



ORIGINAL ARTICLE

THE EFFECT OF HEATHER HONEY ADDITION ON PHYSICOCHEMICAL AND MICROBIOLOGICAL PROPERTIES OF STIRRED-TYPE YOGHURT

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Ethical considerations: When reporting experiments on animals Observation of the ARRIVE guidelines 2.0: Updated guidelines for reporting animal research, published on July 14, 2020 ([DOI: 10.1371/journal.pbio.3000410](https://doi.org/10.1371/journal.pbio.3000410)), is applied. The authors ensure that all procedures were performed in compliance with the guidelines for animal care of their institutions or with national/international guidelines.

ABSTRACT

The aim of this study was to investigate the impact of the heather honey concentrations (2.5% and 5%) on the physicochemical and microbial properties of yoghurt samples made from cow milk. Honey, used as a natural fortifier, enhanced antioxidant activity and probiotic viability of experimental samples. Except for water activity (a_w), each physicochemical variable (dry matter, titratable acidity, water-holding capacity and antioxidant activity) differed significantly ($p < 0.001$) between the control and both experimental yoghurt sample groups (2.50% and 5.00%). Throughout the study, the 5.00% heather honey-added yoghurt consistently exhibited the peak antioxidant activity on days 1, 15, and 22. Multiple factor analysis (MFA) revealed correlations among the variables and visualised the similarity of the analysed samples on the 15th and 22nd days. On the other hand, the results of MFA showed differences in control and both experimental yoghurt sample groups with heather honey addition. As the demand for fermented milk grows, the dairy industry is increasingly combining probiotics with functional foods—most notably through the development of probiotic functional yoghurts.

Keywords: antiradical activity; fermented dairy product; quality; storage

INTRODUCTION

Yoghurt, a widely consumed dairy product, has a rich cultural and historical background [1]. It is derived from the fermentation of milk and has become an essential part of many people's diets due to its well-established reputation as a nutritious food [2]. For centuries, fermentation has served as a method to extend the shelf life of perishable foods while simultaneously enhancing the taste and aroma of the final product [3]. Yoghurt is the outcome of

fermenting pasteurised or sterilised milk using probiotic cultures of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus* (*L.*) *delbrueckii* subsp. *bulgaricus* [4]. These bacteria produce bioactive compounds with nutritional and therapeutic value, such as antioxidants and antidiabetic agents [5]. Yoghurt naturally contains bioactive compounds produced during fermentation (such as probiotics and health-promoting metabolites). However, it is often not primarily recognized for these compounds compared to other fortified or enriched foods [6].

About 300 types of honey are well known (e.g., acacia, citrus, clover, honeydew, Majra, Manuka, Mountain Sidr, and Tualang honey), which are differentiated by their sources and seasonal and geographical origins [7]. Honey, as a natural sweetener, has gained significant attention in dairy processing, particularly in yoghurt production. It not only enhances the flavor of yoghurt but also offers several additional benefits, including antimicrobial, antioxidant, and preservative properties. It is composed mainly of fructose and glucose and contains bioactive compounds such as polyphenols, which contribute to its antioxidant and antimicrobial effects [2]. Therefore, many studies have focused on yoghurt fortified with honey due to its numerous human health benefits. For example, this combination has been shown to increase antioxidant activity [8].

The integration of honey into yoghurt products offers several potential advantages. Honey serves as a natural preservative, extending the shelf life of yoghurt by inhibiting the growth of harmful bacteria. It also improves the viability of probiotics and enhances the overall quality of fermented dairy products. Additionally, honey's water-binding properties, due to its high fructose content, can improve yoghurt texture, preventing syneresis (the separation of liquid from solid content) and contributing to a creamier consistency [2].

The aim of this study was to evaluate the application of the heather honey in the production of yoghurt and to analyse physicochemical and microbiological changes in experimentally prepared yoghurt samples during storage.

MATERIAL AND METHODS

Starter culture and heather honey

A commercial Bulgarian yoghurt starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (1:1) (Genesis Laboratories Ltd., Bulgaria) was used. Starter cultures were in freeze-dried direct-to-vat set form and stored at -18°C until used. Heather honey (Volansky Honey, Slovakia) was obtained from an online market.

