OKU Fen Bilimleri Enstitüsü Dergisi
7(3): 1136-1152, 2024

OKU Journal of The Institute of Science and Technology, 7(3): 1136-1152, 2024

Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi

Osmaniye Korkut Ata University Journal of The Institute of Science and Technology

Effect of Microencapsulated Goat Clarified Butter on Free Fatty Acids and Physicochemical Properties in Cow Butter Production

Aslı ALBAYRAK KARAOĞLU[1*]

[1]Burdur Mehmet Akif Ersoy University Dairy Products and Technologies Application and Research Center, 15200, Burdur.

[1]https://orcid.org/0000-0002-1636-148X
*Corresponding author: aalbayrak@mehmetakif.edu.tr

Research Article

Article History:
Received: 19.10.2023
Accepted: 21.01.2024
Published online:25.06.2024

Keywords:
Goat butter
Cow butter
Butter microencapsulation
Free fatty acids

ABSTRACT

In the study, goat clarified butter was encapsulated using a concentric nozzle and the microencapsulation process. The cow creams were mixed with encapsulated goat clarified butter in various quantities and left for a week. The study looked at the physical and chemical qualities, as well as the levels of free fatty acids and α-tocopherol, of cow butters that had different amounts of goat ghee microcapsules added to them. % Lactic acid, acid value, Polenske number and α-tocopherol of cow butter all went up significantly, when encapsulated goat butter was added *($p<0,05$).* There was no change in the amount of peroxide, the percentage of fat and the percentage of water. TBA value decreased inversely as α-tocopherol level increased. Butters had been found to contain 18 free fatty acids. The highest concentrations of palmitic and myristic fatty acids were discovered. Goat butter contains a high concentration of oleic, caprylic, capric, and palmitic fatty acids. The amount of short and medium chain fatty acids has been discovered to be higher.

Tereyağ Üretiminde Mikroenkapsüle Keçi Tereyağı Kullanılmasının Serbest Yağ Asitleri ve Fizikokimyasal Özellikler Üzerindeki Etkisi

Araştırma Makalesi

Makale Tarihçesi:
Geliş tarihi: 19.10.2023
Kabul tarihi:21.01.2024
Online Yayınlanma: 25.06.2024

Anahtar Kelimeler:
Keçi tereyağı
İnek tereyağı
Tereyağı mikroenkapsülasyonu
Serbest yağ asitleri

ÖZ

Araştırmada keçi kremasından elde edilen sadeyağlar konsantrik nozelle kullanılarak mikroenkapsülasyon tekniği ile kapsüllenmiştir. Konsantrik nozzel kullanarak keçi sadeyağının mikroenkapsülasyonu yapılmıştır. İnek kremalarına farklı oranlarda kapsüllenmiş keçi sadeyağı ilave edilmiş, bir hafta bekletilmiştir. Çalışmada farklı oranlarda kapsüllenmiş keçi sadeyağı ilave edilmiş inek tereyağlarının fizikokimyasal özellikleri, serbest yağ asitleri ve α-tokoferol düzeyleri karşılaştırılmıştır. Kapsüllenmiş keçi sadeyağı ilave edilmesi ile inek tereyağlarının %laktik asit, asit değeri, Polenkse sayısı ve α-tokoferol önemli düzeyde artmıştır *($p<0,05$).* Peroksit miktarı, % yağ içeriği ve % su içeriğinde herhangi bir değişiklik olmamıştır. α-tokoferol düzeyinin artmasıyla ters orantılı olarak TBA değeri düşmüştür. Tereyağlarında 18 adet serbest yağ asidi tespit edilmiştir. Palmitik ve miristik yağ asitleri en yüksek düzeyde bulunmuştur. Keçi tereyağında oleik, kaprilik, kaprik ve palmitik yağ asidi düzeylerinin fazla olduğu görülmüştür. Kısa ve orta zincirli yağ asitleri miktarının daha fazla olduğu tespit edilmiştir.

To Cite: Karaoğlu AA. Effect of Microencapsulated Goat Clarified Butter on Free Fatty Acids and Physicochemical Properties in Cow Butter Production. Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi 2024; 7(3): 1136-1152.

1. Introduction

Butter is a dairy product that contains at least 82% milk fat and is made from milk, cream, and yoghurt (IDF, 2008). Milk cream is commonly used in the production of industrial butter. It is used to describe butter made from yoghurt using traditional methods, as there is no industrial production in our country. It is also possible to make it from goat, sheep, or buffalo milk. It has a pleasant and distinct flavor and aroma. It is easily digestible, soluble at body temperature, and contains essential fatty acids, vitamin A, and/or β-carotene. It is an important source of energy; short-chain fatty acids provide energy quickly and play an important role in human nutrition. TUIK (2022) figures show that 95655 kg of butter was produced. Seasonal fluctuations are known to impact the composition of milk. The scenario is found to effect the alteration in the monthly production amount of butter. The amount of butter produced falls during the summer months due to a drop in milk fat. The volume of butter produced in 2022 increased by 12,8% when compared to 2021.

The fat globules are small size in goat milk. It contains more vitamin A than other milks. Goat's milk butter is whiter because it contains less of the pigment carotenoids. Goat milk fat is composed of short-chain fatty acids like caproic, caprylic, and capric largely. These fatty acids give goat butter its characteristic aroma, flavor, and texture. (Barlowska et al., 2001; Poutzalis et al., 2016).

Albayrak Karaoğlu (2023) discovered that, semi-hard goat milk cheese is whiter than cow cheese. It was discovered that goat cheeses have higher levels of formic, succinic, and tartaric acid.

Previous research has shown that caprylic, capric, and short-chain fatty acids have therapeutic potential in managing several clinical conditions, including epilepsy, cystic fibrosis, coronary bypass surgery, gallstones, and poor newborn feding (Kumar et al., 2012).

Because goat milk lacks agglutinins, it cannot form simple clumps during butter-making. Goat's milk fat has a soft consistency due to its lower melting point than cow's milk fat at room temperature (Pal et al., 2017).

Lipolysis and oxidation are undesirable during butter storage. As a result of these changes, the flavour of butter has changed significantly. Oxidation of lipids causes quality losses, including differences in appearance, shelf life, and nutritional profile (Öztürk and Çakmakçı, 2006).

