Indian Journal of
Nutrition

Open Science Publications

Volume 3, Issue 1 - 2016
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Some Properties of Set Type Yoghurts Produced From Camel (*Camelus Dromedarius*) Milk Enriched With Native Rice Flour and Skim Milk Powder

Research Article

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Article Information: Submission: 08/02/2016; **Accepted:** 26/02/2016; **Published:** 04/03/2016

Abstract

Three different types of set type yoghurt were produced from camel (*Camelus Dromedarius*) milk (CaM). The 1st yoghurt type (Y_{SMP}) was produced by adding 9% (w/v) skim milk powder (SMP) to camel milk, the 2nd yoghurt type (Y_{NRF}) was produced by adding 9% (w/v) native rice flour (NRF) (from *Oryza sativa* L. ssp. *japonica*) to the camel milk and the 3rd yoghurt type ($Y_{SMP+NRF}$) was produced by adding a 4.5% (w/v) SMP+4.5% (w/v) NRF mixture to the camel milk. Samples were stored for 10 days at 4 °C±1. Physicochemical, microbiological and sensory analyses were conducted at the 12th hour and on the 1st, 5th, 7th and 10th days of storage. In the yoghurt samples, it was determined that *Streptococcus thermophilus* count was higher until the 5th day compared to *Lactobacillus delbrueckii subsp. bulgaricus*, which became the dominant flora after the 5th day. Regarding the sensory properties, in Y_{NRF} (until the 5th day) and $Y_{SMP+NRF}$ (throughout the storage), rice flour was not felt in the mouth and also did not cause any defect related to structure and taste. In our study, the general properties of yoghurt produced from unaccompanied rice flour (Y_{NRF}) began to deteriorate after the 5th day, whereas combination with milk powder ($Y_{SMP+NRF}$) had a positive effect on the general properties of the samples until the 10th day of the storage.

Keywords: Camel milk; Native rice flour; Yoghurt

Introduction

Yoghurt is a fermented dairy product produced from the lactic acid fermentation of milk by *Lactobacillus delbrueckii subsp. bulgaricus (Lb.bulgaricus)* and *Streptococcus thermophilus (Str. thermophilus)* bacteria. Starter cultures used in the production grow better in the presence of glucose and some other sugars (sucrose, maltose) [1]. Yoghurt has several industrial types including set type, stirred type, drinking type, frozen type and concentrated type [2]. In order to improve consistency and viscosity in the yoghurt, dry matter should be increased in the processed milk. Skim milk powder is the most frequently used ingredient for this purpose. Camel milk has lower viscosity (1.72 mPas) compared to cow's milk (2.04 mPas) [3], the casein ratio in its total protein content is 52-87% [4], and it is rich in terms of sulphur-containing [5] and essential amino acids [6,7]. There have been studies on the production of yoghurt supplemented with skimmed milk powder [8], probiotic yoghurt [9], stabilizer-supplemented yoghurt [10,11], yoghurt supplemented with different spices [12] and flavored yoghurt [13] from camel milk. In previous studies, it was reported that in yoghurts produced with industrial yoghurt culture, coagulum was not smooth, the structure was heterogeneous and brittle, and viscosity did not change during gelatinization [14,15]. Nevertheless, it was reported that it is possible to produce hardened but low viscosity yoghurt by using twice the amount of main components of milk and yoghurt culture [13]. The problems that occur during fermentation have been associated with the abundance of antimicrobial agents in camel milk (lysozyme 228-500 µg.100 mL^{-1}; lactoperoxidase 79.2%) [16,17], the poor content of serum proteins (20-25% of total protein) [18,19], weak interaction between denatured serum proteins and casein, low or no contents of different β-casein derivatives in the structure of casein and β-lactoglobulin from the serum proteins [16], κ and low ratio of casein (3.47 %) compared to cow's milk (13%) [20,21].

Most of the rice (*Oryza sativa*) produced is directly as food, although some is also consumed as native rice flour (NRF) obtained via trituration. The quality of NRF varies depending on its physicochemical properties [22,23]. Starch, which is the main component of NRF, consists of two glucose polymers called amylose and amylopectin. These polymers affect the functional, adhesion, gelatinization and retrogradation properties of NRF . In this study, NRF obtained from rice (*Oryza sativa L. ssp. japonica*) was examined in terms of its usability for the enrichment of camel milk used for yoghurt production. Its effects on some parameters of yogurt after different storage periods were compared with skim milk powder.