Yoghurt sample preparation

Yoghurt samples were prepared from fresh cow's milk pasteurised and standardised at the dairy plant. The production was performed at the Dairy Technology Laboratory of the Department of Food Hygiene, Technology and

Safety, University of Veterinary Medicine and Pharmacy in Košice, Slovakia. Prior to yoghurt production, physicochemical analysis of the raw milk was performed. Three distinct yoghurt sample groups were evaluated. The control group consisted of conventional yoghurt inoculated with a standard starter culture without honey fortification. Two experimental treatments were prepared by incorporating heather honey at concentrations of 2.5% and 5.0% (w/w) post-fermentation.

For yoghurt manufacture, fresh milk was thermally treated at 90 °C for 30 min, subsequently cooled to 40 °C, and inoculated with the yoghurt starter culture. The inoculated milk was transferred into glass containers and incubated at 35 °C until complete coagulation was achieved, corresponding to a target pH of 4.5. Following incubation, the base yoghurt was stored at 4 °C for 24 h.

The experimental samples were then formulated by blending the matured yoghurt with either 2.5% or 5.0% (w/w) heather honey. Both control and fortified yoghurt samples were maintained under refrigeration at 4 °C. Analytical assessments were conducted on the initial day (Day 0) and after 15 and 22 days of cold storage.

Physicochemical Determination

The milk temperature, fat content, solids non-fat (SNF), density, protein, lactose, added water, freezing point, pH, and mineral salts of the six milk samples (40 ml each) were measured using an ultrasonic milk analyser (Lactoscan MCCW Milk Analyser, Bulgaria).

The milk used for experimental yoghurt production had an average temperature at 18.30 ± 2.49 °C, fat content of $3.43 \pm 0.03\%$, SNF of $8.65 \pm 0.06\%$, density of 1.03 ± 0.00 g/cm³, proteins of $3.17 \pm 0.03\%$, lactose of $4.76 \pm 0.04\%$, added water of 0.00% , freezing point of -0.55 ± 0.00 °C, pH of 6.22 ± 0.08 and mineral salts of $0.72 \pm 0.01\%$.

The dry matter (DM) content of yoghurt samples was determined using moisture analyser (Radwag MA50/1, Poland). It was determined in three replicates as the average moisture content, each time by drying a sample of around 2.5 g at a temperature of 102 ± 2 °C.

Titrate acidity (TA) was determined according to the Soxhlet-Henkel method [9]. The titration of a 25 g yoghurt sample was performed in the presence of a phenolphthalein indicator until a light pink colour developed. The value was expressed as an average of three measurements as a percentage of the lactic acid.

The water-holding capacity (WHC) was assessed using the modified centrifugation method described by Saffon et al. [10]. Yoghurt samples were weighed to approximately 30 g into centrifugation tubes (volume 50 mL) and centrifuged using a Jouan BR4 Refrigerated Centrifuge (Jouan Technology for Life, USA) at a temperature of 4 ± 2 °C and 3500 rpm for 5 min. The difference between the weight of the sample in the centrifuge tube before and after centrifugation represented the amount of the separated supernatant, expressed as a percentage. The measurement was performed three times for each sample.

Antiradical activity (AA) was determined by 2,2-diphenyl-1-picryl-hydrazyl (DPPH) inhibition by the modified methods of Brand-Wiliams et al. [11]. Yoghurt samples (10 g) were weighed, and 30 ml of ethanol was added and properly mixed and centrifuged using a Jouan BR4 Refrigerated Centrifuge (Jouan Technology for Life, USA) at a temperature of 4 ± 2 °C and 3500 rpm for 5 min. Ethanol extracts prepared from yoghurts were homogenized with DPPH solution. This mixture was incubated in the dark at room temperature for 30 min. The absorbance was measured at 517 nm using a spectrophotometer, and distilled water was used as a blank. The DPPH free radical scavenging ability was then determined as the percentage inhibition of DPPH free radicals.

The water activity (a_w) was determined with the LabMaster a_w Sprint instrument (Novasina Division, Switzerland) according to ISO 21807 [12].

Microbiological examination

A stock suspension and subsequent 10-fold dilutions were prepared according to ISO 6887-1 [13]. The prepared 10-fold dilutions were used in the subsequent microbiological cultivation sample examinations.