Microencapsulation technology entails wrapping an active core material in a polymer to create tiny particles (microcapsules) with sizes ranging from 10-1000 m (Corrêa-Filho et al., 2019). The main purpose of microcapsules is to encapsulate active substances so that their activity is not affected by the environment in which, they are used (Gonalves et al., 2016).

Encapsulation can be defined as the process of inserting one substance (internal phase, payload, or payload phase) into another (membrane, shell, capsule, carrier material, external phase, wall, or matrix) (Nedović et al., 2011; Vinceković et al., 2021).

Encapsulation technology was first introduced in the field of biotechnology to improve product efficiency (Vinceković and Jurić, 2022). Encapsulation technology is used in the food industry to improve the delivery of bioactive compounds (such as antioxidants, minerals, vitamins, phytosterols, lutein, fatty acids, lycopene, esters, aromas, and colors) and living cells (such as probiotics, yeast) in real food products (Vos et al., 2010; Belščak-Cvitanović et al., 2017; Jurić et al., 2021; Mrkonjić Fuka et al., 2021).

Encapsulation in biopolymeric particles has notable advantages, including enhanced food compatibility and safety due to the presence of polysaccharides, proteins, and lipids (Fathi et al., 2021).

Prepared microparticle formulations (microspheres/microcapsules) protect the active ingredients from the external environment. The microcapsule loses its effectiveness when it breaks down in a certain environment. This is its most distinctive feature. It can also boost bioavailability and prolong component release. It allows prolonged storage without activity loss (Li et al., 2019).

Microencapsulation reduces lipid autoxidation. Studies have demonstrated that microencapsulation can prevent oil oxidation and increase stability (Ribeiro and Veloso, 2021; Valle et al., 2021). Because they can keep lipids from oxidising, microencapsulated oils are better for storing (Ng et al., 2013). Microencapsulation of lipids can be accomplished using a variety of technologies or processes, the most common of which is emulsion-based systems (Decker et al., 2010). The microcapsules are transformed into a free flowing powder via spray drying or extrusion using various polymer agents.

Microencapsulated milk fat was developed by Keogh et al. (1999) according to the study, milk fat was converted into a more stable form, was protected from oxidation, and was efficient against spoiling.

Butter's physico-chemical properties depends on kinds of animal milk. In this study varying amounts of microencapsulated goat butter were mixed into cow cream. Cow butter was made from matured the cow creams. We analyzed effect of adding cow butter to microencapsulated goat butter. It has been attempted to expose the reflections of goat butter features on cow butter.

2. **Material ve Methods**

2.1. Material

Cow's and goat's milk creams were employed in this study. The creams were supplied by the Dairy Processing facility linked with the Burdur Mehmet Akif Ersoy University Dairy Products and Technologies Application and Research Center, as were the butters. Sigma Aldrich (USA) provided low viscosity sodium alginate (CAS Number: 9005-38-3; molecular weight: 80-120 kDa), while Merck provided calcium chloride (CAS Number: 10043-52-4, molar mass: 110,99 g/mol).

2.2. Microsphere preparation

Sodium alginate was dissolved in 100 mL of distilled water using a magnetic stirrer. It was made with a 1% w/v concentration of sodium alginate. $CaCl_2$ concentration was prepared in the same manner as

sodium alginate concentration. 0,5 kg goat butter has been melted. The sediment was left at the bottom after it was filtered. The residue-free portion was filtered using filter paper. It was fed to the system at various rates with 1% sodium alginate.

The sodium alginate solution was subjected to a flow rate ranging from 5,5 to 7 mL/min. This was achieved by operating the encapsulator Büchi-B390, manufactured by BÜCHI Labortechnik AG in Switzerland, at a vibration frequency of 840 Hz and a pressure of 300 mbar. The encapsulation process was carried out using a Shell-core double-inlet nozzle head, with no additional heating used. The study conducted by Albayrak et al. (2017) determined the value of 1000 for the outer nozzle in a concentric nozzle system, while also considering the inner nozzle.

Microspheres were formed in the crosslinking solution under mechanical stirring, then washed several times with sterilized water and filtered through filter paper. Capsules were stored in deionized water until the next study.

2.3. Methods

As shown in Table 1, goat butters are encapsulated in three distinct formulations. 20 mililiter of melted goat butter was combined with 80 mL of 1% sodium alginate in the first group. The second group was blended with 50 mL of melted goat butter and 50 mL of sodium alginate at 1% concentration. 80 milliliter of melted goat butter was combined with 20 mL of 1% sodium alginate in the third group. Each formulation was separately homogenized using a magnetic stirrer (Daihan Scientific, Korea). As previously described, goat butters were encapsulated with Büchi-B390 using a concentric nozzle and the extrusion procedure. During microencapsulation, the core fluid (goat butter) and the shell fluid (1% sodium alginate) were simultaneously pumped into the concentric nozzle (300 μm /600 μm), at the vibration frequency (840 Hz), by the air pressure (300 mbar), to produce a coreeshell fluid stream that was sprayed out of the nozzle.

Table 1. Formulations of Encapsulated Goat Butter

Methods	Formulations
1	Encapsulation of 20 mL of melted goat butter with 80 ml of 1% sodium alginate
2	Encapsulation of 50 mL of melted goat butter with 50 ml of 1% sodium alginate
3	Encapsulation of 80 mL of melted goat butter with 20 ml of 1% sodium alginate

2.3.1. Butter Production

There were five types of butter produced. The first group, which was used as a control (T1), was made from 1 kg of 100% cow's cream. In the second group (T2), method 1 was used to add microencapsulated goat butter to 1 kg of cow cream. For Group 3 (T3), method 2 was used to add microencapsulated goat butter to 1 kg of cow cream. In the fourth group (T4), method 3 was used to add microencapsulated goat butter to 1 kg of cow cream. For Group 5 (T5) is produced from 1 kg of 100% goat's cream. Table 2 shows the groups that were made.

