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Quality Characteristics of Goat Yogurt Containing *Lactobacillus* Probiotic Bacteria

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ABSTRACT

This research aimed to analyze the influence of probiotic bacteria on the microbiological, physico-chemical, technological, and sensory characteristics of goat yogurt during 28 days of refrigerated storage. Results revealed that the incorporation of two probiotic bacteria did not significantly influence (P> *0.05*) the physico-chemical characteristics such as pH, lactic acidity, total solids, syneresis, water holding capacity and protein, color, viscosity and texture parameters and sensory properties of the inoculated samples, compared to the control. Similarly, the probiotic viability was maintained at all stages of storage at the rate of 10^8 CFU g^{-1}. Therefore, this research shows that yogurt is an appropriate vehicle for probiotic bacteria and provides new insights regarding their impact on the metabolism of this functional food while preserving its quality.

Keywords: Dairy products, Functional food, Probiotic viability, Yogurt quality.

INTRODUCTION

Recently, the demand of consumers increasingly requesting to control their quality of life and their state of health has appeared as a strategic opportunity for agri-food manufacturers (Ben Moussa *et al*., 2019). It has resulted in the emergence of a new category of food products called "functional foods", which have continuously received an increasing market interest (Demirci *et al*., 2020). These health-promoting foods are conventional products that advantageously affect the target functions of the body, following the ingestion of additional micro-nutrients, such as probiotic bacteria. The important contributions of the use of probiotics are manifested by cholesterol reduction, lactose intolerance, immune response, carcinogenesis, etc. (Ayyash *et al*., 2017 ; Ardalanian and Fadaei, 2018).

In general, to deliver the health benefits, probiotic foods are fermented products that contain an adequate amount of viable bacteria sufficient to exert an equilibrating action on the intestinal microbiota (FAO/WHO, 2002). Thus, it is necessary to verify the probiotic viability at the end of product storage (Argyri *et al.,* 2015).

Probiotic bacteria can survive in the intestinal tract ; therefore, they have a beneficial effect and can promote good health. Notably, several *Lactobacillus* strains have been evaluated as probiotics as well as their incorporation into food products to demonstrate their viability (Nagpal *et al.,* 2012).

Dairy products represent one of the most developed sector of functional foods (Saad *et al*., 2013). This field is always in search of new probiotic bacteria. In particular, yogurt is considered a nutritious food and an excellent vehicle for probiotic bacteria that can confer many beneficial effects (Galat *et*

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al., 2016). Assuming a regular consumption of 100 g of yogurt, this product must contain at least 10^7 CFU g^{-1} of probiotic bacteria and contributes to health benefits (FAO/WHO, 2002). Specifically, this product can equilibrate the intestinal flora and control the immune system (Mathieu, 2015).

Chemically, yogurt is a complex gel system that contains proteins, polysaccharides and lipids in its structure. It is regularly made by fermenting cow's milk using a symbiotic culture of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* under controlled environmental conditions. The role of these two starters in the production of yogurt is essentially the fermentation of milk and the synthesis of aromatic compounds. From the technological point of view, the actual metabolic activity of probiotics during the preparation of yogurt is not yet fully understood, especially for maintaining the viability of cultures during storage (Plessas *et al*., 2012).

Probiotics are added with starters to the milk at the beginning of fermentation. As a consequence, it is essential that thermophilic starters do not negatively affect the viability of probiotics during fermentation and refrigerated storage. Also, the incorporated probiotics should not have any adverse effect on the growth of the starters, so that quality is not modified. Probiotics can have different growth behaviors depending on their selection for inoculation in yogurt (Gagné, 2012). In addition to the basic probiotic survival in the final product, sensory properties are identified as a significant factor in influencing the acceptance of functional foods (Urala and Lahteenmaki, 2007). Thus, to ensure the healthy quality of the product, it is necessary to improve alternatives for the incorporation of probiotics into a wide variety of foods, ensuring probiotic viability at the time of consumption, but more importantly providing that probiotics can reach the until colon.

Considering these aspects, this study aimed to compare the physicochemical characteristics, technological, and sensory properties of yogurt produced with and without probiotic bacteria, and to test samples regarding the viability of ferments and probiotic strains during fermentation and storage.

MATERIALS AND METHODS

Probiotic Strains

Two probiotic strains, namely, *Lactobacillus plantarum* BA12 (Mahmoudi *et al*., 2018a) and *Lactobacillus fermentum* CABA16 (Mahmoudi *et al*., 2016), were selected taking into account their probiotic potentials such as their resistance to gastro-intestinal conditions, adhesion properties, antioxidant, hypocholesterolemiant activities (Mahmoudi *et al*., 2017), and their technological performances (Mahmoudi *et al*., 2018b). They were refreshed in MRS broth (Biokar Diagnostics, France) and incubated at 37°C for 24 hours. After that, the bacterial suspensions thus obtained were centrifuged (12,000 rpm min^{-1}, 15 minutes, 4°C) and the cells were washed twice and reconstituted in Phosphate Buffered Saline (PBS) (Sigma, France). They were then served as inoculum.