To determine the number of coliform organisms, the stock and 10-fold dilutions were spread on the surface of Endo agar (HiMedia Laboratories, India), and the plates were incubated in a thermostat at 37 °C for 24 hours, respectively.

The number of staphylococci from the examined yoghurt samples was obtained according to ISO 6888-1 [14] using Baird-Parker selective diagnostic medium. The inoculated plates were incubated at 37 °C for 24 h.

To determine the counts of lactic acid bacteria (LAB) on the surface of the selective diagnostic medium of De Man, Rogosa, and Sharpe (MRS, Hi-Media, India), the

spread plate method was used. The inoculated plates were then incubated under anaerobic conditions at 37 °C for 48 h using AnaeroGen (Oxoid, UK).

The determination of the number of yeasts and moulds (YM) was done according to ISO 21527-1 [15], using the spread plate method and Dichloran Rose-Bengal Chloramphenicol (DRBC) agar (Hi-Media, India). The inoculated plates were incubated at 25 °C for 5–10 days. After incubation, the counts of yeasts and moulds were obtained and converted to the amount per 1 g of the sample.

Detection of the number of bacteria of the family *Enterobacteriaceae* (EB) was performed according to STN EN ISO 21528-1 [16] using the selective diagnostic medium Violet Red Bile Lactose Agar (VRBL; HiMedia, India).

The counts of enterococci (EC) were determined by cultivation on Slanetz-Bartley agar (HiMedia, India) at 37 ± 1 °C for 48 h.

The results of microbiological variable measurements were converted to decadic logarithms ($\log_{10}$) to approximate the data in order to apply statistical testing methods.

Statistical analysis

The results obtained in this experiment were expressed as mean $\pm$ standard deviation (SD). Analysis of variance (ANOVA) and Tukey's test for multiple comparisons of means at a significance level of $p < 0.05$ were carried out via the R-statistics software [17]. The effects of 2.5% and 5.0% heather honey additions, and storage periods were set as the main factors of the statistical evaluation. Multiple factor analysis (MFA) was conducted in R-statistics software with the "FactomineR" [18] and "Factoextra" packages [19] according to Semjon et al. [20].

In the presented experiment, the following hypotheses were tested:

- Hypothesis 1: There exist differences in physico-chemical and microbial variables in yoghurt samples with the heather honey addition in two concentrations (2.50% and 5.00%).
- Hypothesis 2: Observed variables change during storage for 15 and 22 days at 4 ± 2 °C.
- Hypothesis 3: Statistically significant correlations exist between individual measured variables.

RESULTS

The results of physicochemical determinations are presented in Table 1. Statistically significant differences were observed in physicochemical variables between control and experimental groups (honey 2.50% and honey 5.00%) in each variable (DM, TA, WHC, AA) ($p < 0.001$), except for the a_w variable, where honey addition did not influence water activity of the samples. On the initial day of the experiment, the lowest dry matter content was observed in the control group. The heather honey addition increased DM of the experimental yoghurt samples. However, the highest lactic acid concentration during the storage period was observed on the initial day of storage in the control group ($p > 0.05$). Based on the measured results, the lowest WHC during this experiment was observed in the control group. Adding heather honey at both concentrations (2.50% and 5.00%) increased the WHC of the experimental yoghurt samples by more than 10%. Antiradical activity increased with the higher concentration of heather honey addition. However, a significant effect of honey concentration was observed exclusively on the initial day of storage ($p < 0.001$). The highest AA was observed in yoghurt samples with a 5.00% heather honey addition during the whole experiment.

Bacterial counts were converted to logarithmic form ($\log_{10}$) and are listed in Table 2. The main factor of heather honey addition to yoghurt samples showed statistical significance at level $p < 0.001$ in microbiological variables: LAB, YM and EC. Storage period influenced these microbiological variables significantly ($p < 0.001$), except for the presence of enterococci ($p > 0.05$). Microbiological analysis revealed that the control and both experimental samples were below the limit of detection, respectively, the coliform organisms (including faecal coliform and *E. coli*) and staphylococci ($< 1.0 \times 10^2$ CFU/g). Samples stored at 4 ± 2 °C for 15 days showed the highest enumeration of viable lactobacilli, reaching a maximum of 8.88 ± 0.18 log CFU/g in the control group. Compared to experimental groups, the control samples exhibited significantly lower retention of viable lactobacilli during the storage period than experimental samples with 2.50% and 5.00% heather honey additions. The results of yeasts and mould determination in yoghurt samples showed that the average presence ranged from 2.88 to 3.89 log CFU/g on the initial day of storage. During the storage, the yeasts and mould count significantly decreased, but in the control group, their presence of 2.40 and 2.82 log CFU/g was observed in samples on 15 and 22 days of storage, respectively. The highest count of enterococci was observed in the control group after 22 days of storage.