Table 2. Butter Production Groups

Groups	Production Method
T1	1 kg 100% cow's cream
T2	1 kg cow's cream+ Encapsulation of 20 mL of melted goat butter with 80 mL of 1% sodium alginate (50 g capsules)
T3	1 kg cow's cream Encapsulation of 50 mL of melted goat butter with 50 mL of 1% sodium alginate (50 g capsules)
T4	1 kg cow's cream+ Encapsulation of 80 mL of melted goat butter with 20 mL of 1% sodium alginate (50 g capsules)
T5	1 kg 100 % goat's cream

The creams in Table 2 matured after a week of addition of goat butter capsules. Then, they were malaxed separately in groups. Washed with cold water. 5 different butters were produced.

2.3.2. Chemical analysis

Titratable acidity (lactic acid, %), fat determination, and dry matter determination were analyzed according to (Anonymous, 2021). Downey (1975) was used to find the acid value and peroxide values. The Polenske number was arrived at using standard procedures (AOAC, 1995). Thiobarbituric acid value (TBA value) was determined as described by Öztürk and Çakmakçı (2006) as mg malonaldehyde/kg butter.

2.3.3. Determination of free fatty acids

Sample preparation: 30 mL of chloroform:methanol (2:1,v/v) was poured on 10 grammes of sample. It was incubated at 80°C for 2 hours after mixing 200 µL of extracted oil with 1 mL of 1,5 M methanolic HCl. After cooling to room temperature, the methyl esters of fatty acids were extracted using 1 mL of hexane and 0,5 mL of water (Yılmazer and Seçilmis, 2006).

According to Yılmazer and Seçmiş (2006), free fatty acids in butters were analysed using a GC-MS system (mass spectrometry (MS) detector (Agilent 5975 C, Agilent Technologies, Wilmington, DE, USA) with integrated gas chromatography (GC) instrument (Agilent 7890A, Agilent Technologies, Wilmington, DE, USA).

The following GC operating conditions were used: detector: FID (Agilent Tech. Inc., CA, USA) at 240°C, column: DB WAX capillary column (fused silica, 50 m x 0,20 mm, 0,20 m film thickness; Chrompack, Midelburg, Netherlands).

The injection volume was 1 µL. Injection mode/volume: In Split Analysis, helium was utilised as the carrier gas, and the flow rate was set to 1 mL/min.

Temperature of the column oven 60°C for 4 minutes, then from 60°C to 175°C 13°C per minute temperature rise, hold at 175°C for 27 minutes, 4°C per minute temperature rise from 175°C to 215°C, and hold at 215°C for 5 minutes. Heat up from 215°C With a rate of 4°C per minute, it was set to reach 240°C and stay there for 15 minutes. It was set to 240°C for both the pump and the detection.

A standard mixture of fatty acid methyl esters (Supelco® 37 Component FAME Mix, Catalogue No: 47885 U, Sigma-Aldrich, USA) was used to identify fatty acids.

2.3.4. Determination of alpha- tocopherol

The HPLC technique of Havemose et al. (2004) was adapted for the analysis of α-tocopherol. HPLC was used to analyse tocopherols (α-tocopherol) by direct injection of samples in a heptane:tetrahydrofuran (THF) (95:5) solution. Tocopherols were detected and quantified using a Shimadzu CBM 20A prominence System controller (Kyoto, Japan), SIL-20AC HTA prominence Autosampler, LC-20AT prominence pump and RF-10AXL Fluorescence Detector (Ex 295 nm, Em 330 nm). The column Luna Silica (250*4,6 mm, 5 µ Phenomonex, Torrance, USA) was employed. The temperature of the column was fixed to 40°C. The mobile phase was heptane/THF (95/5) (v/v) at 1,2 ml/min flow rate and 10 µl injection volume.

Statistical analysis data were analyzed using SPSS version 10,0 statistical program (SPSS, 2017). One-way analysis of variance was made using the ANOVA.

3. Results and Discussion

Butter's titratable acidity is between 0,16% and 0,27%. The T5 sample showed the highest % lactic acid value. T5 butter differed from other butters in a statistically significant way ($p<0,05$). The Butter standard number TS 1331 says that butter should have no more than 0,27% lactic acid (Anonymous, 2021). Butter's acidity level, the cream's microbiological quality, pH level, lipolysis level, and animal species are all affected (Atamer, 2016).

Table 3. shows the results of the chemistry tests done on the samples.

Sample	Titratable acidity (%)	Fat(%)	Acid value (mg KOH/g fat)	Polenske number	PV (meq O_2/kg fat	Water content (%)	TBA value (mg malonaldehyde/ kg fat)
T1	0,20±0,01^{b}	86,25±0,35^{ab}	1,68±0,01^{a}	1,15±0,07^{b}	0,04±0,01^{a}	13,85±0,80^{a}	0,21±0,02^{a}
T2	0,16±0,01^{b}	82,75±0,35^{c}	1,70±0,01^{c}	1,60±0,01^{b}	0,04±0,01^{a}	15,13±0,25^{a}	0,14±0,01^{b}
T3	0,18±0,01^{b}	87,75±0,35^{a}	1,74±0,20^{a}	1,45±0,21^{a}	0,04±0,01^{a}	16,37±0,25^{a}	0,13±0,01^{b}
T4	0,19±0,01^{b}	85,50±0,71^{b}	1,82±0,20^{b}	1,85±0,07^{bc}	0,04±0,01^{a}	16,44±0,16^{a}	0,12±0,02^{b}
T5	0,27±0,01^{a}	85,50±0,71^{b}	1,96±0,40^{a}	2,15±0,07^{c}	0,02±0,01^{b}	14,86±0,54^{a}	0,09±0,01^{b}

T1:1 kg 100% cow's cream, T2: 1 kg cow's cream+ Encapsulation of 20 ml of melted goat butter with 80 ml of 1% sodium alginate (50 g capsules), T3:1 kg cow's cream Encapsulation of 50 ml of melted goat butter with 50 ml of 1% sodium alginate (50 g capsules), T4:1 kg cow's cream+ Encapsulation of 80 ml of melted goat butter with 20 ml of 1% sodium alginate (50 g capsules), T5:1 kg 100 % goat's cream.

a-c* Different letters indicate a significant difference in each line ($p<0,05$).

However, during butter production, the churning, washing and malaxing stages cause the components that affect acidity to be removed from the environment. For this reason, it is stated that the titratable acidity level is quite low (Walstra and Jennes 1984; Şenel 2006). It is well known that butter made from different kinds of animals has varying degrees of acidity.

