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Physical, chemical, microbial, and sensory evaluation and fatty acid profiling of value-added drinking yogurt (laban) under various storage conditions

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ABSTRACT

Yogurt is defined as a coagulated milk product obtained from the fermentation of lactose into lactic acid. Drinking yogurt (laban) was prepared from buffalo milk, cow milk, and a 50:50 blend (cow + buffalo milks) by adding 0.5% carboxymethyl cellulose to each of the 3 milk treatments. Samples were then refrigerated for 7, 14, and 21 d before determination of physical, microbial, and sensory parameters. Yogurt prepared from buffalo milk had higher fat and protein contents, and better taste, aroma, and overall consumer acceptability compared with laban prepared from cow milk or mixed milk. During storage, protein and total solids contents remained unchanged, whereas milk fat, color, appearance, taste, smell, texture, and overall acceptability of laban decreased in the different treatment groups. The acidity of laban increased with storage time. Bacteria, including coliforms, were not found in any treatment group during storage. In conclusion, overall acceptability of laban prepared from buffalo milk was higher than that made from cow milk or mixed milk, but increased storage time reduced the quality of laban prepared from cow, buffalo, or mixed milk.
Key words: drinking yogurt (laban), cow laban, buffalo laban, sensory parameter, storage

INTRODUCTION

Pakistan ranks fourth in milk-producing countries worldwide; most of the milk in Pakistan is produced by cows, buffaloes, and some small ruminants (Tahir et al., 2019). Milk production in Pakistan has increased 40% during the last decade and reached 63,684,000 t during the year 2020–2021 (GOP, 2020–21). The contribution of cow and buffalo milks to total milk production is 35.7 and 60.9%, respectively (GOP, 2018–2019). Despite a gradual increase in the demand for milk and milk products, dairy producers still face numerous financial, animal health, and management problems. Globally, milk is being utilized in the form of numerous value-added products but few milk products are prepared and consumed in Pakistan.

Buffalo milk is purchased because of its high fat and TS contents (6.5% and 10.5%, respectively; GOP, 2018–2019). Buffalo milk is particularly rich in vitamin A and lacks carotene. Buffalo milk is highly suitable for the manufacturing of several dairy products including fermented milk products such as yogurt, lassi, and cheese (Moioli et al., 2006). In the current industrial scenario of fermented products, cow milk is the predominant starting material for variety of fermented milk products including plain, whipped, semi-solid drinking type, smoked, dried, fruited, flavored, strained, and frozen yogurt. The TS content of cow milk is usually less than that of buffalo milk; therefore, cow milk is generally fortified with skim milk powder to attain the proper curd consistency of fermented products (Chandan et al., 2006). Acidifying milk through fermentation is an ancient method of milk preservation that is still practiced today. Fermentation is done by chemical and microbiological methods, and modifications in these fermentation processes result in a variety of fermented dairy products such as kefir, kumiss, acidophilus milk, laban, and yogurt (Haj et al., 2007).

The dairy processing industries use selected lactic starter cultures to ferment the milk into yogurt, cheese, and drinking yogurt (laban). Ingestion of fermented dairy products helps maintain a balanced intestinal

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microbial milieu that can enhance human immunity by producing vitamins. The intestinal microbial ecosystem is susceptible to damage after antibiotic treatment or hormonal changes caused by stress conditions throughout the life of on individual, which may lead to acute and chronic diseases (Durack and Lynch, 2019). Fermented dairy products with a sufficient beneficial microflora can be administered for the treatment of lactose intolerance, acute diarrhea, irritable bowel syndrome, necrotizing enterocolitis, and mild forms of inflammatory bowel disease (Cancarevic et al., 2020). Various types of traditional and industrial fermented milk products are manufactured throughout the world. The human diet can be supplemented with fermented dairy products that can provide essential nutrients vital for body growth and better health (Serhan et al., 2016). Traditionally, laban, a stirred or drinking form of yogurt, is a fermented liquid milk product that is appreciated and consumed in the Middle East (Guizani et al., 2001). Laban can be produced from the milk of all domestic animals, including camel, cow, and goat milk, but cow and buffalo milk most commonly serve as a base material for laban processing (Hashim et al., 2009). Laban, available in sweet and sour forms, has a higher therapeutic and nutritional value than milk (Serhan et al., 2016).