Table 1. Physicochemical results of experimental yoghurt samples with heather honey addition

Sample	Day	DM (%)	TA (% LA)	WHC (%)	AA (% DPPH in.)	a_w
Control	0 (1)	14.01 ± 0.18^{cde}	1.33 ± 0.02^a	78.45 ± 1.50^e	47.76 ± 3.07^h	0.87 ± 0.00^a
Honey 2.50%		16.92 ± 1.52^a	1.19 ± 0.02^f	93.31 ± 1.53^{bc}	53.01 ± 0.84^f	0.87 ± 0.00^a
Honey 5.00%		16.37 ± 0.35^{ab}	1.25 ± 0.04^{cde}	92.09 ± 0.64^c	61.48 ± 0.15^c	0.87 ± 0.00^a
Control	15	13.67 ± 0.12^{de}	1.20 ± 0.01^{ef}	81.35 ± 1.48^{de}	48.03 ± 6.17^g	0.87 ± 0.00^a
Honey 2.50%		14.36 ± 1.22^{cd}	1.33 ± 0.02^a	100.04 ± 6.47^a	58.52 ± 1.16^d	0.87 ± 0.00^a
Honey 5.00%		17.25 ± 0.13^a	1.22 ± 0.00^{def}	97.63 ± 0.17^{ab}	62.28 ± 1.04^a	0.87 ± 0.00^a
Control	22	13.06 ± 0.27^e	1.30 ± 0.01^{abc}	85.89 ± 2.17^d	57.38 ± 0.76^e	0.87 ± 0.00^a
Honey 2.50%		15.13 ± 0.01^{bc}	1.30 ± 0.00^{ab}	97.02 ± 0.00^{ab}	60.38 ± 0.38^d	0.87 ± 0.00^a
Honey 5.00%		17.54 ± 0.07^a	1.27 ± 0.05^{bcd}	97.37 ± 0.34^{ab}	61.49 ± 1.91^b	0.87 ± 0.00^a
p - value	SA	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p > 0.05$
	ST	$p < 0.05$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p > 0.05$
	SA x ST	$p < 0.001$	$p < 0.001$	$p < 0.05$	$p < 0.001$	$p < 0.001$

DM, dry matter; TA, titratable acidity; LA, lactic acid; WHC, water-holding capacity; AA, antiradical activity; in., inhibition; a_w , water activity; SA, the main factor of heather honey addition; ST, the main factor of the storage period; SA x ST, interaction between main factors. Means in the column with a different superscript letter (^{a-h}) are statistically different (Tukey's, $p < 0.05$).

Table 2. The microbiological culture examination of yoghurt samples (log CFU/g mean $\pm$ SD).

Sample	Day	COLI	STAP	LAB	YM	EB	EC
Control	1	$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	7.30 ± 0.18^d	2.88 ± 0.14^c	$< 1.0 \times 10^2$	3.33 ± 0.16^a
Honey 2.50%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	7.73 ± 0.16^c	3.89 ± 0.12^a	$< 1.0 \times 10^2$	3.34 ± 0.12^a
Honey 5.00%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	6.54 ± 0.18^c	3.35 ± 0.14^b	$< 1.0 \times 10^2$	3.02 ± 0.17^c
Control	15	$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.88 ± 0.18^a	2.40 ± 0.08^d	$< 1.0 \times 10^2$	3.30 ± 0.09^{ab}
Honey 2.50%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.69 ± 0.18^{ab}	$< 1.0 \times 10^{2e}$	$< 1.0 \times 10^2$	3.22 ± 0.18^{abc}
Honey 5.00%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.52 ± 0.18^b	$< 1.0 \times 10^{2e}$	$< 1.0 \times 10^2$	3.03 ± 0.16^c
Control	22	$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.73 ± 0.18^{ab}	2.82 ± 0.12^c	$< 1.0 \times 10^2$	3.40 ± 0.10^a
Honey 2.50%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.63 ± 0.18^{ab}	$< 1.0 \times 10^{2e}$	$< 1.0 \times 10^2$	3.24 ± 0.11^{abc}
Honey 5.00%		$< 1.0 \times 10^2$	$< 1.0 \times 10^2$	8.43 ± 0.18^b	$< 1.0 \times 10^{2e}$	$< 1.0 \times 10^2$	3.05 ± 0.03^{bc}
<i>p</i> - value	SA	<i>n.a.</i>	<i>n.a.</i>	$p < 0.001$	$p < 0.001$	<i>n.a.</i>	$p < 0.001$
	ST	<i>n.a.</i>	<i>n.a.</i>	$p < 0.001$	$p < 0.001$	<i>n.a.</i>	$p > 0.05$
	SA x ST	<i>n.a.</i>	<i>n.a.</i>	$p < 0.001$	$p < 0.001$	<i>n.a.</i>	$p > 0.05$

