. Therefore, the observed texture outcomes reflect a combination of added solids, altered proteolytic activity and EPS dynamics.

Taste

Taste acceptance peaked with beet extract at 1.5%, suggesting that moderate inclusion attenuated the characteristic sourness of kefir while avoiding the pronounced earthy flavor at higher beet levels. Mechanistically, phenolic compounds and betalains may alter microbial acidification rates by exerting antimicrobial effects on certain LAB strains, thereby moderating lactic acid accumulation (Sousa *et al.*, 2021). Dragon fruit contributed sweetness and pleasant fruit notes that improved palatability, especially at 2% concentration. Taste perception is multifactorial, influenced by acidity, residual sugars, volatile profile and texture. The interplay between these factors can explain why a formulation that balances moderate extract solids with controlled fermentation produces superior taste scores. Previous studies on fruit-fortified fermented dairy confirm such interactions (Pratiwi *et al.*, 2018; Cruz *et al.*, 2010).

Overall acceptance

Overall acceptance integrates multiple sensory attributes, including color, aroma, texture and taste. The formulation containing 1.5% beet extract achieved the highest overall hedonic score, indicating an optimal balance between sensory appeal and physicochemical stability. Such balance is critical in the development of functional foods, where sustained consumer acceptance is necessary to ensure regular consumption and potential health benefits (de Souza Oliveira *et al.*, 2012; Cruz *et al.*, 2010). Previous studies have highlighted that consumer acceptance of functional dairy products is strongly influenced by sensory properties, even when health benefits are evident (Granato *et al.*, 2010). Furthermore, increasing the concentration of

bioactive compounds may enhance functional value but can negatively impact sensory quality due to off-flavors, undesirable aromas, or texture modifications (Granato *et al.*, 2010). In fermented dairy systems, interactions between bioactive compounds and microbial activity can further influence product characteristics during storage, affecting both stability and acceptability (Peluzio *et al.*, 2021; Li *et al.*, 2023). Therefore, these findings underscore the importance of dose-response optimization and sensory-guided formulation to achieve a balance between functionality and consumer preference. The figure of overall acceptance is shown in Fig S1.

pH

Final pH values between 3.80 and 3.93 demonstrate consistent acidification across treatments. Dragon fruit treatments trended toward slightly higher pH (3.93), possibly due to buffering effects from fruit sugars and organic acids that can moderate lactic acid production. Although differences were not statistically significant, the observed pH stability is consistent with previous studies on fruit-fortified fermented dairy products, where the addition

of plant matrices does not drastically alter acidification patterns (Peluzio *et al.*, 2021). The pH of fermented milk products plays a critical role in determining color stability particularly for anthocyanins as well as microbial viability and textural properties (Li *et al.*, 2023). Maintaining pH within an optimal acidic range is therefore essential to ensure microbiological safety and desirable sensory characteristics, as also highlighted in studies on functional dairy systems (Granato *et al.*, 2010). Consequently, controlling fermentation parameters such as temperature, starter culture concentration and extract composition is crucial to regulate pH evolution during production. The figure of pH value is shown in Fig S2.

Viscosity

Viscosity varied substantially: beet-enriched kefir showed the highest mean viscosity (363.63 cP), whereas dragon fruit formulations had the lowest (210.88 cP). These differences reflect the interaction between extract solids, soluble fibers and protein network formation. Increased total solids, such as those contributed by beetroot, can enhance gel strength and apparent viscosity through

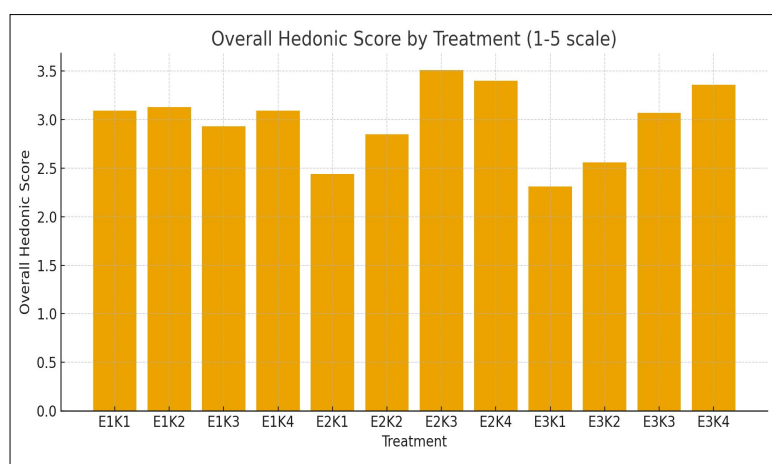


Fig S1: Overall hedonic score by treatment.