Material and Methods

Material

Raw camel (*Camelus Dromedarius)* milk (CaM) used in the study was obtained from a local camel farm in Sarayköy, Denizli (Turkey). Native rice flour (NRF) [content data according to the producer: fat 0.70%; protein 6.79%; starch 85.42%; amylose 18.22%, amylopectin 65.20%; moisture 6.12% and ash 0.35%] produced from *Oryza sativa* L. ssp. *japonica* was obtained from a local company in Turkey. JOINTEC VB530 freeze-dried yogurt culture was obtained from CSL laboratories (Strade per Merlino, 3,26839, Italy). Skim milk powder [content data according to the producer: fat 0.48%; protein 35.12%; lactose 51.14%] was obtained from Pınar Sut Inc. (Kemalpaşa, Izmir, Turkey). Yoghurt samples were produced in pilot plants in Ege University, Faculty of Agriculture, Department of Dairy Technology.

Set Type Yoghurt Production

Set type yoghurts were produced from camel milk enriched with skimmed milk powder (SMP), natural rice flour (NRF) and SMP + NRF with starter cultures (*Lb. bulgaricus* and *Str. thermophilus)*. Camel milk was divided into three parts. 9% (w/v) SMP (Y_{SMP}) was added to the 1st part, 9% (w/v) NRF (Y_{NRF}) was added to the 2nd part and 4.5% (w/v) NRF + 4.5% (w/v) SMP ($Y_{SMP+NRF}$) was added to the 3rd part. The SMP ratio added to the milk was higher than the reference value reported by Salih and Hamid [8] (7% skim milk powder). NRF ratio was determined based on the results of preliminary trials. In the preliminary trials, 4% (w/v), 5% (w/v), 7% (w/v) and 9% (w/v) NRF were added. The best results regarding appearance, structure-consistancy, and flavor-aroma was achieved with the 9% (w/v) treatment. Milks were pasteurized considering the maximum gelatinization temperature of low amylose (18.22%) at 85 °C for 20 minutes and cooled to 42-43 °C. Each treatment was inoculated with 3% starter cultures and left to incubate. Incubation was stopped at pH 4.60 (approximately 12 hours) and stored at 4 °C±1 for 10 days. On the 12th hour, 1st, 5th, 7th and 10th days, physicochemical, rheological, microbiological and sensory analyses were carried out.

Physicochemical and Proximate Analysis

In raw camel milk and yoghurt samples, dry matter (Binder ED-53, Germany) and ash (Protherm PFL 110/6, Turkey) were determined according to gravimetric method, fat was determined according to Gerber method, titratable acidity (lactic acid%), pH value (SS-3 Zeromatic pHmeter, Beckman Instruments Inc., California, USA) and protein (Kjehldahl method) were determined according to AOAC [24]. Lactose levels were measured with an Atago Polax x 2L (Japan) polarimeter [25], serum separation was measured according to Farooq and Haque [26], coagulum stifness was measured with a penetrometer (Model Sur PNR 6, Sommer & Runge K.G., Berlin, Germany), and viscosity levels were measured with a Brookfield Digital Viscometer (Model DV-II+PRO, USA) [for yoghurt samples, 180 rpm, 10 °C, LV4 probe, between 20-70% Torq; for raw camel milk 180 rpm, 10 °C, LV1 probe and 4% Torq] [27] as cP.

Microbiological Analysis

The enumeration of starter cultures in yoghurt samples were performed according to International Dairy Federation standard methods [28-29]. *Lb. bulgaricus* enumeration was carried out by incubating the petri dishes in microaerophilic conditions (5% CO_2) at 37 °C for 72 hours by using De Mann Rogosa Sharpe (MRS) Agar (pH 5.4) (Merck Darmstadt, Germany). *Str. thermophilus* enumeration was conducted by incubating the petri dishes in aerobic conditions at 37 °C at 48 hours on M_{17} Agar (Merc Darmstadt, Germany). At the end of the incubation, colonies formed in petri dishes were counted as cfu/mL on the 12th hour, 1st, 5th, 7th and the 10th days of the storage.

Sensory Evaluation

The sensory evaluation of yoghurts was performed by a consumer acceptance test [30] based on the appearance, texture, flavor, aroma, and overall impression of the product using a 9-point hedonic scale (1- disliked extremely; 9- liked extremely). The sensory evaluation of the yoghurt samples was performed after the 1st and the 10th days of refrigerated storage.

