THE EFFECTS OF STARTER CULTURE LEVEL AND WARMING OF CURD ON THE PROPERTIES OF SEMI-HARD GOAT CHEESE*

YARI SERT KEÇİ PEYNİRİNİN ÖZELLİKLERİ ÜZERİNE STARTER KÜLTÜR ORANININ VE PIHTININ ISITILMASININ ETKİLERİ

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ABSTRACT : In this research, the effects of different ratios of starter culture, warming of curd and ripening period on physical, chemical and organoleptical properties of a semi-hard cheese manufactured from goat milk were investigated.

From the results, it was determined that different treatment applied to cheese affected water-soluble nitrogen, non-protein nitrogen and proteose-peptone nitrogen content of the cheeses significantly ($P < 0.05$). No differences were found in dry matter, salt, fat, protein contents, and pH and ripening degrees of the cheeses during the ripening ($P > 0.05$). Ripening degrees of the cheeses to whose curds warming process was not applied were found to be higher than those of the warmed curd cheeses. Titratable acidity values of the cheeses were affected by different ratios of starter culture and warming of curd process, and increases were found to be significant during ripening period ($P < 0.05$). During storage, changes in pH values, fat in dry matter and proteose-peptone nitrogen contents were not significant. The results of the sensory analysis showed that B cheese had the lowest scores ($P < 0.05$). It was determined that organoleptical properties of the cheeses were not significantly affected during ripening period ($P > 0.05$). It was concluded that warming of curd process negatively influenced some properties of cheeses, i. e. ripening index and organoleptic scores. The best results were obtained in C cheese by adding 1% starter culture. Using of 1 % starter culture is sufficient for manufacture of goat cheese.

Keywords: Goat cheese, starter culture

ABSTRACT: Bu çalışmada, yarı sert keçi peynirinin kimyasal, fiziksel ve duyusal özellikleri üzerine starter kültür oranı ile pıhtının ısıtılmasının ve olgunlaşma süresinin etkileri araştırılmıştır.

Bu çalışmanın sonucunda, pıhtıya uygulanan farklı ısıl işlemlerin peynirlerin suda çözünür azot, protein olmayan azotlu madde ve proteoz-pepton azotu değerlerini önemli düzeyde etkilediği belirlenmiştir ($P < 0.05$). Peynirlerin kurumadde, tuz, yağ, protein ve olgunlaşma indeksi arasında olgunlaşma süresince bir fark bulunamamıştır ($P > 0.05$). Pıhtısı ısıtılmadan üretilen peynirlerin olgunlaşma indekslerinin ısıtılanlardan daha yüksek olduğu bulunmuştur. Peynirlerin titrasyon asitliği değerlerinin farklı starter kültür oranları ile pıhtının ısıtılması işlemlerinden etkilendiği ve bu değerlerin olgunlaşma süresince arttığı bulunmuştur ($P<0.05$). Olgunlaşma süresince peynirlerin kurumadede yağ, pH ve proteoz-pepton azotu değerlerindeki değişimin önemli düzeyde olmadığı saptanmıştır ($P > 0.05$). Duyusal analiz sonuçları değerlendirildiğinde, B peynirinin en düşük puanlara sahip olduğu belirlenmiştir. Peynirlerin duyusal özelliklerinin olgunlaşma süresince önemli düzeyde değişmediği görülmüştür ($P > 0.05$). Yarı sert keçi peyniri üretiminde, pıhtının ısıtılmasının peynirlerin olgunlaşma indeksleri ve duyusal değerleri gibi bazı özellikleri üzerine olumsuz etkilerinin olduğu, en iyi sonuçlara pıhtısı ısıtılmayan ve % 1 oranında starter kültür ilave edilen C peynirinin sahip olduğu belirlenmiştir. % 1 starter kültür kullanımının yeterli olduğu sonucuna varılmıştır.

* This research was supported by the projet ZF/2002/BAP 53 from Çukurova University.