Sağdıç et al. (2003) did a study on cow, sheep, and goat butter and found that cow butter had 0,24% acidity, sheep butter had 0,23% acidity, and goat butter had 0,25% acidity.

The acidity levels of buttermilk produced by cow, goat, and sheep milk were reported as %0,63, %0,32 and %0,21 respectively, by Atamer and Şenel (2007).

Şenel and Atamer (2015) found that the lactic acid% levels of butter made from the milk of three different animals were 0,97% for cows, 1,19% for goats, and 1,65% for sheep. This study says that

sheep's milk buttermilk has a higher amount of lactic acid. This is thought to be because the raw material has a much higher dry matter level.

Tahmas Kahyaoğlu and Çakmakcı (2018) discovered that cow butter contains 0,23% lactic acid and sheep butter has 0,32% lactic acid.

Butter samples have similar lactic acid levels to other research. Butter made from fresh milk, cream from two different animals, and lack of storage time are thought to produce small variations. Acidity is found to be affected, but not statistically significantly, when encapsulated goat butter is added to cow butter in certain proportions. It may be observed that the acidity rises in direct proportion to the ratio of encapsulated goat ghee. The encapsulating material however, is assumed to trap the components that affect acidity. As a result, it appears that the increase in lactic acid is less than the acidity of goat butter. The samples' fat content was found to range from 82,75% to 87,75%.The fat values of the T1, T2, and T3 samples were shown to be statistically different ($p<0,05$). T4 and T5 samples were found to have the same value.

The fat content shows similarities in the studies by Sağdıç et al. (2003), Rodriguez et al. (2003), and Tahmas Kahyaoğlu and Çakmakcı (2018). The fat content was found to be lower compared to the values reported by Eser (2019).

The degree of lipolysis is given as acid value in butter. It provides an estimate of the total free fatty acids produced by triglyceride hydrolysis. When the acid value reaches, rancid flavour and odour develop in fresh butter (Şenel, 2006; Sert, 2022).

While Şenel (2006) discovered that the acid values of churned butter ranged from 0,80 to 1,41 mg KOH/g fat, the acid values of cream butter were found to be between 1,05 and 2,19 mg KOH/g fat. In her statement, he mentioned that the rancid flavour became noticeable in cream butters when the acidity level increased.

Haddar (2017) discovered that churned butter had acid levels of 1,68 to 1,81 mg KOH/g fat during stored for 60 days. It was observed that samples with high acidity values had lower scores in sensory analysis. The acid value was discovered to be between 1,68 and 1,96 mg KOH/g fat of the samples. The acid value of butter has been affected by differences in raw materials at a $p<0,05$ level. The acid value of the T1 sample was measured to be 1,68 mg KOH/g fat. The study revealed a positive correlation between the quantity of encapsulated goat butter incorporated in the samples and the acid value. Notably, the T5 sample, which contained goat butter, exhibited the highest acid value among all the samples. The acid value can be affected by various factors, including the breed and species of the animal, the content of the butter, the technique of production, and the circumstances and processes involved in storage (Haddar, 2017). According to the study, the value of the T5 sample was shown to be different from other samples due to different animal species.

Sağdıç et al. (2004) analysed the acid values of butter made from the milk of cows, goats, and sheep. Cow butter had 0,67 mg KOH/g fat, goat butter had 0,64 mg KOH/g fat, and sheep butter had 0,92 mg KOH/g fat. Uraz (1972) found that the acidity level of butter made from the milk of Saanen and Kilis

goats 1,66 mg KOH/g fat. Butter produced from two different sheep's milk and one goat's milk in Saudi Arabia. Butter made from Nuami sheep's milk has 1,05 mg KOH/g fat, whereas butter made from Aardi goat's milk had 1,82 mg (Sawaya et al., 1984). Tahmas Kahyaoğlu (2014) found that, the acid value of butter made from cow, sheep, and goat milk was 0,84 mg KOH/g fat for cow, 0,83 mg KOH/g fat for sheep, and 0,76 mg KOH/g fat for goat. Tahmas Kahyaoğlu and Çakmakçı (2018) found that, cow butter has an acid value of 0,56 mg KOH/g fat, while goat and sheep butter had 0,45 mg KOH/g fat However, it shows that the acid value of goat and sheep butter goes up more at the end of the storage time than that of cow butter.

The Polenske number indicates whether or not a different type of fat, either animal or vegetable, has been added. The Polenske number for butter made from milk fat only is between 1,0 and 3,3 (Anonymous, 2004). The Polenske number was determined to be 1,15-2,15 in the study, and the statistical difference was shown to be significant across all samples ($p<0,05$). Polenske number shows the amount of volatile and water-insoluble fatty acids (Ahmed et al., 2020). The Reichert-Meissl and Polenske numbers were used to determine the presence of short-chain fatty acids, according to Kurt et al. (2007). Tahmas Kahyaoğlu and Çakmakçı (2018) discovered that, goat butter had a higher Polenske number than cow and sheep butter. Polenske number in goat butter is 2.15; in cow butter, it was determined to be 1.25. He emphasised that, goat butter has less soluble and more insoluble fatty acids than cow butter. According to Karakuş (2022) ghee made from cow cream has a Polenske number of 1.20 whereas ghee made from sheep cream has a Polenske number of 2.70. During the year of storage, he also found that the Polenske population had increased. He explained that the Polenske number may rise if more low-molecular free fatty acids were present during storage. When microencapsulated goat butter was added to cow cream, it also changed the Polenske numbers of the samples. It was seen that Polenske numbers went up as more contained goat clarified butter was added. The results are similar with Sağdıç et al. (2004).