Traditionally, the fermentation process for the production of fermented dairy products is affected by spontaneous proliferation of the initial raw milk flora at ambient temperature. However, in the modern era, fermentation of dairy products is a well-controlled process that involves the addition of milk powders, sugars, fruits, food-grade flavoring and coloring agents, emulsifiers, stabilizers, and isolated cultures of lactic acid bacteria in the milk (Temesgen and Yetneberk, 2015). Laban is the result of lactic acid fermentation of milk by incorporating starter bacterial culture consisting of *Streptococcus salivarius* and *Lactobacillus delbrueckii* (Bintsis, 2018). Sweeteners are added to these cultured dairy products to make them palatable, because laban without added flavor is predominantly sour due to high production of lactic acid during bacterial fermentation. Various food-grade flavoring agents and sweeteners are added to improve the flavor balance and partially mask the acetaldehyde flavor characteristics, thus increasing the acceptability of cultured dairy products. Moreover, physicochemical characteristics of dairy products may be improved by addition of various types of stabilizers such as gelatin, pectin, and starch to achieve the required texture by increasing the TS contents of the processed milk (Andic et al., 2013). In this context, the application of stabilizers in yogurt manufacturing has a positive effect on product stability and consumer acceptance (Agarwal and Prasad, 2013). Storage at recommended temperatures, along with protection from hot and humid conditions with proper ventilation, are critical aspects to maintain product quality (Sheikh et al., 2021).

In Pakistan, consumer interest in fermented dairy products is gradually increasing due to their unique taste, nutritional value, and therapeutic benefits (Widyastuti et al., 2021). Laban is common in most Middle East countries, and there is a great need to introduce this product in Pakistan and standardize it according to the indigenous conditions of the country. Therefore, the sensory and physicochemical properties and microbial balance of laban must be investigated. No research is available yet in Pakistan about processing laban from various sources of milk and adjusting the levels of its ingredients. Hence, we planned the current study to investigate the effects of carboxymethyl cellulose (**CMC**) on physicochemical and sensory characteristics of laban produced using different sources of milk, namely, cow, buffalo, and a 50:50 blend of cow and buffalo milk during short- and long-term storage periods.

MATERIALS AND METHODS

Materials Used

Lactobacillus bulgaricus and *Lactobacillus acidophilus* were used as starter culture (4 g, 50 IU/100 L, STI-12; Chr. Hansen). Skim milk powder (Vania milk powder, Premier Dairies), typical laban starter culture (Sacco Lyofast Y082), and stabilizer (CMC; Sigma-Aldrich) were used to prepare laban (Osthoff et al., 2007; Andic et al., 2013).

Milk and milk products were used during this research activity and, therefore, no ethical approval letter was required for this research.

Analysis of Milk Samples

Freshly drawn milk (9 L/treatment) from buffalo [treatment (**T**)1] and cow (T2) were obtained. Then, cow and buffalo milks were mixed in a 50:50 ratio to make "mixed milk" (T3). The milks were stored at 4°C until further processing at the Postgraduate Research Laboratory, Department of Dairy Technology, University of Veterinary and Animal Sciences (Pattoki, Pakistan). First, the milk samples were analyzed for quantification of TS and SNF (%) using a lactometer/hydrometer. The lactometer is based on Archimedes principle such that a solid suspended in a liquid would be buoyed up by a force equal to the weight of the

liquid displaced. Thus, the lower the density of the substance, the lower the lactometer/hydrometer would sink. In light liquids, such as kerosene, gasoline, and alcohol, the hydrometer sinks deeper to displace its weight of liquid than in heavy liquids such as brine, milk, and acids. The SNF content was determined as follows: SNF = (lactometer reading/4) + 0.72 + (0.22 × fat % of sample); and TS as calculated as follows: TS = SNF + fat % of sample (Osthoff et al., 2007).