Yogurt Preparation

The goat milk was obtained from a farm (Mateur, Bizerte, Tunisia), pasteurized at 65°C per 30 minutes, supplemented with 5% (w/v) sucrose and then subjected to a heat treatment (91±1°C 10 min^{-1}) (Machado *et al*., 2017) (Institute of Vocational Training in Agro-food Industries, Tunis, Tunisia). Next, the milk was cooled to 45°C and divided into three equal batches as follow: (1) Control batch (YC), which was inoculated only with the standard mixed ferments *L. bulgaricus* and *S. thermophilus* (YFL901 ; CHR HANSEN, France) (1.5 g

L^{-1} at a rate of 10^8 CFU mL^{-1}), (2) The second batch was fermented with YFL901 and inoculated with *L. plantarum* (10^8 CFU mL^{-1}) (YP), and (3) The third batch was fermented with YFL901 and *L. fermentum* (10^8 CFU mL^{-1}) (YF). After mixing, each sample was distributed into sterilized and coded glass bottles under aseptic conditions. After that, the fermentation was made in an oven at 44°C. Eventually, the final point of yogurt fermentation was based on checking the clot firmness and pH values, which should reach a maximum of 4.5. Thereafter, the yogurt pots were kept for 28 days of storage at +4°C.

Viable Cell Counts

Streptococcus thermophilus were enumerated on M17 agar (Biokar Diagnostics, France) after aerobic incubation at 44°C for 48 hours. The enumeration of *Lactobacillus bulgaricus* was performed on MRS agar medium at 37°C for 48 hours. The number of *L. plantarum* was carried out on MRS agar supplemented with 4 mg of ciprofloxacin and 20 g of Sorbitol at 37°C for 48 hours (Bujalance *et al*., 2006). Viable counts of *L. fermentum* were determined on MRS agar addition with Vancomycin (20 mg L^{-1}) at 37°C for 48 hours (Coeuret *et al*., 2003).

Physico-Chemical Analysis

The pH of each sample was measured using a Microprocessor pH meter BT-500 (Boeco, Hamburg, Germany). For lactic acidity, changes in values were measured by titrating 10 g of sample with NaOH (0.1N) solution using phenolphthalein as an indicator (AOAC, 1990).

Syneresis and Water Holding Capacity

The syneresis and measurement of Water Holding Capacity (WHC) were carried out according to the method previously reported by Isanga and Zhang (2009). For syneresis, 10 g of yogurt was centrifuged (80,000 rpm, 12 minutes, 4°C) and the supernatant was recovered and weighed, thereafter, syneresis was calculated as follows:

Syneresis (%) = $(W_1/W_2)/100$

After that, the WHC was measured by centrifugation of a five gram yogurt sample (4,500 rpm, 30 minutes, 10°C) and was calculated as follows:

WHC (%) = $(1- W_1/W_2) / 100$

Where, W1= Weight of whey after centrifugation, W2= Yogurt weight.

Protein and Total Solids

The protein content was determined by the Kjeldhal method and the total solid of goat yogurt were determined by drying samples at 105°C overnight to constant weight using an air oven (Memmert, UL 60, Germany) (AOAC, 1990).

Color

The colorimetric parameters L^* (Lightness), a^* (redness) and b^* (yellowness) of yogurts were determined using a colorimeter (Minolta Chroma Meter CR-300, Tokyo, Japan) according to Balthazar *et al*. (2015). These parameters were measured on the surface by capturing the rays reflected by sample. These parameters allow evaluating the state of the freshness of yogurt.

Viscosity an Texture Profile

The apparent viscosity was measured using a viscometer (Rheomat RM-180, Germany) with coaxial cylinders. The shear rate applied at the order of 30 s^{-1}, which was taken as the apparent viscosity of yogurt at 20±2.6°C. For texture profile, a double compression test was performed using the texturometer (TVT 6700, France). All

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samples were kept at +4°C before the trial. The five measured parameter settings were firmness, chewiness, cohesion, gummability, and elasticity (AOAC, 1990).

Sensory Analysis

The yogurt samples were subjected to sensory analysis (color, taste, odor and texture) after seven days of storage at +4°C. For this purpose, a proximity test was carried out, so, we presented the data sheets to fill to a panel of 60 naive tasters. This panel asked questions, sample by sample, about the control, yogurt inoculated with *L. plantarum* strain, and another inoculated with *L. fermentum* strain, based on a 9 point Hedonic scale (Like extremely= 9, like Very much= 8, Like moderately= 7, Like slightly= 6, Neither like nor dislike= 5, Dislike slightly= 4, Dislike moderately= 3, Dislike very much= 2 and Dislike extremely= 1) (Tamjidi *et al*., 2012).