Statistical Analysis

Samples were examined with 3 parallels and 2 repetitions. SPPS version 15 (IBM SPSS Statistics) statistical analysis package software was used for the statistical analyses. The significant differences based on analysis of variance (ANOVA) were tested according to the Duncan multiple comparison test at P<0.05 level.

Results

The composition of the raw camel milk (CaM) used in the study was dry matter 12.63%, fat was 3.70%, protein was 2.90%, lactose was 4.70%, ash was 2.721%, and lactic acid was 0.125%. The pH value was 6.60, density was 1.0286 g/l.

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Table 1: Proximate Composition of YSMP, YNRF and YSMP+NRF samples (n=3).

	Time Storage	Y_{SMP}	Y_{NRF}	$Y_{SMP+NRF}$
Fat (%)	12.hour	3.73±0.34 ^{Aa}	3.76±0.29 ^{Aa}	3.75±0.35 ^{Aa}
	1stday	3.73±0.28 ^{Aa}	3.76±0.20 ^{Aa}	3.75±0.33 ^{Aa}
	5 thday	3.73±0.33 ^{Aa}	3.76±0.35 ^{Aa}	3.75±0.28 ^{Aa}
	7 thday	3.72±0.29 ^{Aa}	3.74±0.39 ^{Ba}	3.75±0.36 ^{Ca}
	10 thday	3.71±0.32 ^{Aa}	3.58±0.23 ^{Ba}	3.73±0.25 ^{Ca}
Protein (%)	12. hour	3.66±0.20 ^{Aa}	3.46±0.32 ^{Ba}	3.53±0.30 ^{Ca}
	1stday	3.66±0.23 ^{Aa}	3.46±0.24 ^{Ba}	3.53±0.33 ^{Ca}
	5 thday	3.60±0.25 ^{Aa}	3.45±0.26 ^{Ba}	3.52±0.28 ^{Ca}
	7 thday	3.57±0.23 ^{Aa}	3.43±0.28 ^{Ba}	3.48±0.29 ^{Ca}
	10 thday	3.54±0.26 ^{Aa}	3.41±0.32 ^{Ba}	3.46±0.30 ^{Ca}
Lactose (%)	12. hour	6.39±0.63 ^{Aa}	4.56±0.66 ^{Ba}	5.41±0.59 ^{Ca}
	1stday	6.16±0.65 ^{Aa}	4.43±0.71 ^{Ba}	5.25±0.63 ^{Ca}
	5 thday	5.97±0.66 ^{Aa}	4.30±0.55 ^{Ba}	5.08±0.56 ^{Ca}
	7 thday	5.79±0.63 ^{Ab}	3.91±0.60 ^{Bb}	4.82±0.70 ^{Ca}
	10 thday	5.59±0.69 ^{Ab}	3.49±0.62 ^{Bb}	4.61±0.68 ^{Ca}
Ash (%)	12. hour	1.22±0.09^{Aa}	0.79±0.06 ^{Aa}	0.95±0.03 ^{Aa}
	1stday	1.38±0.08^{Aa}	0.84±0.07 ^{Aa}	1.02±0.09 ^{Ab}
	5 thday	1.67±0.09^{Ac}	0.89±0.08 ^{Ab}	1.23±0.09 ^{Ac}
	7 thday	0.86±0.07^{Ad}	0.80±0.09^{Aa}	1.23±0.08^{Ac}
	10 thday	0.81±0.08^{Ad}	0.77±0.09 ^{Ac}	1.23±0.08 ^{Ac}
Moisture	12. hour	85.46±9.07 ^{Aa}	84.98±9.07 ^{Ba}	85.17±9.07 ^{Ca}
	1stday	85.93±9.20 ^{Aa}	85.17±9.07 ^{Ba}	85.22±9.07 ^{Ca}
	5thda	87.08±8.77 ^{Aa}	85.86±9.07 ^{Ba}	86.46±9.07 ^{Ca}
	7thday	88.48±9.13 ^{Aa}	89.38±9.07 ^{Ba}	87.07±9.07 ^{Ca}
	10 th day	88.84±9.25 ^{Aa}	91.77±9.07 ^{Ba}	87.95±9.07 ^{Ca}

Proximate Composition

Proximate Composition of set type yoghurts which were produced with the fortification of CaM with 9% (w/v) SMP(Y_{SMP}), 9% (w/v) NRF(Y_{NRF}) and SMP (4.5% w/v)+NRF (4.5% w/v) ($Y_{SMP+NRF}$) are given in Table 1.