The peroxide value is a commonly used indicator of butter's level of lipolysis. It is an indicator of the amount of free fatty acids and their oxidative degradation (Bakırcı et al., 2004). Peroxide value was determined to be 0,04 meq O_2/kg fat, except T5 sample. The T5 sample had a peroxide value of 0,02 meq O_2/kg fat. There was a statistically significant difference between the T5 sample and the other samples ($p<0,05$). Lee (2020) found 1.69 and 1.82 meq peroxide/kg fat in salted and unsalted goat butter, respectively and found that, the peroxide value increased with storage. Pavlova et al. (2022) discovered that fresh and ripened goat butters had higher peroxide values than ripened butters. He claimed that, storing affects the peroxide value. Tahmas Kahyaoğlu (2014) determined, the peroxide value in cow butter after 30 days in the study on cow, sheep, and goat butter. The peroxide value of goat butter was found to be higher than sheep and cow butter. Şenel et al. (2011) found that, goat butter had a higher peroxide number than cow and sheep butter. Eser and İnanç (2022) found the peroxide value of buffalo butter as 1,94-2,01 meq O_2 kg^{-1}. In this study, the lower peroxide level might have been because the study used fresh cream and didn't store the samples for a long time. The water content of butter varies

between 13.85% and 16.44%. No significant difference was seen in water content between samples (p>0,05). Similar results were obtained in various studies (Rodrguez et al., 2003; Sağdıç et al., 2004; Şenel et al., 2011; Kumar et al., 2012; Desouky, 2014).

The TBA value was discovered to between 0.09 and 0.21 mg malonaldehyde/kg fat. The difference between T1 and other samples was shown to be statistically significant (p<0.05). The TBA value is used to determine the amount of malonaldehyde produced in the latter stages of oxidation. Hydroperoxides breakdown into malonaldehydes when oxidation grows during oil storage. Malonaldehydes are identified that cannot be discovered by peroxide analysis. TBA analysis determines oxidative spoilage in butter that has been kept for a long period of time (Anonymous, 2004; Anonymous 2005). The Turkish Food Codex Butter, Other Milk Fat-Based Spreads, and Ghee Communiqué and the Turkish Standards Institute TS 1331 Butter Standard include no information about TBA values (Anonymous, 2005; Anonymous, 2021).

Karakuş (2022) found TBA values of cow and sheep butter at the beginning of storage were in the range of 0,12-0,24 mg malonaldehyde/kg fat. This value was discovered to be 0.48-0.68 mg malonaldehyde/kg oil at the end of the storage period. Tahmas Kahyaoğlu (2014) explained that, the higher TBA value in sheep butter is due to the different fatty acid composition.

Tahmas Kahyaoğlu (2014) reported the TBA value of bovine butter as 0.01 mg malonaldehyde/kg fat, and sheep butter as 0.02 mg malonaldehyde/kg fat. Kamacı (2021) found the TBA values of butter samples ranged from 0.82 to 1,00 mg malonaldehyde/kg fat. In this research, TBA values were higher than Tahmas Kahyaoğlu (2014) and lower than Kamacı (2021). It is believed that the TBA value is minimal because the investigation did not include a storage phase.

Table 4. Values of the αlpha-Tocopherol in the Samples

Sample	mg αlpha- tocopherol/ 100 g oil
T1	5.160
T2	5.240
T3	8.626
T4	9.600
T5	12.650

T1:1 kg 100% cow's cream, T2: 1 kg cow's cream+ Encapsulation of 20 ml of melted goat butter with 80 ml of 1% sodium alginate (50 g capsules), T3:1 kg cow's cream Encapsulation of 50 ml of melted goat butter with 50 ml of 1% sodium alginate (50 g capsules), T4:1 kg cow's cream+ Encapsulation of 80 ml of melted goat butter with 20 ml of 1% sodium alginate (50 g capsules), T5:1 kg 100 % goat's cream.

The T5 sample had 12.650 mg/100g of αlpha-tocopherol. The maximum concentration of αlphatocopherol was found in goat butter. It was found in the T1 sample at the lowest amount. On the other hand, the T2-T3-T4 samples made from cow creams that have goat butter capsules added show that the amount of alpha-phatocopherol goes up as the capsule amount goes up. The amount of fat-soluble vitamins, like α-tocopherol, in raw milk depends on how well the animal was fed and how long it was lactating. It was found goats of milk fed with hay, had higher α-tocopherol levels (Laurent et al.,

2023). Lucas et al. (2008) discovered 0.4-3.70 mg/kg-1 of -tocopherol in Rocamadour cheese made from goat's milk.

The study analysed Njeguski-type cheeses made from cow, sheep, and goat milk. The cheeses made from goat milk had the highest amount of α-tocopherol (Jokanovic et al., 2022). A study looked at market cow milk, raw cow milk, and raw goat milk. The study found that goat milk had the highest amount of α-tocopherol (Sunarić et al., 2012). Eser and İnanç (2022) found the α-tocopherol level in buffalo butter produced by different methods as 24,40-33,20 ng g^{-1}. According to Eser (2019) the amount of α-tocopherol in butters made from various types of creams was lower in buttermilk (25,2 ng/g) than in cream butters (28,8-31,6 ng/g).

Table 5. Fatty acid acid profiles of butters (w/w) %,

Fatty Acids	T1	T2	T3	T4	T5	RT
Butanoic acid methyl ester (C4:0)	0.980	0.290	0.543	0.485	0.580	10.01
Caproic acid methyl ester (C6:0)	1.102	1.089	1.219	1.268	2.161	17.8
Caprylic acid methyl ester (C8:0)	3.024	2.974	2.734	2.858	8.159	42.1
Undecanoic acid methyl ester (C11:0)	0.065	0.063	0.056	0.070	0.059	48.2
Lauric acid methyl ester (C12:0)	3.946	3.615	3.387	3.582	3.975	54.4
10-Undecenoic acid methyl ester (C11:1)	0.089	0.080	0.078	0.085	0.062	56.2
Tridecanoic acid methyl ester (C13:0)	0.145	0.138	0.129	0.133	0.093	60.0
Myristic acid methyl ester (C14:0)	14.577	12.871	12.322	13.010	10.878	66.0
Pentadecanoic acid methyl ester (C15:0)	2.752	2.443	2.314	2.416	1.487	66.7
Palmitic acid methyl ester (C16:0)	37.402	36.671	36.767	37.707	31.418	76.6
Palmitoleic acid methyl ester (C16:1)	0.639	0.805	0.735	0.790	0.822	79.3
Heptadecanoic acid methyl ester (C17:0)	0.570	0.783	0.749	0.798	1.082	80.8
Stearic acid methyl ester (C18:0)	0.874	0.835	0.818	0.863	0.877	84.3
Oleic acid methyl ester (C18:1)	20.658	22.876	23.065	25.009	25.043	85.9
Linoleic acid methyl ester (C18:2)	7.474	9.362	10.053	6.218	8.185	86.1
Linolenic acid methyl ester (C18:3)	1.694	1.756	1.757	1.999	1.886	87.1
Eicosanoicacid acid methyl ester (C20:0)	0.217	0.220	0.118	0.203	0.195	88.3
Total Fatty Acids (FA)	96.208	96.871	96.844	97.654	96.962	