Statistical Analysis

To study the linear relationships between the various variables measured and to compare the averages of the different measured parameters, we carried out a study of the variance (ANOVA). The software used was SPSS version 20.0. The Student's test was also used and the threshold differences ($P< 0.05$) were considered statistically significant.

RESULTS AND DISCUSSION

Bacterial Growth and Survival

The results of the viable counts of the starter bacteria during storage are shown in Table 1. The viability of *S. thermophilus* was stable in YC and YP for 14 days (8.91±0.1 log CFU g^{-1}). After that, a little viability was observed in all samples, reaching 0.5 log CFU g^{-1} at the end of

Table 1. Viable bacteria counts of goat yogurts during storage at 4°C.

Storage (Days)	Viables counts (log CFU g^{-1})	Samples [a] YC	YF	YP
1	*L. bulgaricus*	8±0.08*	8.37 ± 0.15	8.5 ± 0.47
	S. thermophilus	9 ± 0.09	8.5 ± 0.2	8.91 ± 0.57
	L. fermentum	-	9 ± 0.32	-
	L. plantarum	-	-	9 ± 0.29
7	*L. bulgaricus*	7.8 ± 0.55	8.69 ± 0.1	8.9 ± 0.42
	S. thermophilus	8.98 ± 0.09	8.77 ± 0.22	8.98 ± 0.63
	L. fermentum	-	8.89 ± 0.007	-
	L. plantarum	-	-	8.89 ± 0.19
14	*L. bulgaricus*	8.75 ± 0.1	8.75 ± 0.2	8.94 ± 0.1
	S. thermophilus	8.8 ± 0.17	9.02 ± 0.17	9.02 ± 0.1
	L. fermentum	-	9 ± 0.2	-
	L. plantarum	-	-	9 ± 0.1
21	*L. bulgaricus*	8.7 ± 0.1	7.93 ± 0.27	8.8 ± 0.19
	S. thermophilus	9 ± 0.2	8.8 ± 0.09	8.5 ± 0.4
	L. fermentum	-	8.7 ± 0.081	-
	L. plantarum	-	-	8.55 ± 0.09
28	*L. bulgaricus*	8 ± 0.35	7.93 ± 0.6	8.2 ± 0.11
	S. thermophilus	8.54 ± 0.25	8.54 ± 0.001	8.43 ± 0.12
	L. fermentum	-	8.55 ± 0.085	-
	L. plantarum	-	-	8.54 ± 0.19

[a] YC: Control ; YF: Yogurt inoculated with *L. Fermentum*, YP: Pogurt inoculated with *L. Plantarum.* * Mean (±SE).

storage. On another side, the number of *L. bulgaricus* was less than that of *S. thermophilus* (1 log CFU g^{-1}) in YC sample. The behavior of yogurt starters were consistent with those found by Senaka Ranadheera *et al*. (2012) and Machado *et al*. (2017) in goat yogurt fermentation. However, this same trend was not observed in other previous studies that reported an increase in *S. thermophilus* for one week of storage, followed by a subsequent decrease of about one log unit, and in yogurt produced from goat's milk (Guler-Akin and Akin, 2007). These differences could be attributed to the conditions of use applied to the manufacturing process. Similarly, Vinderola *et al*. (2000) reported that the number of *S. thermophilus* remains higher than that of *L. bulgaricus* in different types of yogurt. These results are consistent with Vinderola *et al*. (2000) who found no significant difference in the viability of *L. delbrueckii* ssp. Also, our results are in agreement with those obtained by Dave and Shah (1997) who reported that the viability of *S. thermophilus* remained higher than that of *L. delbrueckii* ssp. In contrast, the study of Senaka Ranadheera *et al*. (2012) showed a better viability of *L. delbrueckii* ssp. compared to *S. thermophilus*. In co-culture with probiotic strains, yogurt starters showed similar growth as found in the samples without probiotics. These results suggest no obvious interference from the addition of probiotics on the viability of yogurt starters.

