Small Ruminant Research 138 (2016) 46–52

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Concentrated yogurt (Labneh) made of a mixture of goats' and cows' milk: Physicochemical, microbiological and sensory analysis

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ARTICLE INFO

Article history:
Received 11 February 2016
Received in revised form 1 April 2016
Accepted 3 April 2016
Available online 6 April 2016

Keywords:
Concentrated yogurt
Goat's milk
Cow's milk
Quality parameters
Consumer acceptance

ABSTRACT

The aim of this study was to characterize concentrated yogurt (Labneh) made of goats' milk, cows' milk and their mixture. Physicochemical, microbiological, and sensory parameters of Labneh were monitored after production, with specific reference to the type of milk. Seven different formulations were prepared by mixing cow and goat milk in different proportions. Mass fraction (%) of goats' milk in the mixtures was 100, 50, 40, 30, 20, 10 and 0. Compositional parameters, profiles of the fatty acids (FAs) and main microbial groups in Labneh were performed. Labneh produced from goat's milk was characterized by its higher moisture, ash and fat content, but lower pH, total solids, protein and lactose content in comparison to that of the Labneh developed using cow's milk. Labneh with goat's milk had a higher short- and medium-chain FAs groups, and a lower long- chain FAs than that only containing cow's milk. Samples with 40% goats' milk/60% cow's milk were the most preferred by the sensory panel. The development of Labneh with both goats' and cows' milk is an interesting opportunity to produce a goat dairy product that is considered satisfactory by consumers.

1. Introduction

Different types of traditional and industrialized fermented milk products are manufactured throughout the world. Products made from milk of cows, goat and sheep originated in the Middle East, perhaps before the Phoenician era, and spread through Europe. Nutritionally these products favorably supplement the diet and provide elements vital to growth and good health.

In Lebanon, there is a wide availability of white cheeses made from cow's milk at industrial scale, such as Labneh (Kaaki et al., 2012), Halloumi (Kamleh et al., 2012) and Akkawi (Elkak et al., 2012), whereas the minor quantities that are produced by small- to medium-scale producers using goat milk are typical cheeses such as Darfiyeh (Serhan et al., 2010) and Serdale (Serhan and Mattar, 2013). Although goat milk is seasonal, there has been an increased interest for its production and its conversion to value added dairy products (Albenzio et al., 2006; Hilali et al., 2011). The nutritional, health and therapeutic benefits enlighten the potentials and values of goat milk and its specialty products (Ribeiro and Ribeiro, 2010). In addition, goat milk possesses many advantages over cow milk, for use as a nutritional source for infants and as a medicinal food (Silanikove et al., 2010).

Traditionally, concentrated yogurt, known as Labneh, is a fermented milk product widely appreciated and consumed as an important protein source. Different types of milk can be used in the production of Labneh; namely cow, sheep and goat milks, although cow and, to a lesser extent, goat are more common (Tamime and Robinson, 2007).

According to the Lebanese dairy production, Labneh is widely made from cow's milk (either full fat or skimmed) or from goat milk in more limited availability. It is produced by an age-old practice by straining milk set yogurt in cloth bags for 12–18 h at refrigeration temperatures, until the desired total solid level is attained. Modern Labneh manufacturing methods used in industrial scale operations include centrifugation, recombination technology and ultrafiltration (Nsabimana et al., 2005).

Total plate counts of 7.5×10^7 to 1.87×10^8 cfu/g have been reported for Labneh products (Rosenthal et al., 1980; Yamani and Abu-Jaber, 1994; Al-Kadamany et al., 2003). Popularity of Labneh has led to more interest in its structure and rheological properties (Ozer et al., 1999). Several methodologies have been utilized in the determination of shelf life of Labneh products by monitoring selected microbiological and physicochemical changes during storage (Al-Kadamany et al. (2002, 2003)). Preference mapping of commercial bovine Labneh products (Kaaki et al., 2012), as well as

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http://dx.doi.org/10.1016/j.smallrumres.2016.04.003
0921-4488/

mapping determinants of purchase intent of Labneh (Haddad et al., 2007) were specifically studied in the Lebanese market.

Several studies mentioned above related to the characterization of bovine or caprine Labneh have been reported in the literature. While cow or goat milk cheeses are classically produced either from 100% of each type, several research studies are made on cheeses produced from mixtures of cows' and goats' milk (Kücükcetin et al., 2011; Campos et al., 2011; Gomes et al., 2013; Queiroga et al., 2013). In this context, the aim to produce another milk product is intended to make a better product under quality characteristics, but no or few references are reported to justify this.

Considering these aspects, the objectives of this work were (1) to assess and evaluate the quality parameters and sensory acceptability of Labneh products made with goats' milk, cows' milk and their mixture, and (2) to compare their quality characteristics with those of Labneh products manufactured with the milk from either cows or goats.