n.a., not applicable; COLI, coliforms; STAP, staphylococci; LAB, lactic acid bacteria; YM, yeasts and moulds; EB, *Enterobacteriaceae*; EC, enterococci; SA, the main factor of heather honey addition; ST, the main factor of the storage period. SA x ST, interaction between main factors. Means in the column with a different superscript letter (^{a-d}) are statistically different (Tukey's, $p < 0.05$).

The MFA method was applied to the measurements of the physicochemical and microbiological analyses of the experimental yoghurt samples in order to evaluate the main factors of the presented study (effect of honey addition and storage period). The analysis extracted the most significant variables with a minimum loss of information, where Kaiser's criterion (eigenvalue > 1) was applied to determine the number of final dimensions from the initial ones [21]. The results of the MFA extracted four components of the experimental yoghurt samples that explained 88.11% of the total variation in the data set. The first dimension (Dim1) explains 32.89% of the variation, dimension 2 (Dim2) 26.78%, dimension 3 (Dim3) 14.72%, and dimension 4 (Dim4) explains 13.72% (Figure 1). The contribution of the analysed data in Dim1-related physicochemical variables (35.27%, $r = 0.94$). The following physicochemical variables correlated significantly in Dim1: a_w ($r = 0.78$), DM ($r = -0.72$), WHC ($r = -0.85$) and AA ($r = -0.87$). Microbial variables such as LAB ($r = 0.95$), EC ($r = 0.31$) and YM ($r = -0.62$) contributed significantly to Dim2 (43.40%, $r = 0.96$). The factor of the sample groups and storage period contributed mainly to Dim3 and Dim4 with 62.44% ($r = 0.84$) and 74.50% ($r = 0.88$), respectively.

The combined graph of individuals (Figure 1) shows representations of individuals in which the individuals' sample ellipses are plotted separately (sorted according to the main analysed factor experimental group of samples). The experimental yoghurt samples analysed on days

15 and 22 of storage at $4 \pm 2^\circ\text{C}$ were plotted overlapped, which means that they were very similar in their physicochemical and microbial characteristics. On the other hand, the control yoghurt samples on the initial day of the experiment differed in the analysed variables. Based on the MFA results, the main analysed factors of the presented study, the heather honey addition and storage period, significantly affected the properties of the experimental yoghurt samples ($p < 0.001$).

DISCUSSION

The dry matter content was significantly increased in samples with honey addition in both concentrations ($p < 0.001$). Tamime and Robinson [22] report that the presence of the soluble carbohydrates leads to an increase in the total dry matter of yoghurt. DM on the first day of storage was 14.01% in the control sample, 16.92% (experimental group with 2.50% of the heather honey addition), and 16.37% in the experimental group with 5% honey. According to McSweeney and Fox [23], fermentation leads to changes in the casein network that can affect the distribution of free and bound water; therefore, these changes are crucial for the formation of the texture and rheological properties of fermented dairy products.