T1:1 kg 100% cow's cream, T2: 1 kg cow's cream+ Encapsulation of 20 ml of melted goat butter with 80 ml of 1% sodium alginate (50 g capsules), T3:1 kg cow's cream Encapsulation of 50 ml of melted goat butter with 50 ml of 1% sodium alginate (50 g capsules), T4:1 kg cow's cream+ Encapsulation of 80 ml of melted goat butter with 20 ml of 1% sodium alginate (50 g capsules), T5:1 kg 100 % goat's cream.

It is well known that α-tocopherol is a powerful fat-soluble antioxidant. α-tocopherol has a positive effect on the oxidative stability of butter. Desouky (2014) studied the oxidative stability of goat butters by mixing in varying quantities of α-tocopherol. They found, when α-tocopherol content was raised, butter's oxidative stability improved noticeably. He said that, the peroxide value and TBA value drop with increasing levels of α-tocopherol. The TBA value fell proportionally as the α-tocopherol value increased in the study. α-tocopherol is thought to have antioxidative properties.

Butter samples included a total of 18 fatty acids. Table 3 shows the average value of each fatty acid. Palmitic acid has the highest proportion in the samples, followed by myristic acid. The smallest amount of eicosanoicacid acid was found. Oleic, caprylic, caproic, palmitoleic, and heptadecanic acid concentrations were found higher in the goat butter sample T5 than in the other samples. It has been

shown that the levels of oleic, caprylic, caproic, and palmitoleic fatty acids rise when more encapsulated goat butter is added to the T2-T3-T4 samples. It is believed that goat butter's characteristics are transferred to cow butters when encapsulated goat butter is added.

Although palmitic and myristic acid levels were greatest in the T1 sample, which was cow butter, they were lowest in the T5 sample, which was goat butter. Both goat and cow butter have predominantly high levels of palmitic, oleic, and myristic acids, respectively T1 included 38,87% palmitic acid, 21,47% oleic acid, and 15,15% myristic acid of the total free fatty acids detected in cow butter. The fatty acid profile of goat butter T5 was found to be 32.4% palmitic acid, 25.78% oleic acid, and 11.21% myristic acid. This observation is similar to the findings of Şenel et al. (2011). The quantities of butyric, lauric, and stearic acid were found to be almost the same.

The high concentration of palmitic and myristic acid in goat butters studied by Sağdıç et al. (2004), Borková et al. (2015) and Akgül et al. (2020) is similar to the research.

Caproic fatty acid was found higher than Şenel et al (2011), Borková et al. (2015) ve Lee (2022) but lower than Sağdıç et al. (2004), Akgül et al. (2020) with Eser and İnanç (2022) at goat's butter sample (T5).

Caprylic fatty acid determined higher than Sağdıç et al. (2004), Şenel et al. (2011), Borková et al. (2015), Akgül et al. (2020), Lee (2022). Fatty acid profiles have correlations to milk fat profiles and nutritional status (Lee, 2020) with variances likely attributable to geographical location and feed diet.

Table 6. Fatty acid profiles of butters (w/w) %,

Fatty Acids	T1	T2	T3	T4	T5
Short chain fatty acids (SCFAs)	2.082	1.379	1.762	1.753	2.741
Medium chain fatty acids (MCFAs)	3.024	2.974	2.734	2.858	8.159
Long-chain fatty acids(LCFAs)	91.102	92.518	92.348	93.043	86.062
SFA; saturated fatty acids	65.654	61.992	61.156	63.393	60.964
MUFA; monounsaturated fatty acids	21.386	23.731	23.878	26.044	25.927
PUFA2; polyunsaturated fatty acids	9.168	11.148	11.810	8.217	10.071
Unsaturated	30.554	34.879	35.688	34.261	35.998

T1:1 kg 100% cow's cream, T2: 1 kg cow's cream+ Encapsulation of 20 ml of melted goat butter with 80 ml of 1% sodium alginate (50 g capsules), T3:1 kg cow's cream Encapsulation of 50 ml of melted goat butter with 50 ml of 1% sodium alginate (50 g capsules), T4:1 kg cow's cream+ Encapsulation of 80 ml of melted goat butter with 20 ml of 1% sodium alginate (50 g capsules), T5:1 kg 100 % goat's cream.

Short chain fatty acids (SCFAs) and medium chain fatty acids (MCFAs) are found to be higher in the T5 sample than in the other samples. It had the lowest amounts of long chain fatty acids (LCFAs). The MCFAs value was found to be greatly higher than those of the other samples.

The mammary gland is responsible for the synthesis of short- and medium-chain fatty acids (C4-C14) as well as half of the palmitic acid (C16:0) found in milk fat. The remaining half of the C16:0 and the C18 and longer fatty acids in milk fat are acquired by the mammary gland through the blood supply, originating from either the diet or adipose tissue. (Walstra and Jenness, 1984; Grummer, 1991). The anatomical differences in the mammary glands of cows and goats are hypothesized to be reflected in the fatty acid content.

4. Conclusion

Various amounts of encapsulated goat clarified butter were added to cow creams in the study. Butters' physicochemical characteristics and free fatty acid variety were investigated. Butters' acidity, acid value, Polenske number, peroxide number, and TBA levels all differed significantly. It was found that there were no significant differences between the amounts of fat and water contents in butter samples. The acid value, Polenske number, and α-tocopherol level increased as the encapsulated goat ghee ratio increased. The incorporation of goat ghee in capsules had a positive impact on the butters. It was determined that the goat butter sample contained higher levels of oleic, caprylic, caproic, palmitoleic, and heptadecanic acid than other samples. There is a belief that the presence of encapsulated goat ghee may have an antioxidative impact on samples of cow butter. The microencapsulation technology can be stated to have a good effect on delaying the oxidation of butter. Furthermore, it was discovered that the encapsulated goat ghee had no deleterious impacts on the level of free fatty acids. The microencapsulation approach has been shown to be effective for long-term storage of oils high in oleic, caprylic, and capric fatty acids, such as goat butter, against oxidation and lipolysis. It has been shown that the microencapsulation method can be used with oils. Different animal fats can be added to cow butter to make it healthier. These fats contain free fatty acids and α-tocopherol, which are antioxidants. It gets better in terms of nutrition and performance.

