The Changes in Goat Milk during Heating and Storage after Milking

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Abstract In this study, it was aimed to investigate the changes in goat milk after heating at different temperatures and during storage in different packaging materials. For this purpose, milks obtained from a farm producing goat milk in Bolu in Turkey were divided into two groups, the first group was pasteurized at 65°C for 30 min and the second group at 95°C for 5 min. Each group of pasteurized milk samples was again divided into two groups and filled into transparent and brown bottles. Samples were taken before and after heat treatments to reveal the effect of heating, and also on 0th, 5th and 10th days of storage period (at +4°C) to determine storage effect. The results showed that heat treatment caused increases in dry matter values of goat milk samples ($P<0.05$). On the contrast, heat treatment had no effect on the values of fat, acidity, viscosity and vitamins significantly ($P>0.05$). Heating the milk samples by High Pasteurization method resulted with significantly high values of sedimentation. Besides hydroxymethylfurfural, nonenzymatic browning compounds and L* values increased as the heating value increased. The acidity values of the samples increased during storage ($P<0.05$). The hydroxymethylfurfural and nonenzymatic browning compounds values of the Low Pasteurized and High Pasteurized milk samples were differed from each other ($P<0.05$) while the packaging materials and the storage time were had no significant effect ($P>0.05$). Also, sedimentation and L* values were affected during storage ($P<0.05$).

Keywords: goat milk, heating, storage

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1. Introduction

Goat milk has important nutritional value and economic benefits in many parts of the world due to its composition [1]. The basic composition of goat milk resembles that of cows; both milk types have high protein, ash and low lactose content. However, it is known that products made with goat milk have some properties that provide technological advantages such as a smoother texture, lower amount of α -casein, smoother gel products, higher water retention capacity and lower viscosity compared to cow milk [2]. In addition, there are also fundamental differences in the structure, composition and size of casein micelle, the proportion of individual protein fractions, the higher non-protein nitrogen and mineral compounds in goat's milk [3,4].

Microbial contamination after milking causes deterioration easily and rapidly because of rich nutrient content of the milk. The most common method applied for deactivation of microorganisms is heat treatment. [5] However, the temperature degree and time combination applied are of great importance. Otherwise, beside of health concern some undesirable changes such as loss of nutritional value, color, taste and flavor may occur [1,5,6,7].

Similarly, in the storage process, many degradation may occur due to internal effects such as protease, lipase, or from external sources like processing, storage conditions, temperature, exposure to light and contamination with metal or microorganisms [8]. While indigenous lipases and proteases of milk are inactivated by pasteurization, the enzymes released from microorganisms after contamination or during cold storage of milk can not be completely inactivated at HTST pasteurization and not even at UHT sterilization [5]. With effective packaging, it is possible to protect milk against external influences such as microbial contamination, light and oxygen, and thus undesirable flavor development and nutrient losses originating from lipid and protein oxidations can be largely avoided [9].

The studies on different heat treatment norms applied to cow and sheep milk and storage in different packaging materials have been frequently encountered in the literature. Reference [10] reported that pasteurization and boiling had no effect on the values of fat, protein, lactose, ash, non-fat dry matter and total dry matter. Review of the literature showed that the studies mostly focused on the effects of heat treatment especially on milk vitamins and the changes during storage [11-28]. In addition, there are many studies on hydroxymethylfurfural (HMF) and non-enzymatic browning compounds (NEBC) formed by heat

treatment [29,30,31]. However, the number of studies related with the effects of heating and storage on goat milk is limited.

Nowadays, there is an increasing interest in goat milk both in our country and in the world, resulting with increasing the production of goat's milk and its products. Therefore, more information is needed on production and processing of goat milk. In this study, it was aimed to reveal the changes in goat milk caused by heating at different temperatures and times, and also by the storage at +4 °C in different packing materials for ten days. The results are important for the processing of goat milk and for the future studies.