Anwar, Faiz, and Hou [2] report that introducing honey prior to fermentation enhances the metabolic activity of bacterial cultures due to the additional fermentable sugars,

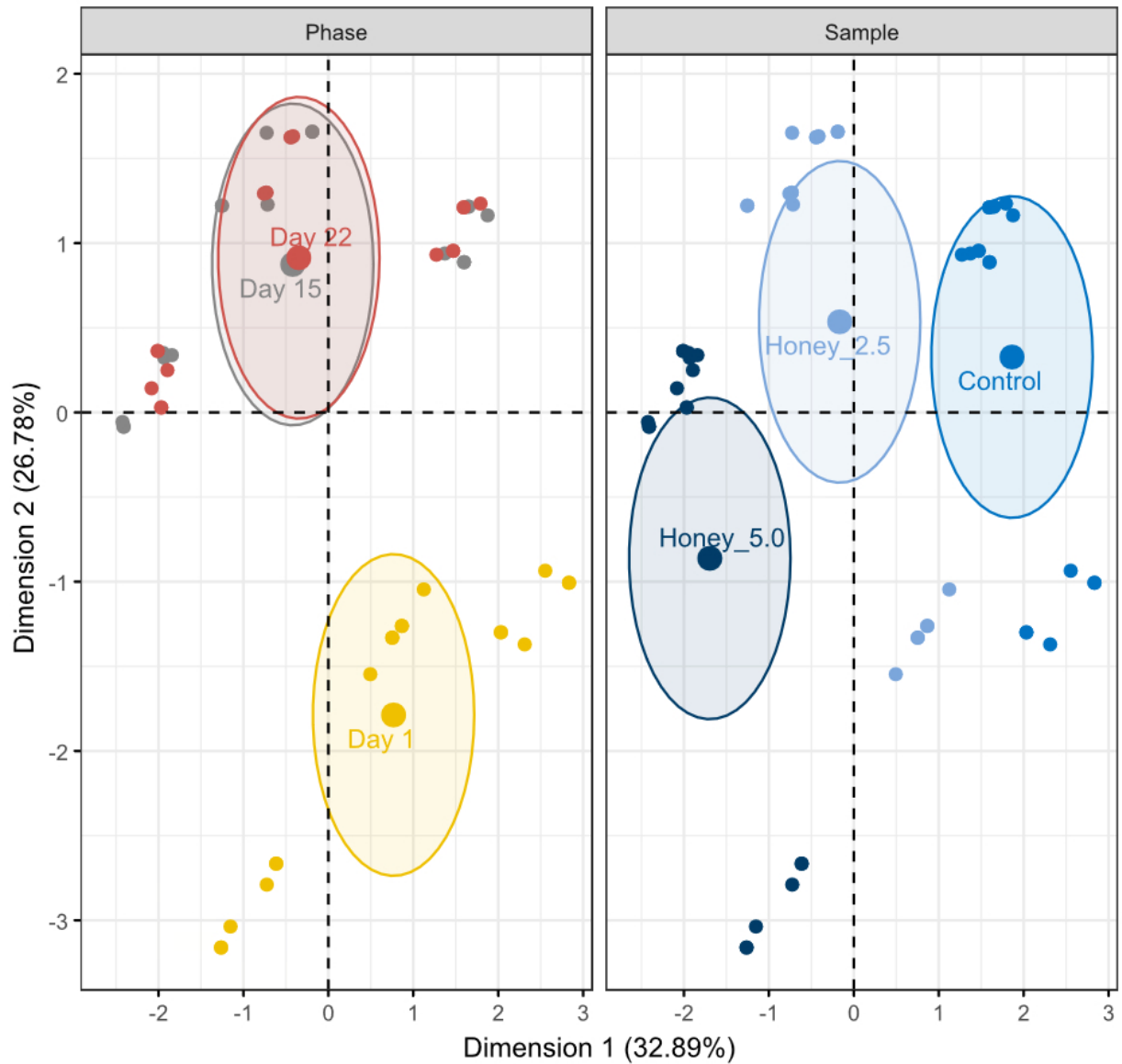


Fig. 1. A combined graph of individual samples with the storage period and experimental group of yoghurt samples as main factors

ultimately leading to higher acidity in the final yoghurt. In contrast, based on our results, incorporating heather honey after fermentation initially led to a decrease in yoghurt acidity on the first day of the storage period, regardless of the concentration used (Table 1).

Experimentally prepared yoghurts were heated during manufacture at temperatures that induce the denaturation of whey proteins (heat-labile), so that they precipitate and coagulate along with casein micelles (heat-stable) on acidification [24]. This step is essential to ensure the yoghurt gel stability, and thus, no major syneresis was observed while the sweetened yoghurts were refrigerated in the containers [25]. Authors Mohan et al. [25] observed statistical difference ($p > 0.05$) in the WHC values among the sweetened yoghurt types when tested at weekly intervals.