Fat values were stable in all samples until the 5th day, after which they decreased. These changes in fat values were found to be compatible with Eissa et al. [31]. In the study, the relationship between colloid type/ratios and fat values of the yoghurt samples up until the 5th day were not significant (P>0.05). However, after the 5th day, the relationship between the decrease in the dry matter due to syneresis and the decrease in fat values of Y_{NRF} was found to be significant (P<0.05). The highest decrease in protein value was determined in Y_{SMP}, followed by $Y_{SMP+NRF}$ and finally by Y_{NRF}, which showed the smallest decrease. The high level decrease in protein in Y_{NRF} was associated with the low protein content in the composition of NRF (6.79%). The high-level protein decreases in Y_{SMP} and $Y_{SMP+NRF}$ were associated with the low protein content in the composition of SMP (35.12%). Lactose levels decreased in all samples on all days of storage. The relationship between the colloid type/ratio and the decrease in lactose was found to be significant (P<0.05). The relationship between the ash value and the colloid type/ratio was found to be not significant (P>0.05).

Physicochemical properties

Physicochemical properties of set type yoghurts produced with the fortification of CaM with 9% (w/v) SMP(Y_{SMP}), 9% (w/v) NRF(Y_{NRF}) and SMP (4.5% w/v)+NRF (4.5% w/v) ($Y_{SMP+NRF}$) are given in Table 2. In yoghurt samples, pH decreased throughout the storage while titration acidity (lactic acid %) increased. This was associated with the glucose levels found in the NRF used in yoghurt production. In this study, dry matter decreased in $Y_{SMP+NRF}$ and Y_{SMP} during storage. Dry matter value of $Y_{SMP+NRF}$ was higher than that of Y_{SMP}. The relationship between colloid type/ratio and dry matter was found to be significant (P<0.05). The effect of storage period on the changes in dry matter values was found to be not significant (P>0.05).

Rheological Analysis (Consistency, serum separation, viscosity)

Coagulum stability is an important quality criterion. Many factors affect the consistency (coagulum stability=hardness), which is known as the rheological property of the coagulum, serum separation and viscosity. Among these factors, pH value, dry matter and protein content [32], denatured serum protein content, and interactions between β-lactoglobulin and k-casein are especially important [33]. In this study, the interactions between consistency values, hydrocolloid types and storage period of the samples were significant (p<0.05). Consistency (penetrometer value) values of Y_{SMP} and $Y_{SMP+NRF}$ decreased; in other words, coagulum stability (hardness) increased. The effect of storage on the consistency values was found to be significant (P<0.05). In our study, hardness increased in $Y_{SMP+NRF}$ and Y_{SMP} during storage. Hardness increased until the 5th day in Y_{NRF} (19.46%) then decreased. Hardness value of Y_{NRF} on the 10th day

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Table 2: Physicochemical properties of YSMP, YNRF and YSMP+NRF samples (n=3).