2. Materials and Methods

The goat milk used in the study was taken from a local goat (Saanen race) milk producer in Bolu in Turkey at the beginning of the lactation period (April 2017). The filtration, pasteurization, storage processes of the goat milk were carried out at the dairy technology laboratory of Department of Food Engineering, Bolu Abant İzzet Baysal University, Turkey. First, 34 L of goat milk was taken and divided into three groups. The first 15 L portion of the milk was pasteurized at 65 ± 2 °C for 30 minutes (LP) and the second 15 L portion was pasteurized at 95 ± 1 °C for 5 minutes (HT). The remaining 4 L of milk was not pasteurized and used for the analyses of raw milk. Each pasteurized goat milk group was then filled into transparent and amber colored glass bottles, intending whether or not the light expose during daily and routine process have any effect on milk properties. All milk bottles were placed in a refrigerator at +4 °C and stored for ten days. Production was repeated twice. Physical, chemical and biochemical analyses were carried out by taking samples from the milk after heat treatments and on days 0, 5 and 10 of storage time.

2.1. Chemical, Biochemical and Color Analysis

In goat milk samples, dry matter, fat, protein and acidity values were determined by the methods of Metin [32].

Color values of goat milk samples were determined using Hunter Lab chroma meter (Hunter, LabColorFlex A60, USA); The viscosity values were measured with a viscometer (AND vibro viscometer SV-10, Japan) (+ 4°C). Sedimentation values of milk samples were determined according to Katsiari et al. [33].

Hydroxymethylfurfural content (HMF) of the milk samples was found by the method of Keeney and Bassette (1958). Nonenzymatic brown colored compounds (NEBC) were determined as described by Guingamp et al. [34].

2.1.1. Determination of Vitamin E

About 1 g of homogenized sample was weighed in a plastic tube with a lid. 200 µl of methanolic pyrocatechol (0.2 g/ml) and 5 ml 1 M KOH were added to the sample. The mixture was vortexed for 20 s, saponified for 10 min in the presence of ultrasound and vortexed again for 20 seconds. Then 5 ml of hexane and 1 ml of distilled water were added to the mixture and it was again vortexed for 1

minute. Subsequently 3 ml from the upper hexane layer were taken and evaporated until dry, using a Büchi rotovapor R-215 rotary evaporator (Büchi Labortechnik GmbH, Essen, Germany). The residue was dissolved in 0.5 ml of methanol and an aliquot was transferred through a nylon filter into 1 ml Eppendorf tube, which was placed in the freezer (-20°C) for 30 minutes. The sample was centrifuged for 2 min (Eppendorf mini spin plus microcentrifuge, by 14.4 rpm) and drained off into a dark vial. The analysis was carried out using an Ultimate 3000 High Performance Liquid Chromatograph (Thermo Fisher Scientific, Dionex, Sunnyvale, USA) with a quaternary pump, refrigerated autosampler, column heater and FLD and DAD detectors. Tocols and tocopherols in the sample were determined by HPLC-FLD under the following conditions: analytical column Develosil 5 µm RP AQUEOUS (250 × 4.6 mm) (Phenomenex, Torrance, USA); precolumn Develosil 5 µm C30 UG-100A (10 × 4 mm) (Phenomenex, Torrance, USA); mobile phase methanol: deionised water (93:3, v/v), HPLC super gradient methanol (Lach-Ner, Neratovice, Czech Republic) and Milli-Q water, isocratic elution; flow rate 1 ml/min; injection 10 µl, column temperature 30 °C; detection FLD (excitation 292 nm, emission 330 nm). Retinol was determined under the same chromatographic conditions using DAD detector ($\lambda = 325$ nm). The detection limits for tocopherol (T), expressed as a ratio of three times the value of the signal-to-noise ratio. All results were expressed in mg/L of milk as the mean value of three replications [35]. All procedures were done at the research centre of YENIGIDAM at Bolu Abant İzzet Baysal University.