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INTRODUCTION

Goats' milk plays an important role in certain parts of the world (Mehaia 2002). The production of goat milk at a world wide level is 12 million tones, a large part of which is used for direct consumption (Morgan and Gaborit 2001). World production of goat's milk has increased in recent years, especially in the Mediterranean area, probably as a result of growing appeal derived from its high nutritional value (Lopez, Luna, Laencina and Falagan 1999; Olarte, Sanz, Gonzalez-Fandos and Torre 2000; Buffa, Guamis, Pavia and Turijillo 2001; Caponio, Gomes, Alloggio and Pasqualone 2000). In Europe, goat milk is used for cheese production. While goat cheeses are consumed as traditional products in Mediterranean countries, the demand for them is on the increase in northern Europe. This new interest could be partially explained by the unique sensorial properties of goat milk products, which are characterised by a specific and typical ("goat") flavour. This specific flavour may be undesirable in milk for direct consumption, but for cheese production its presence can be much sought after (Mehaia 2002).

The use of goat milk has increased in the past few years so much, and nowadays it is being introduced in the human diet as an alternative to cow milk (Gomes, Luz, Silva and Malcata 1998). It was determined that regularly consuming goat milk and its products cure eczema, asthma, allergy and digestion sickness (Guven and Konar 1996). The demand for goat cheese is also rising quite considerably, especially among gourmets and consumers of health and diet products (Fresno, Tornadijo, Carbollo, Bernardo and Gonzalez-Prieto 1997), due to its high nutritional value in terms of proteins and fat (Juarez and Ramos 1984). Forexample, Taurine is the most abundant free amino acid in goats' milk, where it occurs in higher amounts than in other kinds of milk. It is considered an essential nutrient for the infant receiving parenteral nutrition and has a variety of functions in the organism (Pasqualone, Caponio, Alloggio and Gomes 2000).

The majority of European populations of goats is found in Mediterranean countries, where about 86 % of total livestock are situated (Fresno et al. 1997), and the Mediterranean countries (France, Greece, Italy and Spain) were responsible for almost 95 % of this production (Franco, Prieto, Bernardo, Prieto and Carballo 2003). Almost all the goat milk produced in Italy is processed into cheese mainly by means of non-industrial technologies (Caponio et al. 2000). Turkey has a very important position in the production of goat milk and the production of goat milk is 249.000 tones per year (FAO 1999; Boyazoğlu and Morand-Fehr 2001). Most goats' cheese in Turkey is home-made whereas only few are made on an industrial scale. Goats' milk could play an important role in the economy of Turkey if it were converted into good-quality cheeses.

The effects of different ratios of starter culture, warming of curd and ripening period on physical, chemical and organoleptic properties of semi-hard cheese manufactured from goat milk were aimed to be determined.

MATERIALS and METHODS

Manufacture of experimental goat cheeses

Cheesemaking was performed in triplicate within a two week period. Raw goat milk was obtained from the animal husbandry section of Cukurova University, Adana, Turkey. Visbyvac G2 Mix A type mesophilic cheese culture (*Lactococcus lactis* subsp. *lactis* and *Lactococcus lactis* subsp. *cremoris*; Tonder, Denmark), calf rennet (Pınar, Izmir, Turkey), calcium chloride, salt (Merck, Darmstadt, Germany) and PVC for packaging were obtained commercially.

Experimental cheeses were made in the pilot plant of the Food Engineering Department, Faculty of Agriculture, Cukurova University. Raw milk was heat-treated at 68 °C for 15 min and cooled to 38±1 °C, then separated into 4 batches. Calcium chloride was added at 0.02 % to all batches. Starter culture was added at 1 % and 2 % to the first two batches (A, C cheeses) and second two batches (B and D cheeses), respectively.

Thirty minutes after the addition of starter, liquid rennet was added to coagulate the milk within 35 min at 34±1 °C and after coagulation curd was cut into about 2 cm^3 cubes. Some of the whey was drained off and the curds of two batches (A and B) including different concentrations of starter were warmed to 40 °C by adding hot water in, where as C and D were the curd without warming. The curd was placed into a plastic basket shaped molds and applied natural press by hand. The molds were turned reverse at 15, 30, 60 and 120 min after placing the curd in. The cheeses were left to rest overnight and brined (14 %) for 6 h, and removed there after. After cheeses were pre-ripened under controlled conditions for three days (14±2 °C, 85 ±2 RH), they were vacuum packaged with PVC. The cheese ripening was then completed in a ripening room at +4 °C for a 90 day period.