However, our results of the WHC variable showed a significant effect of honey addition and storage period ($p < 0.001$). Higher WHC values for sunflower honey yoghurts analysed by Sert et al. [26] showed increasing WHC with the concentration of honey (2–6% w/v).

Honey can have an antioxidant effect in dairy products. Honey contains various antioxidant compounds, including flavonoids, polyphenols, and ascorbic acid. Combining honey with dairy products may result in a synergistic effect on antioxidant activity [27]. Anwar et al. [2] observed that the antioxidant activity of blended yoghurt increased with higher honey concentrations, reaching 42.36 ± 0.01 at 5% honey concentration. This is in consideration of our presented results (Table 1). On the first day of the sample's storage, the experimental yoghurt sample group with

5.00% of the heather honey addition reached 61.48% anti-radical activity. During this experiment, the yoghurt samples with 5.00% honey concentration had the highest AA on 1, 15 and 22 days. The antioxidant potential of dairy products is related to the quality of the raw material and, primarily, the presence and activity of natural bioactive compounds in milk [28]. The bacterial cultures also have a high impact on the value of the antioxidant potential [29]. Milk fermentation with lactic acid bacteria contributes to the supply of a huge number of bioactive peptides and free amino acids with diverse biological activities [30]. It was noted that the antioxidant activity increased slightly during storage, even in the control group of yoghurts. This may be due to the slow fermentation process during storage or the increasing number of LAB microorganisms, whose numbers have also risen.

Sert et al. [26] reported that 4–6% honey-added yoghurts had maximum survival of *L. bulgaricus*. However, Roumyan et al. [32] studied the effect of acacia honey and polyfloral honey and found a significant inhibition in the growth of *L. bulgaricus* in honey-added Bulgarian yoghurt. On the other hand, Varga [33] noted that the yoghurt with the addition of honey in the amount of 1.0% to 5.0% did not significantly influence the survival of the starter bacteria in yoghurt during storage at 4 °C. Metry Wedad and Oways [34] determined that the *L. bulgaricus* count in a yoghurt sample with 4% honey decreased from the beginning to the 9th day of storage. Ustunol and Gandhis [35] demonstrated that adding honey at a concentration of 5% in yoghurts is optimal for the growth of probiotics and starter culture bacteria and for their survival during the refrigerated storage period. To provide a precise explanation of the kinetics of microorganism growth and their contribution to physicochemical properties, including antioxidant activity, an in-depth kinetic study of the fermentation process will be mandatory for this kind of study, and moreover, with the identification of microorganisms.

CONCLUSION

The study demonstrates the benefits of adding heather honey to improve the quality of yoghurt made from cow's milk. It provides a comprehensive view of the physicochemical and microbial quality parameters of the experimentally prepared yoghurt. The results showed that

yoghurt with heather honey addition is an effective and natural ingredient for enriching probiotic dairy products, such as yoghurt, for at least 22 days of storage. It can be concluded that yoghurt with a 5.00% heather honey addition appears to be the more suitable option than 2.50% for its antiradical activity and better water-holding capacity, which are related to its texture. Honey components and antioxidant properties, which vary by type, enhance the antioxidant properties of the yoghurt. To ensure consumer satisfaction, additional longitudinal sensory testing and testing across several honey types could be conducted to define the exact endpoint of consumer acceptance and honey benefit properties of enriched yoghurts during storage.

Data Availability Statement

The raw data of this article will be made available by the authors, without undue reservation.

Ethical Statement

Ethical approval was not necessary for this work.

Conflict of Interest

The authors have no conflict of interest to declare.

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Authors' Contributions

Conceptualization: B.S., E.K.; Methodology: B.S., Z.M.E., I.R.; Field data and Sampling: B.S., E.K.; Data analysis: B.S.; Resources and Supervision: B.S., Z.M.E., I.R.; Writing-original draft preparation: B.S., E.K.; Writing-review and Editing: Z.M.E., I.R.; All authors read and approved the published version of the manuscript.

Generative AI Statement

No generative artificial intelligence (AI) and AI-assisted technologies were used in writing the manuscript.

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