Furthermore, the probiotics exhibited similar growth behavior during storage period. Regarding *L. fermentum* CABA16, it remained stable during the two weeks of storage with number of 8.9±0.14 log CFU g^{-1}. Similarly, *L. plantarum*BA12 was viable with a number of 9±0.2 log CFU g^{-1}. We observed similar growth during storage and a small decrease at the end of storage. These decreases could be attributed, first, to the exhaustion of lactose in yogurt and, second, to the low temperature of storage. However, these probiotics have been able to maintain their viability due to their excellent adaptation to the acidic environment and their ability to multiply. These levels are consistent with those noted by Demirci *et al*. (2020) and Machado *et al*. (2017) who reported a better survival of probiotics ($\geq 10^6$ CFU g^{-1}) in set yogurt. Furthermore, Settachaimongkon *et al*. (2014) and Xanthopoulos *et al*. (2012) who found that the numbers of *L. rhamnosus* GG and *L. casei* decreased by 0.5 log units compared to *B. animalis* ssp. *Lactis,* which fell by 1.2 log units. Also, these results are consistent with data indicated in the literature showing greater stability of probiotic lactobacilli compared to fermented milk with bifidobacteria (Xanthpoulos *et al*. 2012). The present results also agree with findings by Ayyach *et al*. (2017), who reported that the bacterial population maintained at > 8.5 log CFU g^{-1} in camel and bovine milks fermented by *Lactobacillus acidophilus*. Thus, the viability of probiotic strains, observed at the end of storage, is satisfied and remains above the recommended minimum level of ≥ 6 log CFU g^{-1} to ensure a potential benefit to the health of the host (Shiby and Mishra, 2013). In addition, some authors have observed that thermophilic yogurt starters can affect the viability of probiotic strains during process and storage (Guler-Akin and Akin, 2007). This was not found in the current study. Indeed, the compatibility of these ferments with the probiotic strains studied has been demonstrated while keeping sufficient viability, which has also been reported by Mathieu (2015).

Physicochemical Characteristics

The mean values of the physicochemical parameters of goat yogurts formulations are presented in Figure 1. During storage, similar acidification trends (P> 0.05) were also observed in all samples. Then, the pH levels decreased to reach an average value around 4.1 ±0.01 (P> 0.05). Analysis of the results related to acid production showed a significant decrease (P< 0.05) in all

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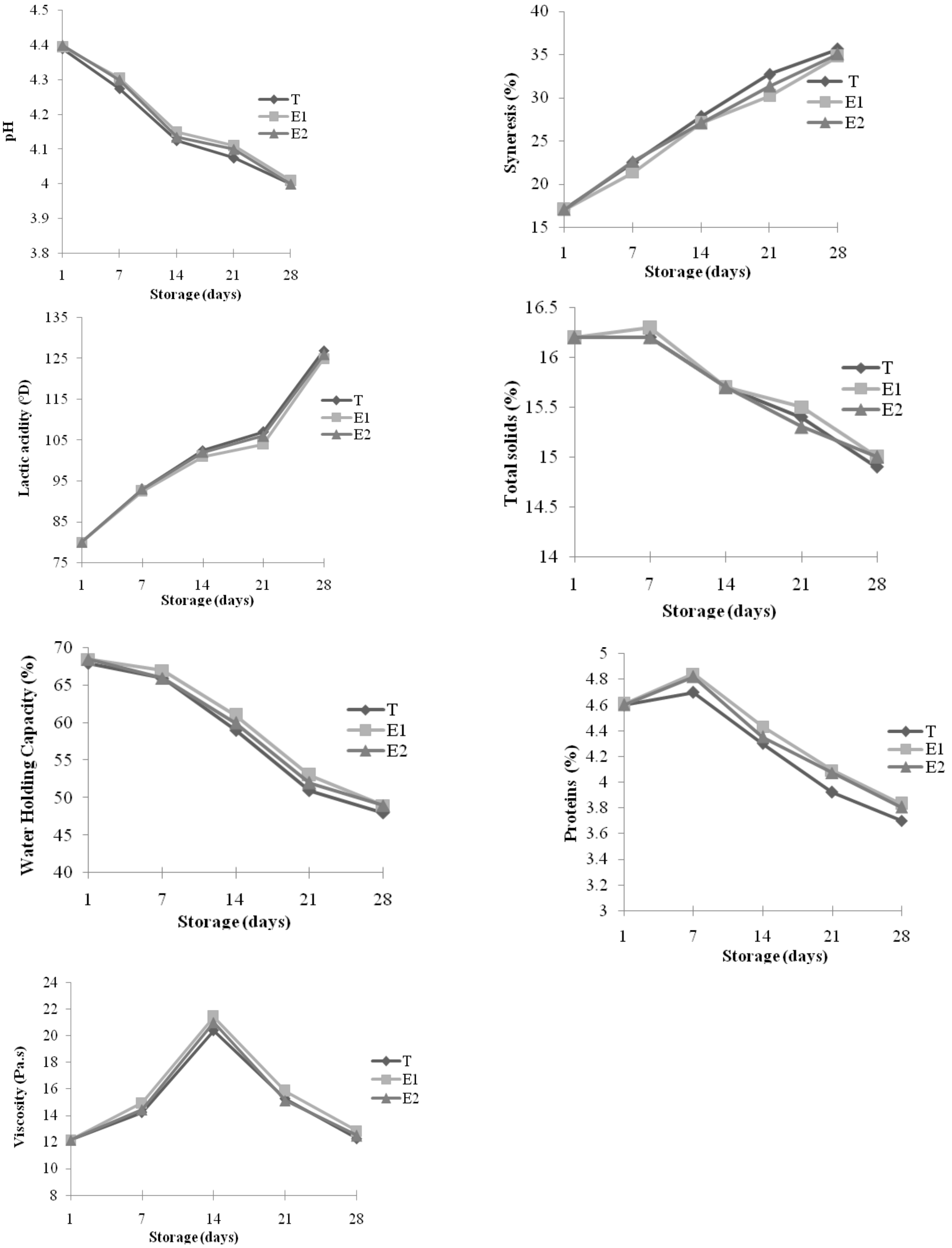