Fat (%) was determined as follows. Everything in milk except fat was dissolved in sulfuric acid, and the fat floated to the top. The centrifuge (270 × *g* at 60°C for 5 min) ensured complete separation with no bubbles in the fat, isoamyl alcohol ensured the complete separation of fat, and the fat content was measured using the graduations on the butyrometer. Acidity (%) was determined based on the following method. Phenolphthalein is colorless in acidic medium. A base is added to the sample to neutralize the acid present in the sample, and the addition of one more drop of base changed the whole medium to become basic, and the phenolphthalein was turned to a pink color in basic medium (Younus et al., 2002). Acidity was expressed as % lactic acid; % acidity = (mL of 0.1 *N* NaOH used × 0.009 × 100)/weight of sample.

The pH was determined using a pH meter (H198164, Hanna). To determine the ash content, a known weight of sample in a crucible was ignited to ash. The weight of ash thus obtained was expressed as a percentage. The ash content (%) was then calculated from as follows: (Z − X)/(Y − X) × 100, where X = empty crucible weight, Y = crucible weight with sample, and Z = weight of crucible with ash after complete ashing (Younus et al., 2002; Osthoff et al., 2007).

Preparation of Laban

Whole-milk samples were standardized to 3.5% fat and 8.9% SNF. The samples were heated at 60°C before the addition of stabilizer and pasteurized at 85°C. The withholding time was 5 min in a water bath followed by cooling at 44°C for addition of starter culture (typical laban starter culture, Lyofast Y082; Sacco). The samples were then incubated for bacterial fermentation with starter culture until the pH reached 4.6 (Irvine et al., 2011). The laban was prepared by the addition of 0.5% CMC to each of 3 treatments (T1, T2, and T3) in 9 L of milk per treatment (Andic et al., 2013). Each treatment was analyzed in triplicate (n = 54) for all parameters. The yogurt curd was transferred to a refrigerator and stored at 4°C for blast cooling, and then homogenized to convert it into laban. The prepared laban was then stored in refrigerator at 4°C for storage studies (Andic et al., 2013).

Physical, Chemical, and Microbiological Analysis of Laban

The time taken for fermentation of each treatment of milk was recorded. The laban samples were analyzed for viscosity using a viscometer (model 5550 HPHT, Chandler Engineering) immediately after fermentation (Irvine et al., 2011). Laban samples were stored in the refrigerator at 4°C for 21 d. Fat, protein, and TS contents, pH, acidity, syneresis, and sensory characteristics were determined (AOAC International, 2000); total viable count or total plate count and coliform count were performed at 0, 7, 14, and 21 d of shelf life as described previously (Leghari et al., 2021).

Sensory Evaluation

Sensory characteristics including taste, appearance, consistency, and odor of laban samples were determined using a 9-point hedonic scale after 0, 7, 14, and 21 d of storage period. These parameters were considered in a sensory evaluation by a panel of semi-trained judges (equal distribution of male and female judges). The product was considered safe for human consumption as it does not contain contamination. Results were obtained by indicating values on a hedonic scale, where 9 is the maximum for a given tested parameter. Water and crackers were served to cleanse the palate between testing of different samples according to standard guidelines (Larmond, 1977).

Fatty Acid Profile of Laban

The fatty acid profiling of buffalo (18 samples) and cow (18 samples) laban was performed using GC (model 7890B; Agilent Technologies) and MS (model 5977B; Agilent Technologies). A separation capillary column DB-5MS (0.25 μm, 60 m long; Agilent Technologies) and a temperature program from 50 to 60°C over 1 min, 60 to 200°C over 8 min, and 200 to 230°C over 2 min were used during fatty acid profiling. Fat extraction was performed followed by Secchiari et al. (2003). Fat samples were *trans*-methylated and their FAME analyzed using GC-MS (Agilent Technologies). Fatty acid profiling results of laban samples were compared with purchased standards of fatty acids (Nu-Chek Prep Inc.). Fatty acid profiling of laban samples was done following the method of Silveira et al. (2019).