Acknowledgments

I would like to thank Burdur Mehmet Akif Ersoy University, Dairy Products and Technologies Application and Research Center, where the laboratory infrastructure is used.

Author's Contributions

The contribution of the authors is 100%.

Conflict of interest

I declare that there is no conflict of interest. Author Contributions: AAK designed the study, set up the trial, conducted the study, analyzed the data, and wrote the article.

References

Ahmed S., Hamıd MA., Rahman MM. Assessment of ghee adulterated with oils and fats in Bangladesh. Journal of Advanced Veterinary and Animal Research 2020; 7(4): 678.

Akgül FY., Ceylan HG., Atasoy AF. Determination of fatty acids profiles and volatile compounds of cows' and goats' butters. International Journal of Agriculture Environment and Food Sciences 2020; 4(1): 7-13.

Albayrak A., Gün İ., Juric S., Kalit Tudor M., Kalit S. Süt ürünlerinde mikroenkapsülasyon tekniğinin uygulanması ve ürün kalitesine etkisi. Süt Dünyası 2017; 12(66): 48-63.

Albayrak A. Some properties of semi-hard cheese made from cow's and goat's milk. Harran Tarım ve Gıda Bilimleri Dergisi 2023; 27(2) : 265-276.

Anonymous AOCS. Offical Methods And Recommended Practices Of The American Oil Chemists' Society, 2nd Printing. AOCS Press, Champaign, IL (USA); 2004.

Anonymous. Türk Gıda Kodeksi Tereyağı, Diğer Süt Yağı Esaslı Sürülebilir Ürünler ve Sadeyağ Tebliği 12.04.2005 tarih ve 19 sayılı Resmi Gazete, Ankara; 2005.

Anonymous. Tereyağ standardı. TS 1331, Türk Standartları Enstitüsü, Ankara.10s; 2021.

AOAC. Official Method of Analysis, 16th Edition, Washington, DC, USA; 1995.

Atamer M. Tereyağı teknolojisi uygulama kılavuzu, Ankara Üniversitesi, Ziraat Fakültesi Yayınları, 1314, Uygulama Kılavuzu: 236, A.Ü. Halkla İlişkiler ve Yayın Ünitesi, 1993; Ankara;

Atamer M. Tereyağı teknolojisi. Sidas Medya Ltd.Şti. ISBN No: 978-605-5267-34-6; 1993

Atamer M., Şenel E., Öztekin FŞ. Farklı tür sütlerden üretilen yayık tereyağlarının bazı nitelikleri, Tübitak Projesi Sonuç Raporu, Proje No:105 O 157, Ankara Üniversitesi Ziraat Fakültesi Bölümü, 2007, Ankara.

Barlowska J., Szwajkowska M., Litwinczu Z., Krol J. Nutritional value and technological suitability of milk from various animal species used for dairy production. Comprehensive Reviews in Food Science and Food Safety 2011; 10(6): 291-302.

Belščak-Cvitanović A., Jurić S., Đorđević V., Barišić L., Komes D., Ježek D., Bugarski B., Nedović V. Chemometric evaluation of binary mixtures of alginate and polysaccharide biopolymers as carriers for microencapsulation of green tea polyphenols. International Journal of Food Properties 2017; 20(9): 1971-1986.

Bakırcı I., Çelik S., Özdemir Ö. The effects of commercial starter culture and storage temperature on the oxidative stability and diacetyl production in butter. International Journal of Dairy Technology 2002; 55: 177-181.

Borková M., Michnová K., Hyršlová I., Fantová M., Elich O. Changes in fatty acid profile of goat butter from goats fed algae. Journal of Hygienic Engineering and Design 2015; 13: 82-89.

Corrêa-Filho L., Moldão-Martins M., Alves V. Advances in the application of microcapsules as carriers of functional compounds for food products. Applied Sciences 2019; 9(3): 571.

Decker EA., Elias RJ., Mcclement DJ. Oxidation in foods and beverages and antioxidant applications: management in different industry sectors. United States: Elsevier; 2010.

Deeth HC., Fitz-Gerald CH. Lipolytic enzymes and hydrolytic rancidity in milk and dairy products. In Fox P.F.(ed.) Advanced Dairy Chemistry. London: Chapman and Hal Lipids 1995; 2: 247-308.

Desouky MM. Phsıco-chemical characterıstıcs of traditional butter oil made from spontaneous fermentation of goats' milk. Journal of Food and Dairy Sciences 2014; 5(7): 459-479.

Downey WK. Butter quality. Dublin, Published by An Foras Taluntais; 1975.

Eser Hİ. Manda yayık ve krema tereyağının niteliklerinin belirlenmesi. Kahramanmaraş Sütçü İmam Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği ABD. Yüksek Lisans Tezi, sayfa no: 60, Kahramanmaraş, Türkiye, 2019.

Eser İH., İnanç AL. Farklı yöntemlerle Anadolu manda tereyağı üretimi. Tekirdağ Ziraat Fakültesi Dergisi 2022; 19(1): 215-226.

Fathi M., Vinceković M., Jurić S., Viskić M., Režek Jambrak A., Donsì F. Food-grade colloidal systems for the delivery of essential oils. Food Reviews International 2021;37(1): 1-45.

Gonalves A., Estevinho BN., Rocha F. Microencapsulation of vitamin A: A review. Trend Food Science Technology 2016; 51: 76–87.

Grummer RR. Effect of feed on the composition of milk fat. Journal of Food and Dairy Sciences 1991; 74: 3244-3257.