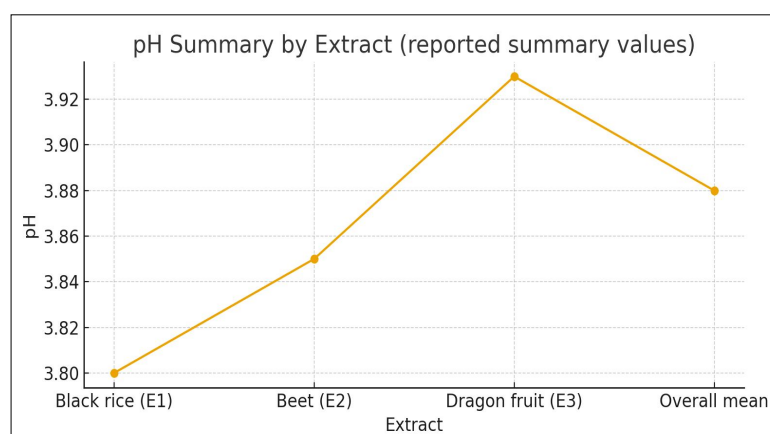


Fig S2: pH summary by extract (Reported summary values).

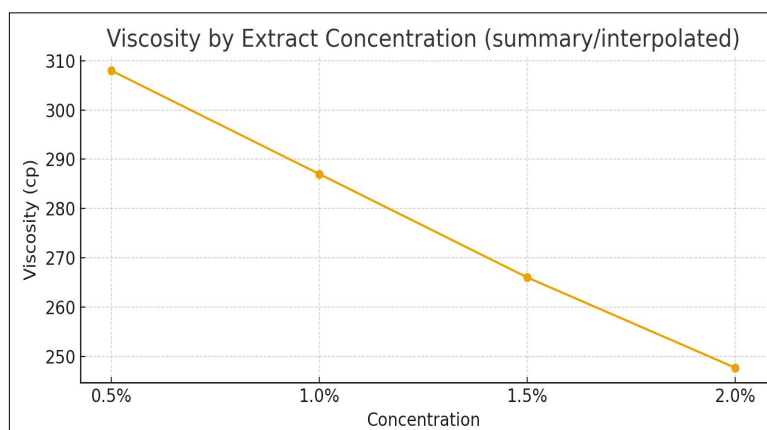


Fig S3: Viscosity by concentration (Summary/interpolated).

reinforcement of the protein-polysaccharide matrix, whereas higher concentrations of low-molecular-weight sugars may weaken network cohesion and reduce viscosity (Isty *et al.*, 2023). Viscosity plays a key role in determining mouthfeel, perceived creaminess and satiety responses in fermented dairy products. In functional beverages targeting obesity management, these textural properties may influence satiation and palatability, thereby affecting consumption behavior. Consistent with previous findings, moderate increases in viscosity tend to improve consumer acceptance, whereas excessive thickening can negatively impact sensory preference (Granato *et al.*, 2010; Li *et al.*, 2023; Liu *et al.*, 2022). The figure of Viscosity value is shown in Fig S3.

CONCLUSION

The incorporation of plant extracts into goat milk kefir significantly improved sensory and physicochemical attributes. Beet extract at 1.5% was the optimal treatment, providing the best overall acceptance, stable pH and favorable viscosity. Dragon fruit extract effectively masked goaty aroma, while black rice contributed less sensory improvement. This study highlights the potential of natural extracts to enhance consumer acceptability and functional value of fermented dairy product.

ACKNOWLEDGEMENT

The present study was supported by the chancellor's decree number 073/C3/DT.05.00/PL/2025 and Agreement/Contract Number 10.7/UN23.34/PT.01/VI/2025 on Hibah Doctor Disertasi in 2025 at KEMDIKTISAINTEK.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

This study involved a sensory evaluation conducted with voluntary panelists. Prior to participation, all respondents were informed about the objectives and procedures of the study and their consent was obtained. The evaluation posed no health risks, as it involved only the assessment of food samples under normal consumption conditions.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

- Cruz, A.G., Cadena, R.S., Walter, E.H., Mortazavian, A.M., Granato, D., Faria, J.A. and Bolini, H.M. (2010). Sensory analysis: Relevance for prebiotic, probiotic and synbiotic product development. *Comprehensive Reviews in Food Science and Food Safety*. **9(4)**: 358-373.
- de Souza Oliveira, R.P., Perego, P., de Oliveira, M.N. and Converti, A. (2012). Effect of inulin on the growth and metabolism of a probiotic strain of *Lactobacillus rhamnosus* in co-culture with *Streptococcus thermophilus*. *LWT*. **47(2)**: 358-363.
- Granato, D., Branco, G.F., Nazzaro, F., Cruz, A.G. and Faria, J.A. (2010). Functional foods and nondairy probiotic food development: trends, concepts and products. *Comprehensive Reviews in Food Science and Food Safety*. **9(3)**: 292-302.
- Hu, Y., Zhang, L., Wen, R., Chen, Q. and Kong, B. (2022). Role of lactic acid bacteria in flavor development in traditional Chinese fermented foods: A review. *Crit. Rev. Food. Sci. Nutr.* **62(10)**: 2741-2755. doi: 10.1080/10408398.2020.1858269. Epub 2020 Dec 30. PMID: 33377402.
- Isty, G.M.N., Setyawardani, T. and Sumarmono, J. (2023). Physical and sensory characteristics of cow's milk kefir enriched with black rice extract. *Journal Triton*. **14(2)**: 573-582.