Statistical Analysis

Data were analyzed through 2-way ANOVA using PROC GLM in SAS software (SAS Institute Inc.). Data are reported as least squares means, and a sig-

nificance level of $P < 0.05$ was used. Treatment means were compared using Duncan's multiple range test and the following mathematical model:

$$Y_{ijk} = \mu + S_i + P_j + (S \times P)_{ij} + \varepsilon_{ijk},$$

where Y_{ijk} = dependent variable for the ith sample and jth storage period; μ = population mean; S_i = effect of ith sample ($i = 1, 2, 3$; cow milk, buffalo milk, and mixed milk); P_j = effect of jth storage period ($j = 0$, 7, 14, 21 d of storage); $(S \times P)_{ij}$ = interaction between sample and storage period; and ε_{ijk} = residual effect of kth observation on jth storage period and ith sample NID ~ 0, σ^2, where NID = normally and independently distributed.

RESULTS AND DISCUSSION

Laban is a fermented dairy product with nutritional and therapeutic advantages. Limited data are available on the physical, chemical, and sensory aspects of laban prepared from the milk of different dairy animals. There is a need to optimize cow and buffalo milks with different fat contents and stabilizer for better formulation of laban at the industrial level to ensure its economic viability in Pakistan.

Physicochemical Properties of Laban

Physicochemical properties of laban prepared from cow and buffalo milks are presented in Table 1. Fat percentage of the laban samples in the current study decreased with an increase in storage time, as reported previously (Younus et al., 2002). Average fat contents of laban prepared from buffalo and cow milks were 5.50 and 3.46%, respectively. Fat content was higher in cow milk from Egypt compared with Pakistan; therefore, fat percentage was also higher in yogurt from Egypt than Pakistan (Aly et al., 2004). The average protein contents of laban from buffalo and cow milk were 3.59 and 2.75%, respectively. The laban prepared from the cow and buffalo blend had a nutritive value (content of protein, fat, and other macro- and microminerals) intermediate between that of the individual cow and buffalo samples. The protein content of the laban did not change until the end of the storage period, in agreement with a previous report (Duttschaever et al., 1972). Cold storage impedes the proliferation of lactic acid bacteria and renders them dormant until they reach a favorable environment for growth (the consumer's gut). Protein contents of laban remained unaffected until the end of storage period because pH of yogurt does not show any abrupt change that would denature protein. Once the laban is consumed, these bacteria resume proliferation as beneficial flora of the gut and exert beneficial effects to the gastrointestinal tract, which is the main objective of laban utilization.

Cow and Buffalo Milk TS Contents

The TS contents were higher in buffalo laban (14.8 ± 0.05%) than in cow laban (11.5 ± 0.02%; Table 1). The lower TS content in cow laban compared with buffalo laban was due to the difference in TS content in the raw milk. Our results were in line with previous findings (Kroger and Weaver, 1973), wherein the authors reported that TS content in the yogurt depended on TS content in the milk. However, a difference in TS content of Sudani yogurt was observed when prepared yogurt was treated with different fruits and other materials (El-Bakri and El-Zubeir, 2009).

Acidity and pH of Buffalo, Cow, and Mixed-Milk Laban

We observed a decrease in pH with increasing acidity and storage time in all of the treatments. Researchers also observed that the addition of fruit in the yogurt resulted in increased acidity because fruit renders the laban more acidic (Béal et al., 1999). In contrast, decreases in acidity from 0.96% to 0.90% during the storage period of commercial yogurt are also reported (Hossain et al., 2012). The highest ash contents (0.73%) in our results were obtained for buffalo yogurt samples. As reported previously, plain yogurt has higher ash content than yogurt with fruit (Hossain et al., 2012).