	Time Storage	Y_{SMP}	Y_{NRF}	$Y_{SMP+NRF}$
Dry matter (%)	12.clock	14.54±1.02 ^{Aa}	15.02±1.11 ^{Ba}	14.83±1.10 ^{Ca}
	1st day	14.07±1.15 ^{Aa}	14.83±1.09 ^{Ba}	14.78±1.08 ^{Ca}
	5 thday	12.92±1.07 ^{Aa}	14.14±1.07 ^{Ba}	13.54±1.07 ^{Ca}
	7 thday	11.52±1.03 ^{Aa}	10.62±1.03 ^{Ba}	12.93±1.09 ^{Ca}
	10 thday	11.16±1.05 ^{Aa}	8.23±1.05 ^{Ba}	12.05±1.10 ^{Ca}
Viscosity (cP)	12.clock	986±20.05 ^{Aa}	1221±22.07 ^{Ba}	1035±21.05 ^{Ca}
	1stday	1341±21.04 ^{Ab}	1811±25.25 ^{Bb}	1528±20.13 ^{Cb}
	5 thday	1364±21.05 ^{Ac}	2320±23.35 ^{Bc}	1724±24.15 ^{Cc}
	7 thday	1371±23.09 ^{Ad}	1295±24.15 ^{Bd}	1814±23.16 ^{Cd}
	10 thday	1410±26.11 ^{Ae}	924±23.22 ^{Be}	1833±20.02 ^{Ce}
Serum separation (%)	12.clock	10.24±0.95 ^{Aa}	9.54±0.93 ^{Ba}	9.81±0.85 ^{Ca}
	1stday	10.41±0.97 ^{Ab}	9.75±0.85 ^{Bb}	10.12±1.07 ^{Cb}
	5 thday	10.84±0.98 ^{Ac}	9.83±0.88 ^{Bc}	10.32±0.99 ^{Cc}
	7 thday	11.43±0.99 ^{Ad}	11.79±1.05 ^{Bd}	10.95±0.96 ^{Cd}
	10 thday	12.56±1.22 ^{Ae}	12.85±1.11 ^{Be}	11.16±0.97 ^{Ce}
Hardness (1/10mm)	12.clock	287.15±19.07 ^{Aa}	275.06±20.95 ^{Ba}	281.14±20.14 ^{Ca}
	1stday	273.63±20.01 ^{Ab}	243.51±21.04 ^{Bb}	263.15±23.27 ^{Cb}
	5 thday	271.54±19.84 ^{Ac}	221.51±20.07 ^{Bc}	252.23±22.29 ^{Cc}
	7 thday	265.06±19.98 ^{Ad}	258.11±20.09 ^{Bd}	241.29±19.30 ^{Cd}
	10 thday	242.56±20.02 ^{Ae}	271.61±21.02 ^{Be}	215.23±23.05 ^{Ce}
pH	12.clock	5.27±0.14 ^{Aa}	5.29±0.25 ^{Ba}	5.28±0.19 ^{Ca}
	1stday	4.84±0.10 ^{Aa}	4.85±0.14 ^{Ba}	4.92±0.23 ^{Ca}
	5 thday	4.75±0.18 ^{Aa}	4.60±0.22 ^{Ba}	4.72±0.24 ^{Ca}
	7 thday	4.45±0.20 ^{Ab}	4.54±0.24 ^{Bb}	4.40±0.21 ^{Cb}
	10 thday	4.32±0.12 ^{Ab}	4.48±0.18 ^{Bb}	4.18±0.19 ^{Cb}
Titration Acidity (LA %)	12.clock	0.67±0.03 ^{Aa}	0.63±0.04 ^{Aa}	0.65±0.06 ^{Aa}
	1stday	0.70±0.04 ^{Aa}	0.74±0.07 ^{Aa}	0.71±0.08 ^{Aa}
	5 thday	0.71±0.03 ^{Aa}	0.78±0.06 ^{Aa}	0.73±0.09 ^{Aa}
	7 thday	0.94±0.02 ^{Ab}	0.81±0.08 ^{Ba}	1.04±0.07 ^{Cb}
	10 thday	1.03±0.04^{Ab}	0.87±0.07 ^{Bb}	1.12±0.06 ^{Cb}

(271.61 1/10mm) was close to the value on the 12^{th} hour (275.06 1/10mm). In Y_{NRF}, the decrease in hardness value after the 5^{th} day was verified by the increase in serum separation after the 5^{th} day (the highest serum separation value among all samples) and the decrease in viscosity (the lowest viscosity value among all the samples). Additionally, it was found that an increase in acidity and storage time had a significant effect on the serum separation. The relationship between the viscosity and the colloid type/ratio was found to be significant ($P<0.05$). In $Y_{SMP+NRF}$ and Y_{SMP}, viscosity values increased during storage and fat loss values were the lowest. In our study, 9% (w/v) rice flour fortification (Y_{NRF}) increased the viscosity until the 5^{th} day of the storage, while 4.5% (w/v) rice flour fortification ($Y_{SMP+NRF}$) increased the viscosity throughout the entire storage period.