2. Materials and methods

2.1. Concentrated yogurt (Labneh) manufacture

Raw cow (local breed) and goat (local breed) milk were collected separately from local farms in the North Lebanon region: 7 farms providing CM and 2 farms providing GM. Milk derived from cow and goat flocks managed under extensive grazing.

Prior to manufacturing, the following tests were conducted on milk. Organoleptic analysis was applied for visual and olfactory nonconformity and physical contamination. The 68% Ethyl alcohol test was used for rapid assessment of stability of milk for processing. BetaStar® Plus apparatus (Neogen corporation) was used for detection of beta-lactam antibiotic residues in milk.

Labneh was made by the procedure normally used in homes (Rosenthal et al., 1980). Fresh raw goat and fresh raw bovine milk were heated separately at 90 °C for 5 min, before being cooled to inoculation temperature (42 °C).

Then, seven different formulations were prepared by mixing both types of milk in different proportions. Mass fraction (%) of goats' milk in the mixtures of concentrated yogurt formulations was 100, 50, 40, 30, 20, 10 and 0. The amount of goats' milk (%) has been used for sample notation throughout the discussion of results.

The mixtures of goat milk (GM) and cow milk (CM) were gently stirred and inoculated with ca. 2% starter culture (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* in equal proportions, Yo-Mix 505 LYO 200 DCU lyophilized powder). The temperature was allowed to drop slowly to the ambient temperature (2 to 3 h), and the bulk subsequently was incubated at 4–5 °C for 24 h. The coagulum was carefully poured in separate sanitized hanging cloth bags and left to drain the whey by gravity at 6 °C overnight (total drainage time was set to 18 h). Salt was added in a concentration of 0.75%. The finished product was put in disinfected labeled PVC containers (500 g), closed with an aluminum foil, and stored in the laboratory refrigerator at (4 °C). Samples were brought to the Laboratory of the Faculty of Health Sciences at the University of Balamand at a temperature of 4 °C. Two replicates of each batch were mixed together prior to analysis.

2.2. Physicochemical analysis

Protein, fat, ash and water contents of goat's and cow's Labneh products were determined according to the Association of Official Analytical Chemist methods (AOAC, 2000). The pH was measured by a WTW pH meter (Inolab pH level 2, WTW GmbH, Weilheim, Germany).

Fat was extracted from Labneh products by Soxhlet method using petroleum ether and diethyl ether solvents. Total free Fatty Acids (FAs) in extracted fat, expressed as mg KOH g^{-1} fat, were determined by titration using KOH 0.1 N, after dissolving 5 g of fat in 50 mL diethyl ether/ethanol (50:50, v/v).

The FA methyl esters (FAME) were obtained by transmethylation of lipid aliquots according to standard procedures of the AOAC (2000). Lipid aliquots (100 mg) were dissolved with 1.5 mL of hexane and 1.5 mL of borontrifluoride in methanol (8%, w/v) and heated at 100 °C for 1 h. After cooling, the FAME were extracted in hexane under nitrogen. They were analyzed by gas chromatography (GC) on a PerichromTM 2000 apparatus (Saulx-les-Chartreux, France), equipped with a flame ionisation detector (FID) and fused silica capillary column (25 m × 0.25 mm × 0.5 μm, BPx70 SGE Australia Pty. Ltd.). Temperature was set as follows: 1 min initial period at 120 °C, increasing at 3 °C min^{-1} to the final step at 220 °C for 20 min. Injection and detection ports were maintained at 230 and 260 °C, respectively.

Peaks were identified by comparison with standards (Sigma–Aldrich, Germany) under identical conditions, using the Winlab 3 software (Perichrom, Saulx-les-Chartreux, France). Results were displayed as percent of total identified FAs. All solvents used were of analytical grade. All analyses were performed in triplicate.

The FA composition was converted to g/100 g using the software Chromquest 4.1 (Thermo Electron, Italy).

The nutritional quality indices of lipids were determined using the monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and the Atherogenicity Index (AI). The latter was calculated using the equation of Ulbright and Southgate (1991).

2.3. Microbiological analysis

Total aerobes, lactic acid bacteria, mesophilic yeasts and molds, and coliforms were enumerated according to standard procedures (Marshall, 1993); psychrotrophic yeasts and molds counts were determined as outlined by Yamani and Abu-Jaber (1994). Labneh samples were wiped, from the outside, with 70% ethanol and were thoroughly mixed. A composite subsample was prepared by transferring Labneh into a flask, that contained sterile phosphate buffer, and blending with warm buffer (40 °C) until an homogeneous mixture was obtained.