2.1.2. Determination of Vitamin B₁ and B₂

The analyses of these vitamins were also done at the research center of YENIGIDAM of Bolu Abant İzzet Baysal University, according to the method given by Albala-Hurtado et al. [36]. For the analysis, 10.5 g of sample were accurately weighed into a 50 ml centrifuge tube (30 mm diameter). Then, 1 g TCA solid and a magnetic stirring bar were added. The mixture was thoroughly shaken for 10 min over a magnetic stirring plate and centrifuged at 1250xg to separate the two phases for 10 min. After, 3 ml 4 % TCA were added to the solid residue, it was mixed thoroughly for 10 min, and centrifuged. Then, solid-phase was discarded. The two acid extracts were combined in a 10 ml volumetric flask and the volume was filled with 4 % TCA. Samples were always protected from light by covering tubes and flasks with aluminum foil and working under subdued lighting conditions. The HPLC system (Hewlett-Packard, CA, USA) consisted of an HP 1050 system controller pump, an HP 1050 Series degassing device, an HP 1100 autosampler with 20 µL fixed loop injector, and an HP 1050 Series UV detector. Data collection was accomplished by a Chemstation system HP 3365-11. Stock solutions: 100 mg/l of riboflavin in 2.4% (v/v) aqueous acetic acid; 1000 mg/l of nicotinamide, pyridoxal, pyridoxine, pyridoxamine, thiamine, and cyanocobalamin in 2.4% (v/v) aqueous acetic acid. Intermediate solutions: 10 mg/l of riboflavin in aqueous acetic acid, and 50 mg/l of the rest of vitamins in aqueous acetic acid. Working solutions: 0.05, 0.1, 0.5, 0.8, 1, 1.5, 2, 3 and 5 mg/l for the analytes, all of them in 2.4% aqueous acetic acid. All standard solutions were

filtered through a 0.45 µm membrane (Millipore), protected from light, and stored at 4 °C. The mobile phase contained 5 mM octanesulfonic acid, 0.5% triethylamine, 2.4% glacial acetic acid, and 15% of methanol. The separation was performed on a Tracer Spherisorb ODS 2 C18 column 250X4.6 mm, 5 Ixm (Teknokroma, Barcelona, Spain), with a matching guard cartridge. Analyses were carried out isocratically at room temperature at a flow-rate of 1 ml/min.

2.2. Statistical Analysis

Variance analysis and the "Tukey Multiple Comparison" test was used to determine the differences between the groups. Minitab (version 16.0) package program was used for performing statistical analysis.

3. Results and Discussion

3.1. The Effect of Heating on Some Characteristics of Goat's Milk

Table 1 shows the physical, chemical and biochemical properties of raw and the heat-treated goat milk samples. According to the Table, the value of dry matter was found to be slightly higher in heat-treated milk samples ($P<0.05$). The reason for this might be due to water loss during the heating process of the milk.

On the other hand, there was no change in protein and fat values in raw and heat-treated milk samples ($P>0.05$). Similar results were reported by Khan et al. [10].

Due to the effect of heating, the acidity of goat milk samples were changed slightly, but not significant ($P>0.05$). As a result of heating the milk, additional acidity principally formic and acetic acid may develop.

The amount of sedimentation in goat milk samples was higher in HP samples ($P<0.05$). This result may be due to destabilization of casein particles [37,38]. Similar results were reportant by Yaman and Coşkun [38].

As seen from Table 1, the viscosity values of the heat-treated samples were found lower (the lowest in HP

samples) than those of raw milk, but this was statistically insignificant ($P>0.05$). The viscosity value of the raw goat milk was measured to be 2.49 mPa.s by El-Hatmi et al. [39] while Yaman and Coşkun [38] found viscosity value as 2.77 mPa.s for pasteurized goat milk samples. It could be said that as the heating degree increases, the collection of caseins and the formation of aggregates may cause a decrease in the viscosity values of the samples. In addition, the viscosity value may be affected by differences in the milk components such as protein and fat due to factors such as animal feeding, lactation period, etc. [40].