Microbiological Analysis

Lb. bulgaricus and *Str. thermophilus* development are given in Figure 1. *Lb. bulgaricus* increased until 5^{th} day of the storage and decreased on the 7^{th} and the 10^{th} days in all samples. *Lb. bulgaricus* counts in Y_{NRF} and $Y_{SMP+NRF}$ increased by 2 log between the 1^{st} and the 5^{th} day of the storage, after which they decreased by a total of 1 log in $Y_{SMP+NRF}$, 2 log in Y_{NRF}, with a decrease of 1 log in Y_{NRF} and maintenance 10^6 cfu/ml levels in $Y_{SMP+NRF}$ between the 7^{th} and the 10^{th} days. *Lb. bulgaricus* counts in Y_{SMP} increased 1 log between the 12^{th} hour ($5.98x10^6$ cfu/ml) and the 7^{th} day ($7.38x10^7$ cfu/ml) and decreased by 1 log on the 10^{th} day ($5.1x10^6$ cfu/ml), a decrease which was higher than that of $Y_{SMP+NRF}$ ($6.63x10^6$ cfu/ml). The increase in *Lb. bulgaricus* counts was higher in Y_{NRF} and $Y_{SMP+NRF}$ (until the 5^{th} day) than that of Y_{SMP}, and the decrease (especially 2 log between the 5^{th} and the 7^{th} days and 1 log on the 10^{th} day) was higher in Y_{NRF}. *Lb. bulgaricus* levels in $Y_{SMP+NRF}$ were high throughout the storage period.

The lowest *Str. thermophilus* counts were found at the 12^{th} hour ($6.54x10^7$ cfu/ml) and the 1^{st} day ($6.32x10^7$ cfu/ml) in Y_{SMP}. The highest *Str. thermophilus* levels on the 12^{th} hour and the 1^{st} day were detected in Y_{NRF} and $Y_{SMP+NRF}$, respectively. The decrease in samples on the 5^{th}, 7^{th} and the 10^{th} days were 1 log for each storage day. *Str. thermophilus* levels in Y_{NRF} decreased to the lowest levels in the following days. On the 5^{th} day, *Str. thermophilus* decreased to $2.33x10^6$ cfu/ml in $Y_{SMP+NRF}$, a decrease that reached to $1.31x10^6$ cfu/ml on the 7^{th} day followed by a 1 log decrease to $6.52x10^5$ cfu/ml on the 10^{th} day. On the 7^{th} and the 10^{th} days, the highest count was in $Y_{SMP+NRF}$, and the lowest was in Y_{NRF}. Between the 5^{th} and the 7^{th} days, the decrease in *Str. thermophilus* counts was the lowest in $Y_{SMP+NRF}$ and highest in Y_{NRF}.

Sensory Evaluation

In the sensory evaluation of yoghurt samples, $Y_{SMP+NRF}$ sample was more appreciated than Y_{SMP} by the end of the storage period and more appreciated than Y_{NRF} by the 5^{th} day in terms of physicochemical, rheological and sensory properties. By the 1^{st} day of the storage, $Y_{SMP+NRF}$ received 6.52 aroma, 6.48 flavor and 5.94 texture points and

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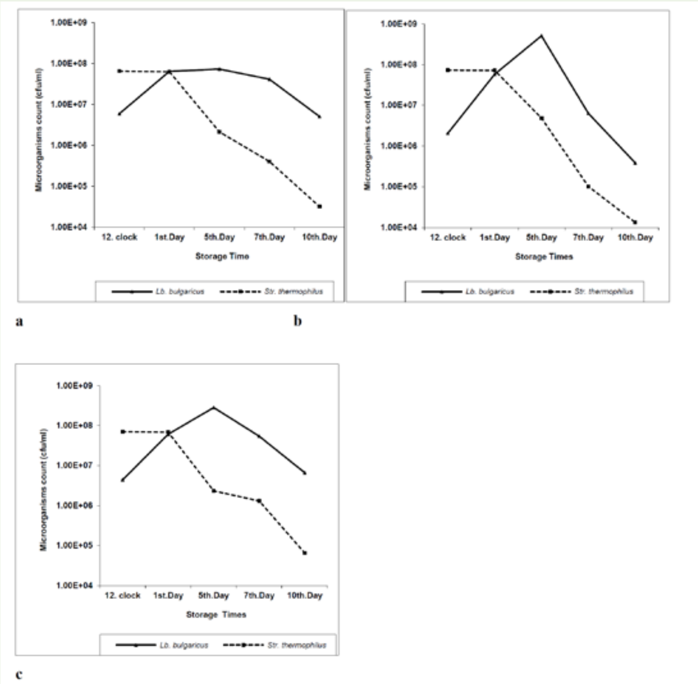

Figure 1: Lb. bulgaricus and Str. thermophilus development in YSMP (a); YNRF (b) and YSMP+NRF (c)samples (cfu/ml).