Subsamples for enumeration of lactic acid bacteria were prepared in a similar manner using 0.1% peptone water as the diluent. Total aerobes, lactic acid bacteria, and presumptive coliforms were determined by the pour plate technique, while yeasts and molds and psychotropic yeasts were enumerated by the spread plate technique. Total aerobes were counted on PCA (plate count agar) medium (Himedia, Mumbia, India) incubated at 32 °C for 48 h; presumptive coliforms on violet red bile agar medium incubated at 37 °C for 24 h. Lactic acid bacteria counts were performed on MRS agar incubated at 37 °C for 48 h. Yeasts and molds and psychrotrophic yeasts counts were also performed on PCA medium that contained 0.01% chloramphenicol and 0.01% chlortetracycline hydrochloride, and incubation at 25 °C for 5 days and at 5 °C for 10 days, respectively. *Staphyococcus aureus*, *Salmonella* and *Listeria monocytogenes* were determined using Mannitol Salt Agar (MSA), Shigella Salmonella (SS) agar and Palcam agar respectively, and incubated at 37 °C for 48 h (Al-Kadamany et al., 2003).

2.4. Sensory testing

2.4.1. Descriptive analysis

Labneh samples were assessed organoleptically by a panel of five laboratory staff members (4 female and 1 male, aged 25–35 years). Selection of members of the sensory panel was based on their capacity to discriminate samples with good reproducibility, the repeatability of the results and the consensus with the team. The panelists were familiar with sensory evaluation techniques and were regular consumers of Labneh products. They were trained for descriptive analysis accordifng to the standard flavor profile guidelines set by ISO 6564:1985. Panel training sessions were performed to familiarize the subjects with the language and the products under investigation, especially Labneh made from goat milk.

Samples were described using the Quantitative Descriptive Analysis (QDA) technique (Stone and Sidel, 1993). The QDA test was administered using a 5-point scale ranging from 1 (little) to 5 (very much) regarding the following attributes: external aspects (color and dry/humid), odor (overall intensity, cows' milk odor, goats' milk odor, butter odor and yogurt odor), texture (hardness, adhesiveness, elasticity and gumminess), basic tastes (acidic, salty and bitter), flavor (overall intensity, milky flavor, butter flavor, cow flavor, goat flavor and yogurt flavor), and after-taste (intensity and persistence), according to Queiroga et al. (2013).

2.4.2. Consumer acceptance testing

The acceptance test was carried out with 35 consumers (aged 21–35 years), preselected according to their interest and habits of Labneh consumption. Consumer evaluation was performed according to an hedonic scale ranging from 1 (dislike very much) to 9 (like very much) for aspect, odor, texture, taste and overall appreciation. The testing sessions (trained panel and consumer testing) were conducted in individual booths with controlled temperature and lighting conditions. Each assessor was served 20 g of each Labneh sample placed on small white plates coded with three-digit random numbers served immediately after being taken out of refrigerated storage. Assessors were asked to use low-salt biscuits and water to clean their palates between the assessed samples. Samples were presented under similar conditions (temperature and quantity) for all panelists, according to Queiroga et al. (2013).

2.5. Reproducibility and statistical analysis

All analyses were carried out in triplicate. Experimental data were subjected to one-way analysis of variance (ANOVA) using the least squares difference (LSD) test ($P < 0.05$). The software Statgrahics® plus version 5.1 (Statistical Graphics Corp., Rockville, MD, USA) was used.

3. Results

3.1. Physicochemical parameters

The goat's and cow's milk used in the production of concentrated yogurt (Labneh) had the following compositions, respectively: total protein content ($g.L^{-1}$) of 34.60 ± 0.13 and 32.50 ± 1.06, fat content ($g.L^{-1}$) of 40.45 ± 0.50 and 30.65 ± 0.35, and pH of 6.67 ± 0.02 and 6.50 ± 0.05.

The physicochemical characteristics of Labneh samples made from cow's milk, goat's milk and their mixture are shown in Table 1. A faster acidification and lower pH values were noticed in 100% Labneh Goat Milk (LGM) compared to 0% LGM. These values were also reported by other authors (Vargas et al., 2008; Kücükcetin et al., 2011). Moreover, the rate of the acid development due to the starter culture in LGM was also observed in the mixtures of milk where GM was used. This behavior was explained by the enhancement of the microbial growth, acidity progress and peptidase activity of *Lactobacillus delbrueckii* subsp. *bulgaricus* in GM (Vargas et al., 2008). Serhan et al. (2010) found that higher moisture content increased the proteolytic activity in artisanal goat cheeses. Plus, the lower values of pH seemed to be related to a high production of lactic acid from residual lactose in dairy product fermentation. The acidification rate of lactic acid bacteria varied with the type of the milk, some yogurt starters are more active in GM while others in CM, regardless the starter type. The acidity in fermented milk is related to lactose fermentation by lactic acid bacteria into lactic acid.