The L^* (lightness-darkness) value of the samples increased as the increase in degree of heating, and the increase was significant ($P<0.05$) in the HP samples compared to the raw milk samples. On the other hand, the a^* values (green-red) of the LP and HP samples were lower than that of raw milk samples ($P<0.05$). Similarly, b^* values of the heated milk samples were lower, but insignificant ($P>0.05$). The L^* , a^* , b^* values obtained are lower than the results of Yaman and Coşkun [38], and similar to those given by Güler and Park [41]; may be due to the feeding of the animal, the composition of the milk, or the different heating parameters applied. It is known that vitamin A (L value), β carotene (b value) and their conversion rate to each other in the composition of the milk directly affect the color of the milk, and also the heat treatment applied to the milk increases the caramelization and browning reactions as the heating intensity increases, resulting with browning in the milk color [40]. In addition, the degradation of vitamin A giving white color of the milk may increase darkness slightly in color of milk [42].

As it can be monitored from Table 1, hydroxy methyl furfural (HMF) values increased as increase in heating temperature and time. When compared to the raw goat milk samples, the LP and HP samples had higher HMF values ($P<0.05$). Similar results were also found by Schamberger and Labuza [31] and Güneşer et al. [29]. The values of non-enzymatic browning compounds (NEBC) were found higher in LP and HP samples than those of raw milk samples, but only HP value was significantly different from R samples ($P<0.05$). Results obtained in our study are similar to those obtained by Guingamp et al. [34].

Table 1. The Effect of Heating on Some Chemical, Physical and Biochemical Properties of Goat Milk Samples ($\bar{x}\pm SD$, $n=2$)

Properties	R	LP	HP
Dry matter (%)	12.11 $\pm$ 0.024 ^{b*}	12.28 $\pm$ 0.011 ^a	12.24 $\pm$ 0.027 ^a
Protein (%)	3.11 $\pm$ 0.170 ^a	3.29 $\pm$ 0.071 ^a	3.15 $\pm$ 0.099 ^a
Fat (%)	3.80 $\pm$ 0.000 ^a	3.75 $\pm$ 0.071 ^a	3.75 $\pm$ 0.071 ^a
Acidity (Lactic Acid, %)	0.14 $\pm$ 0.001 ^a	0.13 $\pm$ 0.004 ^a	0.13 $\pm$ 0.001 ^a
Sedimentation (g dry weight/40 mL)	0.043 $\pm$ 0.001 ^{ab}	0.042 $\pm$ 0.000 ^b	0.050 $\pm$ 0.003 ^a
Viscosity (mPa.s)	2.67 $\pm$ 0.099 ^a	2.52 $\pm$ 0.141 ^a	2.49 $\pm$ 0.099 ^a
Color (L^* , a^* , b^* respectively)	81.323 $\pm$ 0.304 ^b	82.055 $\pm$ 0.226 ^{ab}	82.858 $\pm$ 0.219 ^a
	-2.958 $\pm$ 0.032 ^a	-3.415 $\pm$ 0.079 ^b	-3.318 $\pm$ 0.034 ^b
	5.983 $\pm$ 0.465 ^a	5.964 $\pm$ 0.459 ^a	5.930 $\pm$ 0.485 ^a
HMF (µmol/L)	0.026 $\pm$ 0.004 ^a	0.030 $\pm$ 0.004 ^b	0.052 $\pm$ 0.003 ^b
NEBC (A_{340})	0.095 $\pm$ 0.020 ^b	0.110 $\pm$ 0.017 ^{ab}	0.175 $\pm$ 0.010 ^a
α -tocopherolequivalent (TE) (mg/L)	0.30 $\pm$ 0.028 ^a	0.32 $\pm$ 0.035 ^a	0.32 $\pm$ 0.028 ^a
Vitamin B ₁ (mg/L)	1.76 $\pm$ 0.007 ^a	1.74 $\pm$ 1.230 ^a	1.74 $\pm$ 1.230 ^a
Vitamin B ₂ (mg/L)	0.99 $\pm$ 0.000 ^a	1.17 $\pm$ 0.010 ^a	1.07 $\pm$ 0.085 ^a

R: Raw milk, LP: pasteurized milk at 65°C for 30 minutes, HP: pasteurized milk at 95 °C for 5 minutes, n: number of samples analyzed, SD: standard deviation, HMF: hydroxy methyl furfural, NEBC: nonenzymatic browning compound, L^* : lightness (0= black, 100= white); a^* : green (-) or red (+); b^* : blue (-) or yellow (+), *: the means in each row carrying different letters statistically differ from each other ($P<0.05$), all others not ($P>0.05$).