Figure 1. Physicochemical characteristics of goat yogurts during storage at 4°C. Standard deviations are in the range of : (0.01 to 0.1); (0.01 to 0.08) ; (0.01 to 0.05); (0. 1 to 0.3); (0.05 to 0.07); (0.16 to 0.25) ; (0.4 to 1.52), respectively.

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samples.These results are similar to those obtained by Ayyach *et al*. (2017) for camel and bovine yogurts. Regarding lactic acidity, the values ranged from 80±0.01 to 126± 0.01 °D, which are generally considered unfavorable for the survival of probiotic bacteria (Dave and Shah, 1997). The decrease in pH and organic acid accumulation during yogurt storage are defined as "post-acidification", which is mainly attributed to the metabolic activity of *L. delbrueckii* ssp. *bulgaricus* (Ben Moussa *et al*., 2019 ; Machado *et al* ; Shah, 2000). This phenomenon is one of the most prejudicial factors that affect the stability of probiotics during yogurt storage (Donkor *et al*., 2006). Anyway, *L. fermentum* and *L. plantarum* strains retained their viabilities with high survival rates throughout storage period. However, Settachaimongkon *et al*. (2014) confirmed a significant adverse effect of post-acidification on the viability of *L. rhamnosus* GG and *B. animalis* ssp. *lactis*. In general, lactobacilli are more tolerant to the acidic conditions of fermented milk than bifidobacteria (Donkor *et al*., 2006, El-Dieb *et al*., 2012).

Syneresis, as an undesirable property in yogurt, is the effect of liquid separating from the yogurt gels (Wu *et al*., 2001). We recorded, initially, no significant percentages (P> 0.05) of water released in all tested samples with an average of 17.055±0.04% (Figure 1). Two weeks later, we observed percentages around 27.05±0.01% to reach, at the latest assessed storage period, an average of 35.06±0.01%. We retained, finally, a percentage which was still satisfactory for good preservation of product quality. These results join the study of Senaka Ranadheera *et al*. (2012) pointing out that the syneresis rate in yogurt inoculated with *L. acidophilus* did not exceed 22.33±0.33% after seven days of storage, while maintaining an acceptable rate. In addition, these syneresis rates can be explained by the fat content in yogurt (Isanga and Zhang, 2009). Acidity can also be another factor that contributes to syneresis (Senaka Ranadheera *et al*. 2012 ; Tamime and Robinson, 1999). On the other hand, although yogurts showed a significant degree of acidity, it did not affect the structure of our elaborate gels.

Examination of data on change in water holding capacity of yogurt samples revealed that water retention decreased to 66±0.14% after 7 days of storage (Figure 1). It then decreased significantly by 8% to reach, on the 21st day, 52±0.22% *(*P< *0.05)*. Similarly, a decrease of 4% was detected at the end of storage (P> 0.05). Our results are similar to those found by Senaka Ranadheera *et al*. (2012) who noted significant WHC percentages in yogurts inoculated with *L. acidophilus*. Morover, Wu *et al*. (2001) reported that WHC may be associated with increased water release in yogurt samples due to possible denaturation of proteins following a decrease in pH to the isoelectric point of proteins, therefore this causes destabilization of the casein micelles and the resulting exudation of liquid.

Total solids contents in YC and YP samples decreased after one week of storage (Figure 1). Similarly, Senaka Ranadheera *et al*. (2012) demonstrated an acceptable level. These contents correlated with those found for syneresis and WHC, indicating a good gel structure of the products.