Syneresis in Yogurt from Milk of Different Sources

Determination of sensory characteristics by a panel of judges is an important technique to determine the quality of a product and reliably categorize various attributes of that product (Chammas et al., 2006). Sensory analysis of a product is strongly correlated with laboratory tests. Syneresis (leakage of whey) in laban prepared from different milk sources increased at the end of storage (Table 1). Syneresis reflects imperfect fermentation and is usually not liked by the consumer. The chief factors for the occurrence of whey in cultured products are an increased incubation temperature, excessive protein-to-casein ratio, low TS, low fat or protein, type and concentration of any flavor added, and physical maltreatment during storage, distribution, or delivery (Lucey, 2002). Syneresis increases with increased storage time (Panesar and Shinde, 2012). Moreover, a previous study reported that syneresis also

Table 1. Physiochemical changes in drinking yogurt (laban) prepared from buffalo and cow milk during a 21-d storage period

Item	Storage day	Buffalo milk	Cow milk	Buffalo + cow milk (50:50)
Fat (%)	1	5.53 ± 0.02^{a}	3.47 ± 0.03^{e}	4.47 ± 0.03^{c}
	7	5.54 ± 0.01^{a}	3.48 ± 0.02^{e}	4.48 ± 0.02^{c}
	14	5.51 ± 0.01^{a}	3.44 ± 0.01^{e}	3.99 ± 0.01^{d}
	21	5.42 ± 0.02^{b}	3.44 ± 0.01^{e}	3.98 ± 0.02^{d}
Protein (%)	1	3.59 ± 0.01^{a}	2.76 ± 0.01^{c}	3.13 ± 0.01^{b}
	7	3.58 ± 0.01^{a}	2.76 ± 0.01^{c}	3.13 ± 0.01^{b}
	14	3.56 ± 0.02^{a}	2.75 ± 0.00^{c}	3.13 ± 0.01^{b}
	21	3.56 ± 0.02^{a}	2.73 ± 0.01^{c}	3.11 ± 0.01^{b}
TS (%)	1	14.8 ± 0.17^{a}	11.5 ± 0.03^{c}	13.2 ± 0.03^{b}
	7	14.9 ± 0.01^{a}	11.5 ± 0.02^{c}	13.2 ± 0.01^{b}
	14	14.9 ± 0.01^{a}	11.4 ± 0.01^{c}	13.2 ± 0.01^{b}
	21	14.9 ± 0.02^{a}	11.4 ± 0.01^{c}	13.2 ± 0.02^{b}
pH	1	4.59 ± 0.01^{a}	4.59 ± 0.01^{a}	4.58 ± 0.02^{a}
	7	4.41 ± 0.00^{bc}	4.39 ± 0.00^{bcd}	4.42 ± 0.02^{b}
	14	4.41 ± 0.02^{bc}	4.37 ± 0.01^{ced}	4.36 ± 0.01^{def}
	21	4.34 ± 0.01^{feg}	4.32 ± 0.01^{g}	4.33 ± 0.01^{gf}
Acidity (%)	1	0.91 ± 0.00^{f}	0.90 ± 0.00^{f}	0.90 ± 0.01^{f}
	7	0.91 ± 0.01^{ef}	0.93 ± 0.00^{de}	0.93 ± 0.01^{de}
	14	0.96 ± 0.01^{bc}	0.96 ± 0.00^{abc}	0.95 ± 0.01^{cd}
	21	0.97 ± 0.01^{ab}	0.98 ± 0.01^{a}	0.97 ± 0.01^{ab}
Syneresis (%)	1	40.3 ± 0.67^{d}	40.3 ± 0.67^{d}	40.4 ± 0.60^{d}
	7	44.3 ± 0.33^{bc}	44.7 ± 0.33^{bc}	44.8 ± 0.33^{bc}
	14	43.3 ± 1.17^{c}	47.5 ± 0.50^{a}	45.1 ± 0.62^{abc}
	21	46.7 ± 1.67^{ab}	47.3 ± 0.67^{a}	45.8 ± 0.63^{abc}

[a–g]Means of each item in rows and columns with different superscripts differ significantly ($P < 0.05$).

increases with addition of carrot juice in yogurt (Aly et al., 2004). Interestingly, syneresis in laban increased with longer storage time (even though the yogurt was properly incubated at 4°C), which was not favorable for the quality of the product.

Consumer Acceptability

Results of various sensory evaluation parameters are presented in Table 2. Color, acceptability, appearance, taste, smell, texture, and overall acceptability of different laban samples decreased with the passage of time during storage. The change in sensory values is due to a slight decrease in pH during the long storage period. Thus, a longer storage time decreases various quality parameters of laban and reduces consumer acceptability. Lee et al. (1990) reported that plain yogurt had a higher acceptability than flavored or fruit yogurt. However, acceptability also depends on the personal preference of the consumers; children usually prefer fruit yogurt whereas adults mostly consume plain yogurt (Savage et al., 2007).