The α -tocopherol equivalent (TE) values of raw and heat treated goat milk samples are presented in Table 1. Although the values of TE were obtained slightly higher in heated milks, they were statistically insignificant ($P > 0.05$). It can be said that Vitamin E was not affected by heating [5]. The values obtained are similar to the value 0.31 mg/kg in May and higher than the value 0.19 mg/kg in April in Saanen goat milks, as reported by Michlová et al [22].

The values of Vitamin B₁ of the samples are shown in Table 1. Heated samples LP and HP had lower amount of vitamin B₁ than R samples; however, this was not statistically different ($P > 0.05$), which is normally affected by heating the milk [5]. The values obtained are close to the highest Vitamin B₁ value for goat milk given by Muehlhoff et al. [43].

Vitamin B₂ values of the raw and heated goat milk samples were 0.99, 1.17 (LP) and 1.07 (HP) mg/L, respectively (Table 1). Vitamin B₂ values in heated samples are higher than those of raw samples, but statistically insignificant ($P > 0.05$). The values obtained were among the values reported by Muehlhoff et al [43] for goat milk (0.4-1.8 mg/kg).

3.2. Chemical Changes During Storage

The changes in dry matter, protein, fat, acidity values of the milk samples heated at different temperatures and stored at +4°C for 10 days in different bottles are shown in Table 2. As seen from the table, different heating norms, packaging materials and storage time had no effect ($P > 0.05$) on dry matter values, except on 5th day of storage when dry matter was found higher. Li and Wu [44] found similar results in a study of pasteurized cow milk. Fonseca et al. [45] found no significant change in dry matter of raw milk on the 1st, 3rd and 5th days of storage (at 4 °C).

The Packaging materials and storage time had no effect on protein values of the goat milk samples ($P > 0.05$). However, heating at different temperatures affected ($P < 0.05$) the protein values and lower value was obtained from HP samples, probably because of protein loss [46]. The values obtained are similar to those found by Fonseca et al [45] and Li and Wu [44].

Acidity values of goat milk samples pasteurized at different degrees of temperatures and stored in different packaging materials increased throughout storage. Statistical analyzes showed that the effects of heating methods LP and HP and storing in different packages

of the goat milk samples was insignificant ($P > 0.05$) (Table 2). However, the effect of storage on acidity was significant ($P < 0.05$) on the 10th day, resulting with increase. The increase in acidity might be associated with the increase in microbial growth over time, also the number of microorganisms destroyed by LP method is expected to be less than that of HP method. Similar results were found by Gürsel and Bozbay [47].

3.3. Biochemical Changes During Storage

The effects of the heating, packaging and storage time on hydroxymethylfurfural (HMF), non-enzymatic browning compounds (NEBC), and vitamins E, B₁ and B₂ values of the samples are shown in Table 3. As seen from the table, HMF values of HP samples were higher than those of LP samples, meaning that as heating temperature arises HMF values increased ($P < 0.05$). In addition, HMF values increased during storage time and higher value was obtained on day 10th, but insignificant ($P > 0.05$). Packaging materials had no effect on HMF values of the samples ($P > 0.05$). Schamberger and Labuza [31] reported similar results.

Similarly, the NEBC values was affected by heating method and higher values were obtained from HP samples (pasteurized milk at 65°C for 30 min) ($P < 0.05$). Also, NEBC values increased during storage time and highest value was obtained on day 10th, however, difference was not significant ($P > 0.05$). On the other hand, the NEBC values of goat milk samples were not affected by packaging materials ($P > 0.05$). Güneşer et al. [29] reported similar results on browning compounds during storage.