Y_{SMP} received 7.12, 6.80 and 6.20. By the 10th day of storage, $Y_{SMP+NRF}$ received 7.87 aroma, 7.38 flavor and 7.00 texture points and Y_{SMP} received 7.39, 7.15 and 6.84. By the end of the storage, $Y_{SMP+NRF}$ was found more sour than Y_{SMP}, however this sour taste was not described as a fault. This was associated with the fact that Turkish people have consumed sour yoghurt for many years.

Discussion

In some studies, it was reported that the type and ratio of colloid used in order to increase the dry matter had an effect on the development of acidity, while in other studies (alginate and gelatin), this relationship was reported to be not significant [31,32]. It has been reported that lactic acid bacteria developed better in the presence of glucose and some other sugars (sucrose, maltose) and that the increase in acidity was higher [1]. The results obtained in our study were found to be consistent with those found in the literature regarding the increase in acidity as the glucose ratio increased.

The improvements in rheological properties up until the 5th day of the storage along with the increases in dry matter and acidity, the decelerating acidity increase after the 5th day, the increase in dry matter content, the sudden increase in serum separation, and the decreases in hardness and viscosity were all considered to be related to the starch content of the rice flour. During storage at +4 °C, syneresis also occurred due to starch content [22,23]. This caused the decrease in stability of Y_{NRF} after the 5th day of the storage. Throughout the storage, acidity development, hardness and viscosity values were lower and the serum separation value was higher in Y_{SMP} than in $Y_{SMP+NRF}$. This was associated with higher levels of SMP added to the milk [2,34].

In studies on yoghurt production from cow's milk, SMP supplementation at optimum levels (3-4%) and incubation to desired pH values (for 2.5-3 hours) led to an earlier improvement of the rheological properties [2]. In this study, in Y_{SMP}, which was produced with 2-3 fold SMP supplementation, and $Y_{SMP+NRF}$, which was produced with 4.5% SMP supplementation, the desired pH levels were achieved on the 7th and the 10th days of the storage. This result is consistent with previous studies describing problems that occur due to the milk composition in the production of fermented dairy products from camel milk [16,17,19,21]. It was determined that the lower speed of pH value decrease of dairy products produced from skimmed camel milk was higher than the decreased speed observed in cow's milk by [35]. In fact, milk buffering capacity varies depending on the levels of various milk components including casein, soluble minerals, whey proteins and colloidal calcium phosphate, also on lactation, nutrition/feeding and animal health [36]. Besides, despite the delayed acidity increase, an increase was detected in viscosity. In yoghurts produced from camel milk, it was reported that the viscosity increased with longer cold storage [37]. Additionally, the increases in acidity, viscosity and hardness in all samples (until the 5th day in Y_{NRF}) were found to be related with the decrease in serum separation. The increase in viscosity in $Y_{SMP+NRF}$ was considered to be related with the interaction between SMP ratio (4.5% w/v), amylose in the starch composition (at low levels), starch (NRF) and casein (SMP and CaM). This interaction reveals the relationhip between positively charged casein (pH<4.6) and negatively charged starch molecules. Takeuchi [38] explains that this starch-protein interaction causes an electrostatic change. Additionally, it was explained that calcium [the concentration of calcium in the casein micelles of camel milk varies between 109 mg/100ml and 114 mg/100ml, levels which make it regarded as a good source of calcium [15,39] became more soluble and interacted with the negatively charged starch molecules as the pH decreased, which strengthened the gel structure [40]. In our study, syneresis was observed after the 5th day in Y_{NRF} after cold storage. As a result, serum separation increased, hardness dropped and viscosity decreased. However, the opposite situation was observed in $Y_{SMP+NRF}$, in which the rheological properties were found to be better those of the other samples throughout the storage period. This was associated with some factors related to the decrease in pH (interactions between starch-casein, starch-calcium, and casein-amylose). SMP (4.5% w/v) and NRF (4.5% w/v) ratios used in $Y_{SMP+NRF}$ were found to be more suitable for yoghurt production from camel milk. According to Salih and Hamid [8], a 7% SMP ratio used for yoghurt production from camel milk, compared to 5% SMP, improved the sensory properties related to viscosity and caused an increase in total bacterial count. The SMP ratio used in Y_{SMP} in our study (9% w/v) had an effect on dry matter, viscosity and rheological properties. However, the SMP ratio used in $Y_{SMP+NRF}$ (4.5% w/v), which also contained with starch, had a stronger effect on these properties.