Microbial Counts

Microbiological changes in laban prepared from buffalo and cow milks are presented in Table 3. All treatments were tested for bacterial counts, including coliforms, and no bacterial cells were found in any treatment on any day of storage. Fermentation by lactic acid bacteria transforms carbohydrates into lactic acid, which leads to an increase in the shelf life of product by inhibiting microbial spoilage under various enzymatic reactions (Béal and Chammas, 2012). In the current experiment, samples were allowed to ferment, and laban samples were placed in a controlled cool environment to avoid the effects of external conditions on laban quality. Our microbiological results indicated that all treatments were properly placed in a sterile, microbe-free environment, and no deterioration by harmful bacteria was observed through the end of the experiment.

Fatty Acid Content

Results of fatty acid profiling (by GC-MS) of laban prepared from cow and buffalo milks are presented in Table 4. Both cow and buffalo milk laban samples contained saturated and unsaturated fatty acids. Buffalo laban had more unsaturated essential fatty acids than cow laban. A total of 9 individual fatty acids were analyzed (5 long-chain FA, 1 PUFA, and 3 short-chain fatty acids) and these fatty acids were quantified using GC-MS. Saturated fatty acids are the major fatty acids of ruminants and contributed 60% of total laban fat; very short chain fatty acids were not detected due to

Table 2. Sensory evaluation (9-point hedonic scale) of drinking yogurt (laban) prepared from buffalo and cow milk during a 21-d storage period

Item	Storage day	Buffalo milk	Cow milk	Buffalo + cow milk (50:50)
Color	1	8.17 ± 0.17^{a}	7.90 ± 0.06^{ab}	8.03 ± 0.03^{ab}
	7	7.70 ± 0.10^{bcd}	7.50 ± 0.06^{dc}	7.74 ± 0.04^{bcd}
	14	7.87 ± 0.03^{ab}	7.47 ± 0.12^{d}	7.87 ± 0.03^{ab}
	21	7.83 ± 0.17^{abc}	7.13 ± 0.13^{e}	7.83 ± 0.17^{abc}
Appearance	1	7.87 ± 0.13^{ab}	7.70 ± 0.06^{bc}	7.85 ± 0.03^{ab}
	7	7.87 ± 0.07^{ab}	7.40 ± 0.06^{d}	7.63 ± 0.06^{c}
	14	7.00 ± 0.00^{e}	7.10 ± 0.06^{e}	7.05 ± 0.03^{e}
	21	8.00 ± 0.00^{a}	7.70 ± 0.00^{bc}	7.85 ± 0.00^{ab}
Taste	1	7.90 ± 0.10^{abc}	6.80 ± 0.06^{g}	7.40 ± 0.03^{cdef}
	7	7.67 ± 0.33^{bcde}	6.30 ± 0.06^{h}	7.15 ± 0.03^{feg}
	14	7.97 ± 0.03^{ab}	6.10 ± 0.06^{h}	7.03 ± 0.04^{fg}
	21	8.23 ± 0.39^{a}	7.20 ± 0.06^{fdeg}	7.72 ± 0.22^{abcd}
Aroma	1	7.93 ± 0.07^{a}	7.30 ± 0.06^{d}	7.65 ± 0.03^{bc}
	7	7.83 ± 0.09^{ab}	7.20 ± 0.06^{d}	7.52 ± 0.07^{c}
	14	7.77 ± 0.03^{ab}	6.70 ± 0.06^{e}	7.23 ± 0.03^{d}
	21	7.73 ± 0.15^{abc}	7.80 ± 0.06^{ab}	7.77 ± 0.09^{ab}
Texture	1	7.87 ± 0.13^{a}	7.10 ± 0.06^{bcd}	7.55 ± 0.03^{ab}
	7	7.67 ± 0.33^{ab}	6.70 ± 0.06^{de}	7.35 ± 0.03^{abc}
	14	7.43 ± 0.38^{abc}	6.30 ± 0.06^{e}	6.87 ± 0.17^{cde}
	21	7.60 ± 0.31^{ab}	7.70 ± 0.06^{ab}	7.65 ± 0.13^{ab}
Overall acceptability	1	7.95 ± 0.05^{a}	7.36 ± 0.06^{ef}	7.70 ± 0.02^{c}
	7	7.75 ± 0.07^{bc}	7.02 ± 0.06^{g}	7.48 ± 0.04^{de}
	14	7.61 ± 0.07^{cd}	6.73 ± 0.07^{h}	7.21 ± 0.02^{f}
	21	7.88 ± 0.06^{ab}	7.51 ± 0.02^{de}	7.76 ± 0.06^{bc}