The values of vitamin E as α -TE did not affected by heating methods (LP and HP) and packaging materials ($P > 0.05$). Also there is no change during 0th and 5th of the storage time ($P > 0.05$), however, the value was higher on day 10th ($P < 0.05$). Vidal-Valverde et al. [48] reported that UHT studies on cow milk showed significant reductions in 4-8 months of storage while no change in the amount of vitamin E detected during shorter storage periods of two months.

The differences between heating methods, packaging materials and storage time had no effect on the values of both vitamins B₁ and B₂. However, less amount of vitamin B₂ (1.11 mg/L) was found from HP samples. Heating at high temperatures might cause loss in amount of vitamin B₂, but it was statistically insignificant ($P > 0.05$). The similar results were obtained by Scott et al. [25].

Table 2. The Changes in Chemical Properties of Goat Milk Samples During Storage ($\bar{x} \pm \text{SD}$, n=2)

Factors	Chemical properties (%)			
	Dry Matter	Protein	Fat	Acidity
Heating (n=12)				
HP	12.25 $\pm$ 0.069 ^a	3.16 $\pm$ 0.055 ^b	3.76 $\pm$ 0.052 ^a	0.136 $\pm$ 0.004 ^a
LP	12.28 $\pm$ 0.058 ^a	3.30 $\pm$ 0.059 ^a	3.80 $\pm$ 0.074 ^a	0.142 $\pm$ 0.018 ^a
Packaging (Glass) (n=12)				
Colored	12.28 $\pm$ 0.053 ^a	3.22 $\pm$ 0.087 ^a	3.78 $\pm$ 0.072 ^a	0.136 $\pm$ 0.005 ^a
Transparent	12.26 $\pm$ 0.075 ^a	3.23 $\pm$ 0.099 ^a	3.78 $\pm$ 0.062 ^a	0.142 $\pm$ 0.017 ^a
Storage Time (Day) (n=8)				
0	12.26 $\pm$ 0.029 ^{ab}	3.22 $\pm$ 0.099 ^a	3.75 $\pm$ 0.054 ^a	0.131 $\pm$ 0.003 ^b
5	12.31 $\pm$ 0.038 ^a	3.24 $\pm$ 0.099 ^a	3.80 $\pm$ 0.093 ^a	0.136 $\pm$ 0.002 ^b
10	12.23 $\pm$ 0.083 ^b	3.22 $\pm$ 0.086 ^a	3.79 $\pm$ 0.035 ^a	0.150 $\pm$ 0.018 ^a

LP: pasteurized milk at 65 °C for 30 minutes, HP: pasteurized milk at 95 °C for 5 minutes, n = number of samples analyzed, SD: standard deviation, *: Means of each factor on one column carrying different letters are statistically different from each other ($P < 0.05$), all others not.

Table 3. The Changes in Biochemical Properties of Goat Milk Samples During Storage ($\bar{x}\pm$ SD, n=2)