Sample analysis

In the raw milk, dry matter was determined by the gravimetric method according to Kaptan (1969), fat was determined by the Gerber method (IDF, 1981), and total protein was determined according to IDF (1993). pH was measured with a Beckman-type pH meter (WTW, Weilheim, Germany). Titratable acidity was done by the alkali titration method according to Turkish Standard, TS 11046 (Anon., 1993).

In the cheese samples, the amount of rennet for milk coagulation was determined according to Gönç (1984). Total nitrogen (TN), water soluble nitrogen (WSN), and nonprotein nitrogen (NPN) were determined by the micro-Kjeldahl method of Gripon, Desmadezaud, Bars and Bergere (1975). Ripening degrees were found as the proportion of water-soluble nitrogen matter to total nitrogen matter. Proteose-pepton nitrogen was calculated by subtracting the nonprotein nitrogen matter contents from the water-soluble nitrogen matter contents. Casein nitrogen was calculated according to Lenoir (1979). Acidity was determined according to AOAC (1965) and expressed as °SH. A Surberlin PHR 6 penetrometer (Berlin, Germany) was used to measure of a conical spindle, which was 95,5 g in weight (x 1/10 mm). Cheeses were analysed for moisture by the oven drying method at 102 °C (IDF 1982), salt by titration with $AgNO_3$ (Bradley, Arnold, Barbano, Semerad, Smith and Vines 1993), fat by the Van Gulik method (Kotterer and Munch 1978) and total protein by the Kjeldahl method (IDF 1993).

Organoleptic properties were evaluated after 1, 30, 60 and 90 days of ripening by five dairy academic staff members from the Food Engineering Department, Çukurova University, according to a scoring card as stated in the Turkish Standard TS 591 (Anon. 1995). Physical, chemical and sensory analyses were done on days 1, 30, 60 and 90 during ripening.

Data for each sampling stage was analysed statistically by analysis of variance. Means with a significant difference ($P < 0.05$) were compared by the least squares difference (LSD) test (Düzgüneş, Kesici, Kavuncu and Gürbüz 1987).

Results and Discussions

Table 1 shows the results obtained from the physicochemical analyses of the cheese samples during the ripening period.

In fresh cheeses, acidity was between 81.97-97.21 °SH. Titratable acidity was lower in C and D cheeses than the warmed-cheeses. The differences in acidity were found to be significant after day 30 ($P < 0.05$). The titratable acidity increased considerably during ripening period and this increase that occurred within the first 60 days was significant ($P < 0.05$). However, the slower acidification of 1 % starter cheeses could have retarded whey drainage, increasing the amount of lactose retained and finally causing a lower pH of these cheeses during most of the ripening period. Lactic acid was produced faster in the cheeses made with higher volume of starter (Fernandez-Garcia, Tomillo and Nunez 1999).

In general composition of warmed cheeses was very similar to that of non-warmed, but the protein content showed differences on day 90. No significant differences were found for dry matter, fat and salt contents of the cheeses and the change of the ripening period was found to be insignificant ($P > 0.05$). These