Interesting to changes in protein contents, the values increased with 0.22 % (P> 0.05). After that, this parameter regularly decreased to 4.4%. Eventually, these levels remained stable around the value of 3.8±0.06% in the end of storage, in YP and YF. This decrease could be attributed to the partial mineralization of organic nitrogen following the acidification conditions contributed by the inoculated ferments. However, these levels are similar to those found by Xanthopoulos *et al*. (2012) and Senaka Ranadheera *et al*. (2012) pointing out that these quantities reflect the consistency of gel assigned to the caseins present in the fermented milk by indicating a protective role of probiotics with respect to the proteins that remained at levels above 2.7%, required by the Codex Alimentarius (FAO/WHO, 2002).

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Table 2. Color parameters (L, a and b) of goat yogurts during storage at 4°C.

Storage (Days)	Samples	Color parameters		
		Lightness (L)	Redness (a)	Yellowness (b)
1	YC	94.1 ± 0.01	-1.86 ± 0.05	6.76 ± 0.007
	YF	94.35 ± 0.02	-1.82 ± 0.02	6.79 ± 0.07
	YP	94.44 ± 0.01	-1.83 ± 0.02	6.8 ± 0.002
7	YC	93.52 ± 0.015	-1.77 ± 0.001	6.65 ± 0.02
	YF	93.6 ± 0.006	-1.76 ± 0.022	6.66 ± 0.03
	YP	93.62 ± 0.011	-1.75± 0.014	6.67 ± 0.01
14	YC	92.8 ± 0.001	-1.55 ± 0.002	5.97 ± 0.01
	YF	92.81 ± 0.007	-1.62 ± 0.017	5.97 ± 0.01
	YP	92.81 ± 0.01	-1.55 ± 0.008	5.98 ± 0.03
21	YC	91.03 ± 0.01	-1.31 ± 0.007	5.69 ± 0.019
	YF	91.05 ± 0.02	-1.32 ± 0.009	5.7 ± 0.004
	YP	91.07 ± 0.07	-1.33 ± 0.003	5.7 ± 0.002
28	YC	91.27 ± 0.035	-1.25 ± 0.006	5.24 ± 0.001
	YF	91.25 ± 0.025	-1.24 ± 0.001	5.31 ± 0.002
	YP	91.28 ± 0.004	-1.21 ± 0.001	5.3 ± 0.005

Since color is an essential sensory attribute and is a critical factor affecting the quality of food product, the mean values for color parameters (L, a and b) for different goat yogurt formulations are presented in Table 2. The lightness values decreased during storage for all yogurt formulations (P> 0.05). Thus, the values passed, initially from 94.1, 94.44 and 94.35, to reach, at the end of storage, 91.27, 91.28, and 91.25, respectively for YC, YP, and YF (P> 0.05). The evolution profiles of the parameter (L) are comparable to those noted on the redness color (a), indicating a good color stability for all yogurt formulations. This color characteristic may be associated with the oxidation of fatty acids and protolithic activity naturally occurring in yogurts (Machado *et al*., 2017). Also, we pointed out that the parameter (b) (positive zone) decreased significantly (P< 0.05) during storage period. These results are in agreement with those confirmed by Oroian *et al*. (2011) pointing out that the color of yogurt (Spanish mark) is characterized by a lightness of 91.17 and indicating that this parameter is directly related to the fat contents in yogurt product. Similarly, The values of a and b parameters are similar. It should be noted that the absence of colorants in yogurt is a factor allowing the conservation of color. Similarly, it should be noted that the incorporation of probiotics makes it possible to stabilize the color of yogurts and to significantly prevent the yellowing phenomenon throughout conservation because of the deceleration of non-browning enzymatic activity affecting this product.

The results for the estimation of apparent viscosity are shown in Figure 1. At the first day of storage, we noted an average of 12.15 Pa.s (P> 0.05). Then, the apparent viscosities were in the order of 20.38±0.44, 21.39±0.78 and 21 ± 1.22 Pa s, respectively, in YC, YP and YF formulations. A decrease of 20% was measured in all samples to reach, at the end of conservation, the value of 12.48 Pa s. These apparent viscosity levels are similar to those reported by Xanthopoulos *et al*. (2012) for a final value of 12.48 Pa s. So, it should be noted that our products behaved like rheo-fluidifying or pseudo-elastic fluids. Also, our values are comparable to those found by Senaka Ranadheera *et al*. (2012). This phenomenon could be attributed to the high total solids content, as well as to the fat content of yogurt samples (Isanga and Zhang, 2009). On the other hand, Xanthopoulos *et al*. (2012) reported viscosity values of yogurt produced from goat milk not exceeding 11.7

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Pa.s. The caseins improve the hydrophilicity of the proteins, which leads to the formation of a copolymer between proteins and fat globules thus reinforcing the yogurt gel structure by improving its viscosity.