- Li, Q., Zhang, F., Wang, Z., Feng, Y. and Han, Y. (2023). Advances in the preparation, stability, metabolism and physiological roles of anthocyanins: A review. *Foods*. **12(21)**: 3969.
- Liu, J., Yong, H., Yao, X. and Zhang, X. (2022). Anthocyanins: Natural colorants with health-promoting properties and their application in dairy. *Comprehensive Reviews in Food Science and Food Safety*. **21(6)**: 5954-5978.
- Lu, G., Edwards, C.G., Fellman, J.K., Mattinson, D.S. and Navazio, J. (2003). Biosynthetic origin of geosmin in red beets (*Beta vulgaris* L.). *Journal of Agricultural and Food Chemistry*. **51(4)**: 1026-1029.
- Mulyadewi, A.L., Bakhrul, I.I.M. and Hardiansyah, A. (2024). Effects of honey goat milk kefir on pancreatic histopathology and renal function in diabetic rats. *Amerta Nutrition*. **8(3SP)**: 412-421.
- Naufalin, R., Arsil, P., Wibowo, C., Wijonarko, G., Latifasari, N. and Nugroho, M.Y. (2026). Optimization of torch ginger (*Etlingera elatior*) tea addition in kefir powder production for enhanced functional quality using response surface methodology. *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DRF-613.
- Panche, A.N., Diwan, A.D. and Chandra, S.R. (2016). Flavonoids: an overview. *Journal of Nutritional Science*. **5**: e47.
- Peluzio, M.D.C.G., Martinez, J.A. and Milagro, F.I. (2021). Kefir and intestinal microbiota modulation: Implications in human health. *Frontiers in Nutrition*. **8**: 638740.
- Pratiwi, B.M., Rizqiaty, H. and Pratama, Y. (2018). Effect of red dragon fruit substitution on antioxidant activity, pH, lactic acid bacteria and organoleptic properties of soybean kefir. *Journal Teknologi Pangan*. **2(2)**: 98-105.
- Roy, S. and Rhim, J.W. (2021). Anthocyanin food colorant and its application in pH-responsive color change indicator films. *Critical Reviews in Food Science and Nutrition*. **61(14)**: 2297-2325.
- Setyawardani, T., Sumarmono, J., Rahardjo, A.H.D., Sulistyowati, M. and Widayaka, K. (2017). Chemical, physical and sensory quality of goat milk kefir during storage under different temperatures. *Bulletin of Animal Science*. **41(3)**: 298-306.
- Sousa, G.G.D., Sousa, S.B., Pereira, A.C.D.S., Marques, V.B., Silva, M.L.D. and Lopes, J.D.S. (2021). Effect of saline water and shading on dragon fruit ('pitaya') seedling growth. *Revista Brasileira de Engenharia Agrícola e Ambiental*. **25(8)**: 547-552.
- Spence, C. (2015). On the psychological impact of food colour. *Flavour*. **4(1)**: 21.
- Subbalakshmi, S., Devika, H.R., Harsha, K.M., Kalpana, R., Shet, K.G. and Rashmi, D. (2024). Development of a fermented probiotic beverage inoculated with kefir grain. *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DR-2155.
- Wang, J., Wei, B., Xu, J., Jiang, H., Xu, Y. and Wang, C. (2024). Influence of lactic acid fermentation on the phenolic profile, antioxidant activities and volatile compounds of black chokeberry (*Aronia melanocarpa*) juice. *J. Food Sci.* **89(2)**: 834-850. doi: 10.1111/1750-3841.16899. Epub 2024Jan3. PMID: 38167751.
- Wibawanti, J.M.W. and Rinawidiastuti, R. (2018). Sifat fisik dan organoleptik yogurt drink susu kambing dengan penambahan ekstrak kulit manggis (*Garcinia mangostana* L.). *Journal Ilmu dan Teknologi Hasil Ternak*. **13(1)**: 27-37.
- Wulansari, P.D., Rahayu, N., Frasiska, N., Kusuma, R.J. and Wibawanti, J.M.W. (2026). Probiotic potential of *Lactiplantibacillus plantarum* isolates from Indonesian kefir grains cultured in goat milk. *Asian Journal of Dairy and Food Research*. **45(2)**: 219-226. doi: 10.18805/ajdfr.DRF-616.
- Yilmaz-Ersan, L., Ozcan, T. and Akpınar-Bayazit, A. (2020). Assessment of socio-demographic factors, health status and the knowledge on probiotic dairy products. *Food Science and Human Wellness*. **9(3)**: 272-279.
- Zhao, Y.W., Wang, C.K., Huang, X.Y. and Hu, D.G. (2021). Anthocyanin stability and degradation in plants. *Plant Signal Behavior*. **16(12)**: 1987767. <https://doi.org/10.1080/15592324.2021.1987767>.