Table 1. Chemical and Physical Properties of Goat Cheeses During Ripening

Properties	Cheeses	Ripening Period (day) 1	30	60	90
Titratable acidity (SH)	A	85.85±2.08[a]	94.52±2.88[a]	110.56±2.36[a]	110.60±1.03[a]
	B	97.21±2.27[b]	99.90±2.40[b]	109.56±1.56[a]	108.01±1.99[ab]
	C	81.97±1.71[a]	92.43±3.13[a]	104.38±2.04[b]	105.92±2.59[b]
	D	83.27±3.55[a]	93.23±2.86[a]	105.18±2.97[b]	106.46±2.75[b]
pH	A	4.86±0.13[a]	4.74±0.23[a]	4.76±0.22[a]	4.79±0.22[a]
	B	4.76±0.15[a]	4.72±0.28[a]	4.75±0.21[a]	4.82±0.25[a]
	C	4.88±0.16[a]	4.88±0.23[a]	4.93±0.18[a]	4.95±0.23[a]
	D	4.86±0.19[a]	4.90±0.28[a]	4.91±0.27[a]	4.95±0.30[a]
Drymatter (%)	A	52.28±1.15[a]	51.35±3.63[a]	53.62±0.69[a]	53.08±1.81[a]
	B	52.84±2.98[a]	51.14±2.61[a]	53.08±3.49[a]	52.81±1.69[a]
	C	54.31±3.88[a]	51.91±5.10[a]	55.91±2.16[a]	53.65±0.38[a]
	D	52.43±0.40[a]	50.73±3.65[a]	55.29±1.38[a]	53.83±2.02[a]
Fat (%)	A	22.13±1.32[a]	21.75±1.32[a]	23.50±1.32[a]	22.00±1.32[a]
	B	22.00±1.32[a]	21.00±1.32[a]	22.50±1.32[a]	22.00±1.32[a]
	C	23.00±1.32[a]	22.50±1.32[a]	23.75±1.32[a]	21.75±1.32[a]
	D	22.00±1.32[a]	21.00±1.32[a]	23.00±1.32[a]	21.75±1.32[a]
Salt (%)	A	2.35±0.54[ab]	2.86±0.20[a]	2.34±0.54[a]	2.66±0.60[a]
	B	2.72±0.34[b]	2.79±0.09[a]	2.62±0.66[a]	2.77±0.79[a]
	C	1.96±0.40[a]	2.78±0.08[a]	2.30±0.19[a]	2.37±0.45[a]
	D	2.01±0.02[a]	2.76±0.36[a]	2.43±0.21[a]	2.47±0.53[a]
Protein (%)	A	21.89±1.87[a]	21.32±0.74[a]	25.37±0.74[a]	25.72±1.14[a]
	B	23.35±3.94[a]	20.28±1.88[a]	22.92±0.88[b]	23.94±0.96[ab]
	C	22.99±2.09[a]	21.45±1.25[a]	25.39±2.87[a]	23.00±0.56[b]
	D	23.75±0.73[a]	21.07±2.83[a]	23.74±1.21[ab]	24.16±0.85[ab]
Fat in Dry Matter (%)	A	42.38±3.45[a]	42.48±2.64[ab]	43.82±0.52[a]	41.46±1.40[a]
	B	41.92±2.95[a]	41.16±1.45[a]	40.69±1.76[b]	41.69±1.34[a]
	C	42.40±0.90[a]	44.19±1.14[b]	42.52±0.99[ab]	41.54±0.68[a]
	D	41.97±2.47[a]	41.56±2.99[a]	41.62±1.04[ab]	40.46±2.09[a]
Penetration s Value (x 1/10 mm)	A	27.00±1.41[a]	34.50±2.38[a]	33.50±0.58[a]	26.75±0.96[a]
	B	28.00±2.45[ab]	32.75±1.71[a]	32.75±1.50[a]	34.25±1.71[b]
	C	29.50±1.73[ab]	39.50±0.58[b]	37.75±2.06[b]	38.25±2.63[c]
	D	32.00±2.31[b]	39.25±0.96[b]	36.00±1.63[b]	38.00±0.82[c]

[a]Means in the same column followed by different letters are significantly different (p<0.05).

results agreed with the values found by other authors for cheeses with similar characteristics (Olarte et al. 2000, Fresno et al. 1997). The changes in fat in dry matter contents obtained at 30 and 60 days were statistically significant ($P < 0.01$).

In fresh cheeses, a slight increase in protein content of the cheeses with 2 % starter culture were observed, whereas protein content of the cheeses with 1 % starter culture showed a significant increase on day 60 ($P<0.05$). An increase in the nitrogen content was also observed, which agrees with the result published by Lopez et al. (1999). The protein contents of the cheeses decreased on day 30 whereas these contents of the cheeses increased significantly on day 60 ($P < 0.05$).