The pH values were different among the assessed Labneh products ($P < 0.05$). Low pH values and higher acidification rate result in the release of whey, increasing the solubilisation of calcium phosphate micelles that cause the loss of the soluble calcium present in the curd whey (Park and Lee, 2006).

Examination of the data revealed higher moisture content of 100% LGM reaching values of 76% than in 0% LGM (71%). Labneh formulations containing a mass fraction of goats' milk of 20, 30, 40 and 50% have developed moisture content between the above mentioned values ($P > 0.05$). The data found are similar to those reported by Tamime et al. (2011). Opposite findings were determined by Chandan et al. (2006) and Ceballos et al. (2009). Cow's milk products exhibited lower values for moisture content and fat, and higher values of proteins compared to goat's milk ($P < 0.05$). The values for these parameters were different from those reported by Escuadero et al. (2011). This difference may be linked to several factors related to the initial difference in the milk source and type, as well as its composition, such as lactation stage, age and breed of the animals, milking intervals, the season and environmental temperature, milking efficiency, dietary nutrients, hormones and/or diseases in the animal udder (Park et al., 2007; Tamime et al., 2011). It is important to mention that the technology used for Labneh production may influence the physicochemical composition of the final product. Moisture content differs according to processing techniques since different methods of manufacturing may produce end products with different gelling properties (Abu-Jdayil and Mohameed, 2002). The longer the draining of the yogurt in the cloth bags, the higher the total solids of the final product. Thus, moisture content is related to syneresis. This latter hypothesis was supported by Vargas et al. (2008) upon trials on mixing GM and CM for yogurt production. These authors concluded that the gel's capacity to hold whey increased when the proportion of GM was 75% or above. Inversely, the opposite result was found for formulations with 50% GM or less. This can be due to occurrence of new interactions between caprine and bovine caseins micelles when they are mixed together.

Protein content of Labneh samples made from 100% caprine or bovine milk are shown in Table 1. Reference our production, 100% LGM had lower protein content than 0% LGM. According to Vargas et al. (2008), protein content of GM is higher than in CM (which is the case of the milk used for the manufacturing of Labneh samples), whereas other studies carried by Chandan et al. (2006) and Tamime et al. (2011) have stated that protein content in CM is higher than in GM. This can be due to the original composition of the fermented milk or due to the enhancement of *Lactobacillus delbrueckii* subsp. *bulgaricus* microbial growth and peptidase activity in GM compared to CM. Protein content affects the final product texture. The maximum firmness of the gel of GM is usually much less, and even a gel from GM with equal casein content is not as firm as from CM. It is important to add that protein contents vary widely within species (Park et al., 2007).

Reference the composition of the milk used for the production of concentrated yogurts, fat content in GM was higher than in CM. This was supported in the literature (Chandan et al., 2006; Vargas et al., 2008), whereas Tamime et al. (2011) reported the opposite. 100% LGM had more fat than 0% LGM (Hilali et al., 2011). According to LIBNOR (2011), full fat Labneh (whether made from cow or goat milk) should have a minimum of 8% fat, which confirms the results of the present study. Fat content found in goat dairy beverage was higher than those found in a mixed dairy beverage and in a cow dairy beverage as reported by Gomes et al. (2013).

Table 1
Mean values (±Standard Deviation) of the compositional parameters of Labneh made from goats', cows' milk and their mixture, as a function of goats' milk content.

Parameter	0% LGM*	10% LGM	20% LGM	30% LGM	40% LGM	50% LGM	100% LGM
pH	3.90 ± (0.02)[a]	3.84 ± (0.05)[b]	3.66 ± (0.01)[c]	3.72 ± (0.02)[c]	3.70 ± (0.08)[c]	3.82 ± (0.05)[b]	3.82 ± (0.07)[b]
Moisture (g/100 g)	71.00 ± (1.06)[a]	72.00 ± (0.06)[ab]	73.00 ± (0.70)[c]	73.00 ± (0.49)[c]	73.00 ± (0.70)[c]	73.00 ± (1.41)[bc]	76.00 ± (2.31)[d]
Protein (g/100 g)	9.12 ± (0.15)[a]	9.10 ± (0.12)[a]	9.08 ± (0.12)[ab]	9.00 ± (0.27)[b]	8.95 ± (0.14)[b]	8.95 ± (0.10)[b]	8.93 ± (0.00)[b]
Fat (g/100 g)	9.25 ± (0.16)[a]	9.38 ± (0.18)[a]	9.40 ± (0.02)[ab]	9.62 ± (0.39)[c]	9.70 ± (0.19)[cd]	9.74 ± (0.69)[d]	9.86 ± (0.21)[d]
Ash (g/100 g)	1.16 ± (0.04)[c]	1.18 ± (0.01)[c]	1.38 ± (0.10)[e]	1.31 ± (0.02)[d]	1.10 ± (0.01)[b]	1.03 ± (0.10)[a]	1.30 ± (0.04)[d]