[a–g]Means of each item in rows and columns with different superscripts differ significantly ($P < 0.05$).

absorption of butyrate and propionate from the rumen and their metabolism to caprylic acid and capric acid (Chilliard et al., 2003). The particular pleasant aroma of laban is due to the presence of short-chain fatty acids in buffalo and cow laban samples.

CONCLUSIONS

Laban prepared from buffalo milk maintained high fat and protein contents throughout storage compared with that made from cow milk. Laban prepared from buffalo milk had better taste, aroma, and overall consumer acceptability than laban prepared from cow milk or mixed milk (cow + buffalo). The aroma of laban samples was due to the presence of short- and medium-chain fatty acids. No growth of harmful microbes occurred during storage. Commercial production of laban is increasing in the dairy industries of Pakistan. Its consumption increases the beneficial microflora in the gut and immunity. Future research will examine the addition of ingredients to maintain pH and ultimately increase the shelf life of laban during storage. Moreover, better packaging material may increase storage time as well as consumer convenience.

Table 3. Microbiological changes in drinking yogurt (laban) prepared from buffalo and cow milk during a 21-d storage period

Item	Storage day	Buffalo milk	Cow milk	Buffalo + cow milk (50:50)
Total plate count (cfu/mL)	1	7.94 ± 0.02^{a}	6.92 ± 0.02^{e}	7.46 ± 0.00^{c}
	7	7.88 ± 0.00^{b}	6.88 ± 0.00^{f}	7.39 ± 0.00^{d}
	14	7.88 ± 0.00^{b}	6.86 ± 0.00^{f}	7.37 ± 0.00^{d}
	21	7.86 ± 0.00^{b}	6.86 ± 0.00^{f}	7.36 ± 0.00^{d}
Coliform count (cfu/mL)	1	0.00	0.00	0.00
	7	0.00	0.00	0.00
	14	0.00	0.00	0.00
	21	0.00	0.00	0.00

[a–f]Means of each item in rows and columns with different superscripts differ significantly ($P < 0.05$).

Table 4. Fatty acid profile (GC-MS) of drinking yogurt (laban) prepared from buffalo and cow milk

Fatty acid	Carbon atoms	RT[1] value	Buffalo (%)	Cow (%)
Caproic acid	6:0	10.3	2.00 ± 0.3^{g}	1.60 ± 0.2^{h}
Caprylic acid	8:0	14.8	1.30 ± 0.1^{h}	2.10 ± 0.2^{f}
Capric acid	10:0	18.9	2.00 ± 0.3^{g}	2.00 ± 0.4^{g}
Lauric acid	12:0	22.8	2.20 ± 0.3^{f}	3.00 ± 0.3^{e}
Myristic acid	14:0	28.0	7.10 ± 0.3^{c}	10.3 ± 0.2^{d}
Palmitic acid	16:0	34.8	45.5 ± 0.4^{a}	31.3 ± 0.3^{a}
Stearic acid	18:0	43.0	3.70 ± 0.2^{e}	17.1 ± 0.3^{c}
Oleic acid	18:1	41.9	27.1 ± 0.2^{b}	24.1 ± 0.4^{b}
Linoleic acid	18:2	41.6	3.80 ± 0.1^{d}	3.50 ± 0.1^{e}

[a–g]Means in a row with different superscripts differ significantly ($P < 0.05$).

[1]RT = retention time of peak.

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