The penetrometer values (x 1/10) for the cheeses ranged between 26.75 and 39.50. It was observed that the lower the value, the harder the structure formed. It was also found in the cheeses C and D, that the structure got softer ($P < 0.05$).

Table 2 shows the mean values of different nitrogen fractions obtained from cheeses throughout the ripening period. It was determined that the curd without warming caused significant increase in water soluble nitrogen, which agrees with the results obtained by Trujillo, Buffa, Casals, Fernandez and Guamis (2002) in semi-hard goat cheese. Proteose-peptone nitrogen contents changed irregularly during the ripening period and the highest value was determined in cheese C on day 90. Non-protein nitrogen (NPN) content of the cheeses increased significantly during ripening period. The highest NPN contents were in cheese D (0.289 %), followed consecutively by cheeses C, A and B. During ripening, the nitrogen fractions of the cheeses increased and this increase was statistically significant ($P < 0.05$).

Table 2. Changes in Nitrogen Fractions of the Cheeses During Ripening

Properties	Cheese	Ripening Period (day)			
		1	30	60	90
Total Nitrogen (%)	A	3.43±0.29[a]	3.34±0.12[a]	3.97±0.11[a]	4.03±0.49[a]
	B	3.66±0.93[a]	3.02±0.29[a]	3.59±0.14[b]	3.75±0.15[ab]
	C	3.61±0.33[a]	3.49±0.33[a]	3.98±0.45[a]	3.56±0.09[b]
	D	3.72±0.12[a]	3.30±0.44[a]	3.72±0.19[ab]	3.78±0.13[ab]
Water Soluble Nitrogen (%)	A	0.100±0.01[a]	0.150±0.03[a]	0.231±0.07[a]	0.298±0.10[a]
	B	0,116±0.01[b]	0.142±0.01[b]	0.226±0.05[a]	0.272±0.04[b]
	C	0.118±0.01[b]	0.179±0.05[c]	0.303±0.10[b]	0.345±0.10[c]
	D	0.119±0.01[b]	0.174±0.06[c]	0.296±0.10[b]	0.332±0.10[c]
Non-Protein Nitrogen (%)	A	0.092±0.02[a]	0.133±0.02[a]	0.198±0.04[a]	0.247±0.07[a]
	B	0.101±0.02[b]	0.122±0.01[b]	0.201±0.03[a]	0.237±0.03[a]
	C	0.075±0.01[c]	0.143±0.04[c]	0.259±0.06[b]	0.286±0.05[b]
	D	0.078±0.01[d]	0.134±0.06[ac]	0.224±0.03[c]	0.289±0.09[b]
Proteoz-Pepton Nitrogen (%)	A	0.001±0.02[a]	0.017±0.02[a]	0.033±0.03[a]	0.051±0.04[a]
	B	0.015±0.01[b]	0.020±0.01[a]	0.025±0.02[b]	0.035±0.02[b]
	C	0.043±0.08[c]	0.036±0.01[b]	0.044±0.04[a]	0.059±0.03[c]
	D	0.041±0.01[c]	0.040±0.01[b]	0.072±0.05[c]	0.043±0.02[d]
Ripening Index (%)	A	2.92±0.43[a]	4.49±0.80[a]	5.82±1.92[a]	7.39±1.69[a]
	B	3.17±1.09[a]	4.70±0.34[a]	6.30±1.53[a]	7.25±0.84[a]
	C	3.27±0.33[a]	5.13±1.75[a]	7.61±1.60[a]	9.69±2.14[a]
	D	3.20±0.10[a]	5.27±2.42[a]	7.96±1.83[a]	8.78±2.36[a]

[a]Means in the same column followed by different letters are significantly different ($p<0.05$).

The ratio of soluble nitrogen/total nitrogen, which indicates the protein degradation of the cheese gradually, increased during the ripening period. In the first day, ripening indices of the cheeses were between 2.92-3.27 %, and increased significantly throughout the ripening. A similar observation was reported by Güven and Konar (1996) who showed that warming of curd and starter culture had highly significant effects on cheese ripening and quality. The lowest ripening indices were obtained in cheese A throughout the ripening period. Warming of curd significantly influenced ripening degree and cheeses C and D had higher ripening degree than the cheeses A and B during ripening.