0% LGM (100% CM), 10%LGM (10% GM/90% CM), 20% LGM (20% GM/80% CM), 30% LGM (30% GM/70% CM), 40% LGM (40% GM/60% CM), 50% LGM (50% GM/50% CM), 100% LGM (0% CM).
[a–e] Means of pairs in the same row with different superscripts are significantly different ($P < 0.05$), according to the LSD test.
[*] The following abbreviations are used: LGM: Labneh made from Goat's Milk; GM: Goat Milk; and CM: Cow Milk.

Table 2
Mean values of fatty acids (FAs) content (g/100 g) of Labneh products[a] made from goats', cows' milk and their mixture, as a function of goats' milk content (Standard Deviation < 0.05).

FAs	0% LGM[b]	10% LGM	20% LGM	30% LGM	40% LGM	50% LGM	100% LGM
C8:0	0.9	1.0	0.5	0.6	1.3	1.6	3.1
C10:0	2.7	3.6	3.1	2.4	4.5	5.2	10.0
C12:0	3.3	3.6	2.3	2.5	2.8	3.6	4.4
C14:0	12.0	11.9	9.4	10.0	10.5	11.1	9.6
C16:0	35.7	34.5	37.7	37.8	33.7	34.2	28.6
C16:1	1.2	1.1	0.9	0.9	1.1	1.0	0.7
C17:0	0.5	0.5	0.5	0.5	0.5	0.5	0.6
C17:1	0.2	0.2	0.2	0.4	0.4	0.3	0.5
C18:0	13.3	12.9	15.9	15.2	12.8	12.9	10.5
C18:1	26.0	26.4	25.7	25.3	27.7	25.6	26.8
C18:2	3.2	3.3	3.1	3.3	3.5	3.2	4.4
C18:3	0.2	0.2	Traces	0.2	0.3	Traces	0.2
C20:0	0.7	0.7	0.5	0.6	0.9	0.5	0.4
C22:0	Traces	Traces	Traces	0.2	Traces	0.2	0.2
MUFA[c]	27.2	27.5	26.6	26.2	28.8	26.6	27.5
PUFA[d]	3.4	3.5	3.1	3.5	3.8	3.2	4.6
AI[e]	2.84	2.76	2.61	2.70	2.40	2.75	2.22

[a] Mean values of three Labneh makes.
[b] The following abbreviations are used: LGM: Labneh made from Goat's Milk; GM: Goat Milk; and CM: Cow Milk.
0% LGM (100% CM), 10%LGM (10% GM/90% CM), 20% LGM (20% GM/80% CM), 30% LGM (30% GM/70% CM), 40% LGM (40% GM/60% CM), 50% LGM (50% GM/50% CM), 100% LGM (0% CM).
[c] MUFA: monounsaturated fatty acids (C16:1 + C18:1).
[d] PUFA: polyunsaturated fatty acids (C18:2 + C18:3).
[e] AI: atherogenicity index.

Ash content of all samples varied between 1.03% and 1.38% ($P < 0.05$). Most importantly, the difference between 100% LGM and 0% LGM is compared. Ashing procedure is based on the fact that minerals are not usually destroyed by heating since they have lower volatility compared to other food components. Since the quantity of the added salt was the same in all samples during production (0.75%), Na and Cl content differences are due to the chemical composition of the milk used. In fact, many authors have stated that GM had higher mineral content, therefore more ash percentage, than CM (Soliman, 2005; Chandan et al., 2006; Raynal-Ljutovac et al., 2008). The concentration of minerals depends on the breed, diet, individual animal, stage of lactation, and status of udder health (Park et al., 2007). Overall, GM had more Ca, P, K, Mg and Cl contents than CM. No available detailed data concerning the mineral content differences between bovine and caprine Labneh exist.

3.2. Fatty acid methyl esters (FAME) profile

The FAs profiles of Labneh formulations expressed in percentage, as a function of goat's milk content are shown in Table 2. Free fatty acids (FFA) were not separated from triacylglycerols and the resulting FAME obtained after derivatization with boron trifluoride in methanol were an indication of the mixture formed of FFA and triacylglycerols unseparately. Under the analytical conditions, the content of butyric acid (C4:0) and hexanoic acid (C6:0) could not be defined. This could be related to the fact that it can be eluted with the solvent. By studying Darfiyeh cheese, a raw goat milk cheese ripened in goat skin, findings proved that the content of short-chain FAs had a significant impact on the development of its characteristic aroma (Serhan et al., 2010). The FAs hexanoic, octanoic and decanoic acids have long been considered responsible for the characteristic aroma of goat cheeses, giving rise to the popular terms caproic, caprilic and capric acids. Accordingly, theses FAs have contributed most probably to this particular flavor in any goat dairy product, including Labneh. Reference the data shown in Table 2, C8:0, C10:0 and C12:0 were higher than in 0% LGM. One of the most interesting aspects of the milk of small ruminants concerns the nature of its fat. The milk of goats and sheep has a fat rich in short-chain triglycerides, made up of fatty acids with a carbon chain composed of 6–10 atoms of carbon. This is why the FAs known as caproic, caprylic and capric are so termed from the milk in which they are preferentially found.