The texture is a property of food products that is always related to their physico-chemical characteristics. Thus, it can define the quality of yogurt and affect its appearance. The firmness was not significant (P> 0.05) during storage (Table 3). The values ranged, initially, from 2.03±0.14, 2.04±0.03 and 2.05±0.08 N to 1.95±0.07, 1.97±0.08 and 2±0.05 N for, respectively, YC, YP and YF products. These values indicated in our study are higher than those found in other reviews that do not exceed a value of 1.17 N (Oroian *et al*., 2011). This difference could be attributed to the technological performances of the ferments and the initial quality of milk.

During 21 days of storage, we recorded similar values (P> 0.05) of chewiness, even of 2.25±0.16 (N mm^{-1}). In general, the cohesion indictes the excellent yogurt gel structure produced and the good relationship between its constituents (proteins and fats) (Xanthopoulos *et al*., 2012).This parameter did not exceed 1.17±0.07 (P> 0.05). From the 21st day of storage, this parameter increased significantly (P< 0.05) to reach an average value of 1.72. Then, the cohesion decreased to a value of 1.13±0.03 at the end of conservation. These values are similar to those noted by Oroian *et al*. (2011) who found a cohesion spectrum not exceeding 1.74. The elasticity (or flexibility) of yogurt gels could be attributed to stable proteolysis over the refrigerated storage. Similarly, the gummability remained similar (P> 0.05) with an average value not exceeding 2.33±0.22 N. Regarding the elasticity, non significant values (P> 0.05), except the 14th day of preservation, were measured on yogurts. Thus, yogurt gels had levels of flexibility between 8.3 and 9.7 mm. The analysis of the different texture parameters of goat yogurts is assigned to a well-maintained structure, as well as all yogurt formulations. Also, the pseudo-elastic behavior and viscosity are two factors that depend on the previous yogurt texture (Ares *et al*., 2007).

Sensory Profiles

Examination of the sensory quality data from goat yogurts after seven days of refrigerated storage revealed similar patterns (P> 0.05) for all tested parameters (Figure 2). Thus, the tasting panel did not find any significant difference even in terms of the

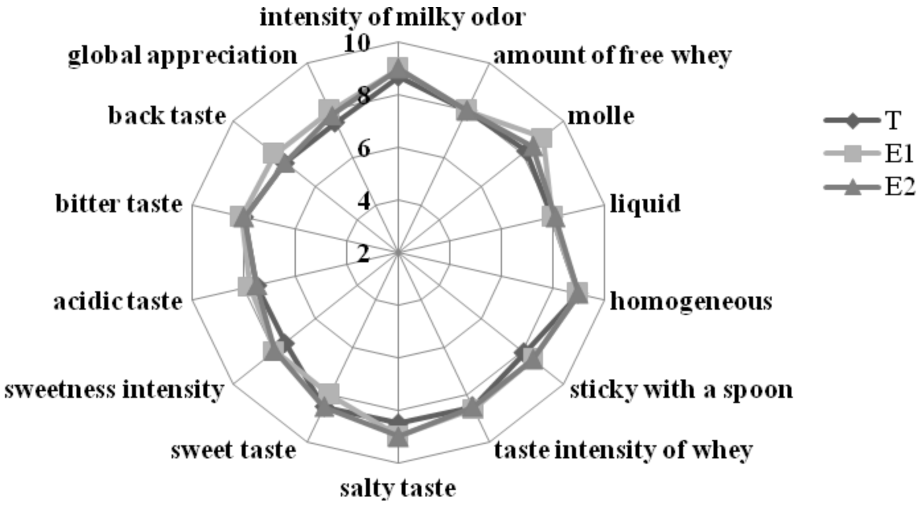

Figure 2. Sensory profiles of goat yogurts after one week of storage at 4°C.

Table 3. Texture parametersof goat yogurts during storage at 4°C.