Biochemical Properties	Biochemical Properties					
	HMF (μ mol/L)	NEBC (A ₃₄₀)	Vit-E (mg/L)	Vit-B ₁ (mg/L)	Vit-B ₂ (mg/L)	Phosphatase test
Heating (n=12)						
HP	0.056 $\pm$ 0.006 ^{a*}	0.180 $\pm$ 0.007 ^a	0.34 $\pm$ 0.0370 ^a	1.74 $\pm$ 0.010 ^a	1.11 $\pm$ 0.065 ^a	-
LP	0.033 $\pm$ 0.004 ^b	0.121 $\pm$ 0.015 ^b	0.33 $\pm$ 0.0397 ^a	1.75 $\pm$ 0.007 ^a	1.15 $\pm$ 0.060 ^a	-
Packaging (Glass) (n=12)						
Colored	0.045 $\pm$ 0.012 ^a	0.152 $\pm$ 0.032 ^a	0.34 $\pm$ 0.0398 ^a	1.74 $\pm$ 0.010 ^a	1.14 $\pm$ 0.062 ^a	-
Transparent	0.045 $\pm$ 0.013 ^a	0.150 $\pm$ 0.034 ^a	0.34 $\pm$ 0.0384 ^a	1.75 $\pm$ 0.007 ^a	1.12 $\pm$ 0.071 ^a	-
Storage Time (Day) (n=8)						
0	0.041 $\pm$ 0.012 ^a	0.142 $\pm$ 0.036 ^a	0.32 $\pm$ 0.024 ^b	1.74 $\pm$ 0.000 ^a	1.12 $\pm$ 0.088 ^a	-
5	0.044 $\pm$ 0.012 ^a	0.154 $\pm$ 0.032 ^a	0.33 $\pm$ 0.027 ^b	1.75 $\pm$ 0.012 ^a	1.13 $\pm$ 0.054 ^a	-
10	0.050 $\pm$ 0.014 ^a	0.155 $\pm$ 0.031 ^a	0.37 $\pm$ 0.039 ^a	1.75 $\pm$ 0.005 ^a	1.14 $\pm$ 0.058 ^a	-

LP: pasteurized milk at 65 °C for 30 minutes, HP: pasteurized milk at 95 °C for 5 minutes, n = number of samples analyzed, SD: standard deviation, HMF: hydroxy methyl furfural, NEBC: nonenzymatic browning compound, *: Means of each factor on one column carrying different letters are statistically different from each other (P<0.05), all others not, -: negative reaction.

Figure 1. Color Change of Alkaline Phosphatase Enzyme Reaction (Left Tube from Raw Milk and The Right Two Tubes from Heated Milks)

Alkaline phosphatase test was performed on raw and all heated milk samples and the color changes of alkaline phosphatase enzyme activity of goat milk samples are shown in Figure 1. In the Figure, the left tube shows the reaction color with raw milk and the right two tubes show the reaction color of heated samples. During storage all samples gave negative reaction for alkaline phosphatase test (see Table 3). It is known that alkaline phosphatase enzyme is only a control test to determine the adequacy of

heat treatment and for this reason negative reaction was expected during storage.

3.4. Physical Changes During Storage

Table 4 shows the results of statistical analysis of data of the physical properties of the goat milk samples.

According to the results, there were significant differences between sedimentation values obtained from LP and HP milks, and also storage time (P<0.05). Higher amounts of sedimentation values were obtained from HP samples and on day 10th of storage time, meaning that higher temperature and prolonged storage time resulted with higher amount of sedimentation. However, using different packaging materials had no effect on the values of sedimentation (P>0.05). Storing the milk in the refrigerator causes a decrease in the amount of soluble calcium over time, resulting in the formation of residue of protein destabilization [38]. The results obtained are in agreement with those found by Ramsey and Swartzel [49] and Yaman and Coşkun [38] while they differ from the results of Wilson et al. [50].

Table 4. The Changes in Physical Properties of Goat Milk Samples During Storage ($\bar{x}\pm$ SD, n=2)

Factors	Physical Properties (%)				
	Sedi-mentation	Viscosity	Color Values		
			L*	a*	b*
Heating (n=12)					
HP	0.055±0.007 ^{a*}	3.74±0.960 ^a	82.460±0.374 ^a	-3.214±0.113 ^a	5.603±0.403 ^a
LP	0.045±0.004 ^b	3.41±0.766 ^a	81.751±0.322 ^b	-3.240±0.145 ^a	5.835±0.396 ^a
Packaging (Glass) (n=12)					
Colored	0.050±0.008 ^a	3.59±0.890 ^a	82.153±0.506 ^a	-3.192±0.146 ^a	5.708±0.342 ^a
Transparent	0.050±0.006 ^a	3.56±0.880 ^a	82.058±0.506 ^a	-3.261±0.102 ^a	5.730±0.481 ^a
Storage Time (Day) (n=8)					
0	0.046±0.004 ^b	2.50±0.094 ^c	82.457±0.461 ^a	-3.366±0.069 ^b	5.947±0.357 ^a
5	0.047±0.006 ^{ab}	3.78±0.367 ^b	81.997±0.440 ^{ab}	-3.178±0.090 ^a	5.484±0.285 ^a
10	0.056±0.008 ^a	4.43±0.358 ^a	81.863±0.430 ^b	-3.136±0.078 ^a	5.726±0.465 ^a