According to Park et al. (2007), levels of the metabolically valuable fatty acids: C8:0 (2.7%, 1.3%), C10:0 (10.0%, 3.0%), and C12:0 (5.0%, 3.1%) are significantly higher in GM than in CM, respectively (supporting the results). As per these authors, GM creams up slower than CM because of agglutination, which causes clustering of the fat globules

In total, long-chain FAs contents in all formulations were higher than those of the medium-chain. C16:0 was the FA present at the highest level (ca. 28.6%-37.8% of total FAs for 100% LGM and 30% LGM respectively). C14:0 and C16:1 were highest in 0% LGM. However, palmitic Acid (C16:0) was highest in the product when GM was 20% and 30% and lowest in 100% LGM. Interestingly, heptadacanoic acid (C17:0) was the same in all formulations (0.5%), except for 100% LGM (0.6%). The percentages of C18:1 in all formu-

Table 3
Log counts (expressed as CFU g^{-1})[b] of the main microbial groups in Labneh made from goats', cows' milk and their mixture, as a function of goats' milk content (Standard Deviation < 0.05).[a]

	0% LGM[i]	10% LGM	20% LGM	30% LGM	40% LGM	50% LGM	100% LGM
TPC[c]	3.77	5.92	6.78	6.92	6.40	7.24	7. 35
PC[d]	3.52	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
P & M-Yeasts[e]	n.d.[j]	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
P-Molds[f]	n.d.	5.52	3.00	2.52	n.d.	n.d.	n.d.
M-Molds[g]	n.d.	4.52	n.d.	n.d.	n.d.	n.d.	n.d.
Total coliforms	n.d.	n.d.	3.47	n.d.	n.d.	n.d.	n.d.
Fecal coliforms	n.d.	n.d.	6.02	n.d.	n.d.	n.d.	n.d.
LAB[h]	3.52	5.73	6.68	6.64	5.95	6.81	6.92

[a] Results are expressed as the mean of three independent determinations, [b]CFU refers to Colony Forming Unit.
[c] Total Plate Count.
[d] Psychrotrophic Count.
[e] Psychrotrophic and Mesophilic Yeasts.
[f] Psychotrophic Molds.
[g] Mesophilic Molds.
[h] Lactic Acid Bacteria.
[i] The following abbreviations are used: LGM, Labneh made from Goat's Milk; GM, Goat Milk; and CM, Cow Milk.
[j] n.d.: not detected.

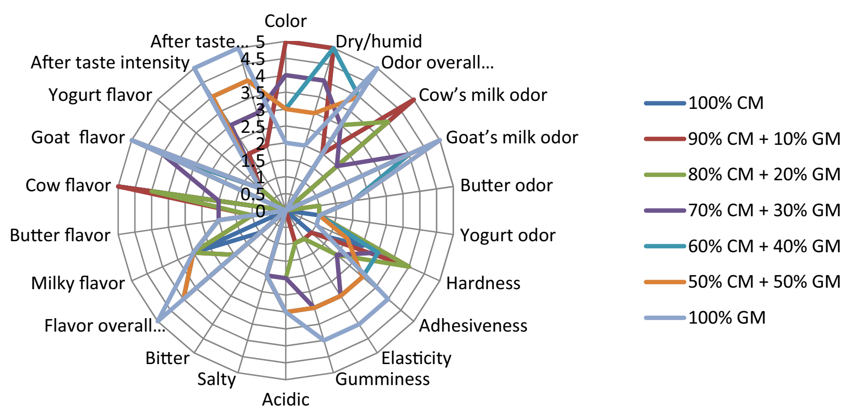

Fig. 1. Graphical representation of sensory evaluation by quantitative descriptive analysis (QDA) of Labneh products made from goats', cows' milk and their mixture.
The following abbreviations are used: LGM: Labneh made from Goat's Milk; GM: Goat Milk; and CM: Cow Milk.
0% LGM (100% CM), 10%LGM (10% GM/90% CM), 20% LGM (20% GM/80% CM), 30% LGM (30% GM/70% CM), 40% LGM (40% GM/60% CM), 50% LGM (50% GM/50% CM), 100% LGM (0% CM).

lations varied between 25% and 26%. These results agree with those reported by Queiroga et al. (2013) for Coalho cheese made of goats', cows' milk and their mixture.