Storage (Days)	Samples	Texture parameters				
		Firmness (N)	Chewiness (N mm^{-1})	Cohesion	Gummability (N)	Elasticity (mm)
1	YC	2.03 ± 0.14 [a] [a]	2.13 ± 0.11 [a]	1.15 ± 0.03 [a]	2.22 ± 0.13 [a]	9.6 ± 0.02 [a]
	YF	2.05 ± 0.08 [a]	2.21 ± 0.08 [a]	1.17 ± 0.07 [a]	2.3 ± 0.1 [a]	9.6 ± 0.02 [a]
	YP	2.04 ± 0.03 [a]	2.15 ± 0.06 [a]	1.12 ± 0.04 [a]	2.28 ± 0.09 [a]	9.5 ± 0.03 [a]
7	YC	2.02 ± 0.03 [a]	2.11 ± 0.1 [a]	1.15 ± 0.04 [a]	2.32 ± 0.1 [a]	9.7 ± 0.00 [a]
	YF	2.04 ± 0.06 [a]	2.11 ± 0.22 [a]	1.16 ± 0.03 [a]	2.26 ± 0.11 [a]	9.3 ± 0.07 [a]
	YP	2 ± 0.12 [a]	1.99 ± 0.29 [a]	1.14 ± 0.05 [a]	2.19 ± 0.13 [a]	9 ± 0.09 [a]
14	YC	1.9 ± 0.21 [a]	1.65 ± 0.41 [b]	1.1 ± 0.05 [a]	1.99 ± 0.32 [a]	8.3 ± 0.08 [b]
	YF	2.02 ± 0.14 [a]	2.12 ± 0.31 [a]	1.15 ± 0.03 [a]	2.3 ± 0.16 [a]	9.2 ± 0.09 [a]
	YP	2 ± 0.17 [a]	2.25 ± 0.16 [a]	1.13 ± 0.03 [a]	2.33 ± 0.22 [a]	9.7 ± 0.02 [a]
21	YC	1.98 ± 0.04 [a]	1.94 ± 0.28 [a]	1.7 ± 1.29 [b]	1.95 ± 0.58 [a]	9.1 ± 0.09 [a]
	YF	2 ± 0.08 [a]	2.21 ± 0.09 [a]	1.73 ± 0.04 [b]	2.32 ± 0.1 [a]	9.7 ± 0.01 [a]
	YP	1.99 ± 0.14 [a]	2.13 ± 0.12 [a]	1.73 ± 0.02 [b]	2.23 ± 0.13 [a]	9.6 ± 0.02 [a]
28	YC	1.95 ± 0.07 [a]	2.05 ± 0.08 [a]	1.13 ± 0.03 [a]	2.2 ± 0.09 [a]	9.3 ± 0.03 [a]
	YF	2 ± 0.05 [a]	2.01 ± 0.1 [a]	1.17 ± 0.02 [a]	2.21 ± 0.19 [a]	9.1 ± 0.04 [a]
	YP	1.97 ± 0.08 [a]	2.11 ± 0.1 [a]	1.16 ± 0.08 [a]	2.22 ± 0.08 [a]	9.5 ± 0.02 [a]

[a] Values in the same row having different superscripts differ significantly ($P < 0.05$).

general acceptability, regardless of the sensory setting considered. The sensory characteristics found in this study are similar to the previously discussed results concerning texture (homogeneous), syneresis (amount of free whey) and viscosity (sticky with a spoon). Similarly Xanthopoulos *et al*. (2012) showed non significant sensory quality of the sensory quality of yogurt samples concerning flavor and texture. Finally, it is essential to indicate that the overall sensory quality is not affected following the inoculation of probiotics. Moreover, Ekinci and Gurel (2008) and Senaka Ranadheera *et al*. (2012) showed that the inoculation of *propionibacterium* did not change either yogurt production or its quality during storage period.

CONCLUSIONS

The present study showed that the addition of the probiotic bacteria had no effect on physicochemical characteristics of goat yogurts. The probiotic yogurts received good sensory scores, and no flavor associated to goat's milk or the inoculation of probiotics was detected. Also, results showed that satisfactory viability of probiotics (10^8 CFU g^{-1}) was maintained at levels above the minimum therapeutic threshold (10^6 CFU g^{-1}) throughout the 28 days of storage.

Finally, the results of this study presented a successful integration of the probiotics *L. fermentum* CABA16 and *L. plantarum* BA12 into a new goat milk product with satisfactory nutritional and sensory quality, as well as added value on the market due to the potential functional properties.

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ویژگی های ماست بزی دارای باکتری پروبیوتیک ***Lactobacillus* Probiotic**

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چکیده

هدف این پژوهش تجزیه تحلیل تاثیر باکتری های پروبیوتیک روی ویژگی های میکروبیولوژیکی، فیزیکوشیمیایی، فناورانه، و خواص حسی ماست بزی در طی ۲۸ روز نگهداری در سردخانه بود. نتایج نشان داد که افزودن دو باکتری پروبیوتیک، در مقایسه با تیمارهای شاهد، تاثیر معناداری روی ویژگی

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های فیزیکوشیمیایی مانند پ هاش، محتوای لاکتیک اسید، جامدات کل، آب انداختن(syneresis)، و ظرفیت نگهداری آب و پروتئین، رنگ و ویسکوزیته و پارامترهای بافت و خواص حسی نمونه های تلقیح شده نداشت. همچنین، دوام و زیستایی پروبیوتیک در همه مراحل با نرخ 10^8 CFU g^{-1} حفظ شد. بنا براین، پژوهش حاضر نشان می دهد که ماست حامل خوبی برای باکترهای پروبیوتیک است و بینش نوینی در مورد تاثیر آنها روی متابولیسم این غذای زیست فعال(functional food) و حفظ کیفیت آن فراهم می آورد.

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