LP: pasteurized milk at 65 °C for 30 minutes, HP: pasteurized milk at 95°C for 5 minutes, n: number of samples analyzed, SD: standard deviation, L*: lightness (0= black, 100= white); a: green (-) or red (+); b: blue (-) or yellow (+), *: Means of each factor on one column carrying different letters are statistically different from each other (P<0.05), all others not.

Table 4 also shows that the viscosity values of goat milk samples were affected by different methods of heat treatments during storage and higher value was obtained from the samples of HP, however, difference was not significant ($P>0.05$). Packaging the milks in colored and transparent glasses had no effect on viscosity values ($P>0.05$). On the contrast, as storage time was prolonged, viscosity values increased dramatically and reached the highest value on day 10th ($P<0.05$). This result is attributed to the thixotropy of the product as the water partially evaporates during heating and gel formation occurs during cooling and storage. The thixotropy of the whey protein solution is characterized by the fragmentation of disulfide and Van der Waals bonds, and ionic and hydrophobic interactions between protein particles [2]. It is also thought that with the increase in acidity, the clot formed by casein micelles may increase due to the water binding capacity. Yaman and Coşkun [38] observed that the viscosity values of frozen goat milk increased during storage.

The changes in color values of goat milk samples heat-treated at different temperatures, packaged in different containers and stored in a refrigerator at +4 °C for ten days are shown in Table 5. As in can be understand from the table, HP milk samples had higher L* (lightness) value than LP samples ($P<0.05$). In addition, The L* values of the samples tend to decrease during storage and lower value was obtained from day 10th ($P<0.05$). The packaging materials did not change the L* values of the samples ($P>0.05$). In terms of a* (green-red) values, they were not affected by ether heat treatments nor packaging materials ($P>0.05$), however, storage time lowered the a* values ($P<0.05$). The values of b* (blue-yellow) did not change significantly by heating with different methods, packaging materials and storage time ($P>0.05$). The change in the L* value of the samples may be due to changes in the fat and protein structure during storage [50,51]. Also, degradation of vitamin A can cause a decrease in L* value, while degradation of β -carotene can cause a decrease in b* value. The results obtained are similar to those of reported by Popov-Raljić et al. [42] and Akbulut Pınar [52].

4. Conclusion

In this study, the changes in some characteristics of goat milk samples heated at different temperatures and stored at +4 °C for ten days in transparent and colored bottles were investigated. According to the results obtained; the heating affected the values of dry matter, sedimentation, L*, a*, HMF and NEBC of the goat milk samples ($P<0.05$) when compared with those of raw goat milk samples. In addition, storing the milk samples in colored and transparent bottles did not create any changes on the characteristics analyzed. Heating at different temperatures affected ($P<0.05$) the protein values and lower value was obtained from HP samples during storage. Acidity values of goat milk samples increased throughout storage ($P<0.05$). HMF and NEBC values of HP samples were higher than those of LP samples ($P<0.05$), also, higher HMF and NEBC value was obtained on day 10th of the storage. The different heating methods, packaging

materials and storage time had no effect on the values of vitamins E, B1, B2. However, less amount of vitamin B2 (1.11 mg/L) was found from HP samples. During storage all samples gave negative reaction for alkaline phosphatase test. Higher heating temperature (HP) and storage time resulted with higher amount of sedimentation ($P<0.05$). As storage time was prolonged, viscosity values increased dramatically and reached the highest value on day 10th ($P<0.05$). HP milk samples had higher L* (lightness) values than LP samples ($P<0.05$). In addition, The L* values of the samples tend to decrease during storage. Storage time lowered a* values significantly ($P<0.05$).

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