AI value for LGM (2.22) was similar to those reported in the literature for goat cheeses by Taboada et al. (2015) and lower than those reported by De Medeiros et al. (2013). The lower AI value (2.40) among the different range of AI values of Labneh formulations (2.40-2.76), was registered for 40% LGM. Foods with high atherogenicity index are considered more detrimental to human health. In their review, Silanikove et al. (2010) reported that several studies showed that milk and cheese from grazing goats had better quality parameters for human nutrition than that produced from the milk of goats fed indoors.

The higher content of MUFA (28.8) and PUFA in 40%LGM product (28.8) has a favorable effect on human nutrition, compared to 100% LCM (27.2) and LGM (27.5). MUFA have a neutral effect on the cholesterol levels while PUFA incline to decrease the quantity of the total cholesterol and the HDL cholesterol (Sacks and Katan, 2002). The milk fat with high content of unsaturated fatty acids is characterized by a lower atherogenicity index.

3.3. *Microbiological parameters*

The microbiota present in Labneh samples was enumerated by cultivating on media (Table 3). The plate counts revealed a low microbial population that explains the absence of almost any ripening process. The high salt concentration and the acidity of the product preclude the germination of bacterial spores and growth of bacterial contaminants. Psychrotrophic and mesophilic molds were only detected in 10% LGM. According to the Lebanese microbiological standards (LIBNOR, 2011), the levels detected were high for 10% LGM, and low (acceptable) for 20% LGM and 30% LGM. Similar total plate counts and psychotrophic yeasts and molds have been reported for the product from cow milk (Yamani and Abou jaber, 1994).

20% LGM showed the presence of total and fecal coliforms. The presence of coliforms in the sample is indicative of post-pasteurization contamination at one or more stages during processing. Coliforms were not detected in the other samples indicative of adequate heat treatment of milk and high hygienic standards of processing and packaging that precluded recontamination of the product. Coliforms have been reported to be present in Labneh samples produced by the cloth-bag method especially as conditions of processing provide opportunities for contamination at different stages of production (Al-Kadamany et al., 2003).

LAB growing on MRS medium were markedly present at higher levels in Labneh samples made of goat's milk. Mesophilic lactobacilli present at higher levels constitute the majority of the 'non-starter LAB' (NSLAB) present in most types of cheese (Mannu et al., 2000). They are known to grow well in the hostile environment of the cheese (low pH and high salt content) (Marino et al., 2003).

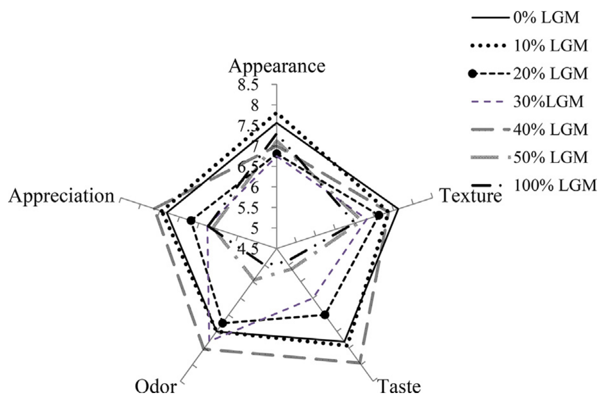

Fig. 2. Graphical representation of sensory acceptance of Labneh products made from goats', cows' milk and their mixture.
The following abbreviations are used: LGM: Labneh made from Goat's Milk; GM: Goat Milk; and CM: Cow Milk.
0% LGM (100% CM), 10%LGM (10% GM/90% CM), 20% LGM (20% GM/80% CM), 30% LGM (30% GM/70% CM), 40% LGM (40% GM/60% CM), 50% LGM (50% GM/50% CM), 100% LGM (0% CM).

Psychrotrophic bacteria were only detected in 0% LGM.

The growth of *Staphyococcus aureus*, *Salmonella* and *Listeria monocytogenes* were determined using Mannitol Salt Agar (MSA), Shigella Salmonella (SS) agar and Palcam agar respectively. There was a total absence of colonies. This indicated that all tested samples were free from the aforementioned pathogenic bacteria.

3.4. Sensory parameters

The Labneh samples made from goats', cows' milk and their mixture were assessed for sensory attributes using both QDA (Fig. 1) and an acceptance test after production (Fig. 2).

Analysis of QDA results showed that scores found for color, cow's milk odor, goat's milk odor, adhesiveness, gumminess, flavor overall, cow flavor, goat flavor and aftertaste were significantly different ($P < 0.05$) among the evaluated samples.