The sensory properties of the cheeses are shown in Table 3. The appearance (exterior and interior) values of cheeses received very similar scores in all cheeses. On day 90, A and B cheeses had higher exterior

Table 3. Organoleptical Properties of Goat Cheeses

Properties	Cheeses	Ripening Period (day) 1	30	60	90
Appearance Exterior	A	4.10±0.57[a]	4.35±0.47[a]	4.00±0.94[a]	5.00±0.00[a]
	B	3.80±0.42[b]	4.00±1.25[a]	4.30±0.82[a]	5.00±0.00[a]
	C	4.10±0.74[a]	3.45±0.50[b]	3.35±0.67[a]	4.50±0.53[b]
	D	4.10±0.99[a]	4.10±0.57[a]	4.35±0.47[a]	4.40±0.52[b]
Appearance Interior	A	3.90±0.74[a]	4.10±0.52[a]	4.55±0.50[a]	4.30±0.82[a]
	B	3.80±0.53[a]	3.85±0.82[a]	4.45±0.50[a]	4.20±0.79[a]
	C	4.00±0.47[a]	4.35±0.75[a]	3.95±0.60[a]	4.70±0.48[a]
	D	4.10±0.74[a]	4.15±0.82[a]	4.40±0.52[a]	4.80±0.42[a]
Body and Texture	A	4.30±0.95[a]	4.40±0.70[a]	3.95±0.60[a]	3.90±0.74[a]
	B	3.90±1.34[a]	4.20±0.03[a]	4.05±0.83[a]	4.10±0.89[a]
	C	4.20±0.79[a]	4.30±0.82[a]	4.60±0.52[a]	4.60±0.52[a]
	D	4.30±0.68[a]	4.10±0.99[a]	4.60±0.52[a]	4.60±0.52[a]
Smell	A	4.30±0.82[a]	4.30±0.82[a]	4.40±0.74[a]	4.10±0.32[a]
	B	4.20±0.79[a]	4.20±0.63[a]	4.50±0.71[a]	4.10±0.57[ab]
	C	4.30±0.95[a]	4.40±0.84[a]	4.70±0.48[a]	4.90±0.32[b]
	D	4.40±0.70[a]	4.10±1.29[a]	4.80±0.00[a]	4.55±0.69[ab]
Taste	A	4.40±0.70[ac]	4.60±0.84[a]	4.05±0.69[a]	4.00±0.00[a]
	B	3.90±0.32[b]	4.15±0.85[a]	4.00±0.53[a]	3.80±0.63[a]
	C	4.75±0.64[c]	4.50±0.53[a]	4.60±0.52[ab]	4.90±0.32[b]
	D	4.70±0.68[c]	4.10±1.02[a]	5.00±0.00[b]	4.80±0.63[b]
Total Score	A	21.00±2.00[a]	21.75±2.25[a]	20.65±2.85[a]	21.30±1.25[a]
	B	19.10±1.97[b]	19.90±3.79[a]	21.30±2.28[a]	21.20±1.81[a]
	C	21.35±2.24[a]	21.00±2.93[a]	21.20±1.89[a]	23.60±1.17[a]
	D	21.60±2.32[a]	20.55±3.91[a]	23.35±1.06[a]	23.15±1.70[a]

[a]Means in the same column followed by different letters are significantly different ($p<0.05$).

appearance scores ($P < 0.05$) and lower interior appearance scores ($P > 0.05$). The highest scores of body and texture, taste and smell were obtained from the cheeses made by the curd without warming ($P < 0.05$). In addition, the results show that cheeses C and D made by the curd without warming were mostly preferred by the panellists. The highest scores for general acceptance were obtained from the cheeses C and D. Cheeses C and D also received high preference in terms of taste, smell, body and texture and interior-appearance. No flavour or texture defect was detected for all cheeses produced.

It was concluded that warming of curd process negatively influenced some properties of cheeses, i. e. ripening index and organoleptic scores. The best results were obtained in cheese by adding 1% starter culture. Using of 1 % starter culture is sufficient for manufacture of goat cheese.

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