During the production of fermented dairy products, especially during the incubation period, lactose is metabolized to its components glucose and galactose by the culture bacteria and the glucose is metabolized to lactic acid. The increase in bacterial counts in Y_{NRF} and $Y_{SMP+NRF}$ were likely due to the high levels of starch in the NRF. *Str. thermophilus* first metabolizes starch to maltose and glucose using α-amylase, then metabolizes maltose to glucose monomers via α-glucosidase [41]. As a result, sugar concentration in the medium increases. High levels of *Str. thermophilus* in Y_{NRF} and $Y_{SMP+NRF}$ until the 5th day of the storage is associated with the effect of *Str. thermophilus* on the hydrolysis of starch. The higher levels of *Str. thermophilus* in $Y_{SMP+NRF}$ on the 7th and the 10th days of the storage were associated with combined use of NRF and SMP. The lowest levels of *Lb. bulgaricus* and *Str. thermophiles* and slower acidification on the 7th and the 10th days of the storage of Y_{NRF} is associated with the serum separation observed in Y_{NRF} after the 5th day. With the increase in serum separation in yoghurts, the symbiotic relationship between the microorganisms is disrupted and thus pH progress decelerates or halts [2]. Consequently, the increase in sugar concentration within the milk due to the hydrolysis of starch promotes the development of yogurt bacteria on the one hand and increases the acidity on the other hand. In our study, there were relationships of glucose levels with bacterial growth and bacterial growth with an increase in acidity. Moreover, there were relationships between increase in acidity and hardness and between viscosity and serum separation. These results are consistent with other studies [1]. In previous studies, it was demonstrated that combined use of microorganisms in yoghurt production is important [42,43]. Microorganism levels (except Y_{NRF} sample after the 5th day) were also compatible with the literature [33,34]. Until the 5th day, *Str. thermophilus* levels were found to be higher than *Lb. bulgaricus* levels. This result was compatible with some studies [44], but not compatible with some others [45]. *Lb. bulgaricus* became dominant in the flora on the 5th day and on the following days. This case verifies the dominance of *Lactobacillus ssp.* in the flora of traditional fermented dairy products produced from camel milk [22,46,47]. In our study, considering the incubation period (12 hours), the lag phases of the microorganisms were determined to be long [9].

In Y_{NRF} and $Y_{SMP+NRF}$ set type yoghurts, the rice flour addition was not perceived and that the yoghurt aromas of the samples were satisfactory. In Y_{NRF} and $Y_{SMP+NRF}$ set type yoghurts, it was determined that rice flour addition had no significant effect on color. Also, colloids which were added to high levels to the milk did not cause any defects of the texture properties of the yoghurt; on the contrary, the texture was homogeneous and smooth. In the sensory analysis, Y_{NRF} and $Y_{SMP+NRF}$ set type yoghurts created a better feeling of fullness in the mouth, compared to Y_{SMP}.

Rheological properties of yoghurt coagulum vary depending on some factors. Interactions of one or more of these factors during fermentation affect the acidity. Increases in acidity led to an increase in the interaction between serum proteins and casein micelles and between casein micelles and starch molecules, and a decrease in hardness; as a result, viscosity increases. It has been reported that some problems are observed during the production of fermented dairy products from camel milk (especially depending on the composition) due to increases in acidity, which leads to unsuitable rheological properties [9,25,29,30]. However, it was reported that with a certain ratio of thickener and gelling agent concentration, the formation of a gel with appropriate rhelogical properties can be encouraged [21]. In this study, despite the long incubation period (12 hours), physicochemical (especially the increase in acidity), rheological, microbiological and sensory properties were suitable in Y_{NRF} until the 5th day and $Y_{SMP+NRF}$ and Y_{SMP} until the 10th day of the storage. In this study, unaccompanied use of rice flour in yoghurt production was not possible. However, it was concluded that it is possible to produce yoghurt from camel milk with the addition of 4.5% SMP and 4.5% NRF containing low levels of amylose (18.22%).

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Citation: Kavas N, Kavas G. Some Properties of Set Type Yoghurts Produced From Camel (*Camelus Dromedarius*) Milk Enriched With Native Rice Flour and Skim Milk Powder. Indian J Nutri. 2016;3(1): 120.