The higher scores for goat flavor and overall flavor were found for 100% LGM. The highest scores for cow flavor were found for 0% LGM. Higher scores for color were found for 10% LGM.

The scores of after taste and after taste intensity increased significantly ($P < 0.05$) when more GM was added. The same trend was found for adhesiveness, gumminess and elasticity in all samples. The increased hardness could reflect a particular sensory characteristic of cheeses made from goat's milk, which is in accordance with the results of Queiroga et al. (2013).

According to Delgado et al. (2011), the flavor of cheeses depends on several reactions, especially the metabolism of lactose and lactate, lipolysis and proteolysis in the cheese matrix. Some researchers propose that the flavor of goat cheeses could be strongly related to the presence of branched chain fatty acids (such as 4-ethyl-octanoic and 4-methyloctanoic). Haenlein (2004) states that branched C4 fatty acids exhibit a characteristic caprine flavor. 4-methyloctanoic acid and 4-ethyl-octanoic acid at a minimum concentration of 100 ppb are responsible for the characteristic goat taste in cheeses. Moreover, 4-ethyl-octanoic fatty acid is not found in cow's milk.

In this study, the sensory analysis results agree with the results of the fatty acids profile analysis, in which the cheeses made from goat's milk showed higher contents of short-chain fatty acids (caproic, caprilic and capric). The characteristic goat flavor in cheeses is intensified when the product possesses pH values of six or higher (Ceballos et al., 2009), although the pH values of the samples studied here were always lower than six (Table 1). Morand-Fehr et al. (2004) reported that fresh cheeses present a less pronounced caprine taste, making them more attractive to most consumers. The same researchers emphasize that the use of hygienic practices during milking can decrease the development of disagreeable taste in cheeses made from goat's milk during storage because of the decrease in lipolysis caused by contaminating bacteria in particular lipase producers.

Acceptance tests revealed no significant difference ($P > 0.05$) for the overall appreciation, appearance, taste, texture and odor among the Labneh samples made with the mixture of cow's and goat's milk. In general, these results reflect good acceptance of the assessed products, although Labneh from GM deserved to be highlighted because no data has been previously available concerning the evaluation of its sensory parameters and even though the samples produced with goat's milk presented lower acceptability, the mixture with cow's milk allowed improving sensory acceptability. As shown in Fig. 2, 10% LGM had the higher score for appearance, 40% LGM was the most tasteful and overall accepted, and 100% LGM had the lowest score for texture. A recent study on rheological and textural properties of goat and cow milk set type yogurts showed that the textural properties of goat milk yogurts such as firmness, consistency, cohesiveness and viscosity index were very poor. Fortification of goat milk with a cow milk protein isolate contributed to a significant improvement of the rheological and textural properties of yogurt (Miocinovic et al., 2015).

From a total score of 9, the rate for appearance of Labneh samples was between 6.75 and 7.81; the texture perceived a score between 6.5 and 7.62; the taste rated a minimum score of 4.9 and a maximum of 7.93; and the overall acceptability profile stood minimum score of 6.14 and a maximum of 7.64. The most significant difference was spotted in flavor.

Some recent studies have highlighted the difference in acceptance of dairy products made with cow and goat milk. Costa et al. (2014) have reported the changes on expected taste perception of probiotic and conventional yogurts made from goat milk after rapidly repeated exposure. The latter test has been used to increase the consumption of particular foods. Results have shown that the increasing of exposure sessions could be a strategy to increase goat milk product acceptance. Costa et al. (2015) have evaluated the presence of biogenic amines in fermented cow's and goat's milks containing probiotic bacteria and acceptance. Results have shown that fermented cow's milk was well accepted compared to fermented goat's milk. Ranadheera et al. (2012) have studied the physico-chemical and sensory properties of plain and stirred fruit yogurts made from goat's milk. It has been revealed that addition of fruit juice has enhanced the product sensory acceptability.

4. Conclusion

This study was conducted with the aim of characterizing physicochemical, microbiological and sensory parameters of concentrated yogurt (Labneh) made of a mixture of goats' and cows' milk. The above results have shown that the milk type affects the evaluated parameters. The replacement of cow's milk by goat's milk led to changes with respect to fatty acid profiles with a reduction in short fatty and linoleic acids and a slight increase of palmitoleic acid, which affected positively the sensory acceptance of mixture Labneh. For practical application, the addition of an amount of 40% of goat's milk to cow's milk can be optimized for the purpose of developing a differentiated Labneh product. The latter presented a less pronounced caprine taste, which contributes to better acceptance by consumers, nevertheless maintaining relevant positive nutritional aspects of goat's milk.

Conflict of interests

None.

Acknowledgements

The authors would like to thank the panelists who took part in this study.

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