Haddar M. Yayık Tereyağı üretiminde farklı kültür kullanım olanaklarının araştırılması. Ankara Üniversitesi, Fen Bilimleri Enstitüsü Süt Teknolojisi Bölümü ABD Yüksek Lisans Tezi. sayfa no: 69, Ankara,Türkiye, 2017.

Havemose MS., Weisbjerg MR., Bredie WL., Nielsen JH. Influence of feeding different types of roughage on the oxidative stability of milk. International Dairy Journal 2004; 14(7): 563-570.

IDF (International Dairy Federation Nutritional quality of milkfat. International (Dairy Nutrition Website); 1-10; 2008.

Jokanovic O., Markovic B.,, Mirecki S., Veljic M., Miloradovic Z., Radulovic A., Miocinovic J. Composition and a-tocopherol content of Njeguski-type cheese made from cow, ewe and goat milk. International Dairy Journal 2022; 134: 105469.

Kamacı S. Tereyağı eritme sıcaklığının Şanlıurfa sadeyağının (Urfa yağı) kalite özelliklerine olan etkisinin araştırılması. Harran Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği ABD Yüksek Lisans Tezi, sayfa no:88,Şanlıurfa, Türkiye, 2021.

Karakuş MŞ. İnek ve koyun krema ve yoğurdundan üretilen tereyağların özellikleri ve bu tereyağlardan elde edilen sadeyağların depolama sırasında kalite kriterlerinde meydana gelen değişimlerin belirlenmesi. Harran Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği ABD Doktora Tezi, sayfa no:236, Şanlıurfa, Türkiye, 2022.

Kurt A., Çakmakçı S., Çağlar A. Süt ve mamülleri muayene analiz metotları rehberi. Atatürk Üniversitesi, Ziraat Fakültesi Yayın No: 257, Erzurum.

Keogh MK., O'Kennedy TB. Milk fat microencapsulation using whey proteins. International Dairy Journal Sciences 1999; 9: 657-663.

Kumar S., Kumar B., Kumar R., Kumar S., Khatkar SK., Kanawjia SK. Nutritional features of goat milk- a review. Indian Journal Dairy Sciences 2012; 65(4): 266-272.

Laurent C., Caillat H., Girard CL., Ferlay A., Laverroux S., Jost J., Graulet B. Impacts of production conditions on goat milk vitamin, carotenoid contents and colour indices. Animal 2023; 17(1): 100683.

Li T., Teng D., Mao R., Hao Y., Wang X., Wang J. Recent progress in preparation and agricultural application of microcapsules. Journal of Biomedical Materials Research 2019; 107(10): 2371-2385.

Lee JH. Changes in flavor compounds and quality parameters of goat cream butter during extended refrigerated storage. International Journal of Food Properties 2020; 23(1): 306-318.

Lucas A., Coulon JB., Agabriel C., Chilliard Y., Rock E. Relationships between the conditions of goat's milk production and the contents of some components of nutritional interest in Rocamadour cheese. Small Ruminant Research 2008; 74: 91-106.

Mrkonjić Fuka M., Žgomba Maksimović A., Hulak N., Kos I., Marušić Radovčić N., Jurić S., Tanuwidjaja I., Karolyi D., Vinceković M. The survival rate and efficiency of nonencapsulated and encapsulated native starter cultures to improve the quality of artisanal game meat sausages. Journal Food Science Technology 2021; 58(1): 710-719.

Nedović V., Kalusević A., Manojlović V., Lević S., Bugarski B. An overview of encapsulation technologies for food applications. Proced Food Science 2011; 1(1): 1806–1815.

Ng SK., Jessie LYL., Tan CP., Long K., Nyam KL. Effect of accelerated storage on microencapsulated kenaf seed oil. Journal of the American Oil Chemists' Society 2013; 90: 1023-1029.

Öztürk S., Çakmakçı S. The effect of antioxidants on butter in relation to storage temperature and duration. European Journal of Lipid Science and Technology 2006; 108(11): 951-959.

Pal M., Dudhrejiya TP., Pinto S., Brahamani D., Vijayageetha V., Reddy YK., Kate P. Goat milk products and their significance. Beverage & Food World. 2017; 44(7): 21-25.

Pavlova TA., Dunaev AV., Danilova ES. Technology of producing butter with long-term storage from goat milk. IOP Conf. Series: Earth and Environmental Science 2022; 1052(1): 012047.

Poutzalis S., Anastasiadou A., Nasopoulou C., Megalemou K., Sioriki E., Zabetakis I. Evaluation of the in vitro anti-atherogenic activities of goat milk and goat dairy products. Dairy Science Technology 2016; 96(3): 317-327.

Ribeiro JS., Veloso CM. Microencapsulation of natural dyes with biopolymers for application in food: A review. Food Hydrocolloids 2021;112: 106374.

Rodriguez A., Bunger A., Castro E., Sousa I., Empis J. Development and optimization of cultured goat cream butter. journal of the American Oil Chemists' Society 2003; 80: 987-992.

Sağdıç O., Dönmez M., Demirci M. Comparison of characteristics and fatty acid profiles of traditional Turkish yayik butters produced from goats', ewes' or cows' milk. Food Control 2003; 15: 485–490.

Sawaya WN., Khan PA, Al-Shalhat F. Physical and chemical characteristics of ghee and butter from goat's and sheep's milk, Food Chemistry 1982;14: 227-232.

Sert D. Peyniraltı suyu ve yayıkaltından elde edilen kremalardan üretilen tereyağların nitelikleri. Ankara Üniversitesi Fen Bilimleri Enstitüsü Süt Teknolojisi ABD Yüksek Lisans Tezi, sayfa no: 92, Ankara, Türkiye,2022.

SPSS Statistics Student Version 16.0, 2017 SPSS Inc., Chicago, IL; 2017

Sunarić S., Živković J., Pavlović R., Kocić G., Trutić N., Živanović S. Assessment of α-tocopherol content in cow and goat milk from the Serbian market. Hemıjska Industrıja. 2012; 66(4): 559-566.

Şenel E. Bazı üretim arametrelerinin yoğurttan üretilen yayık tereyağının nitelikleri üzerine etkisi. Ankara Üniversitesi, Fen Bilimleri Enstitüsü Süt Teknolojisi ABD Doktora Tezi, sayfa no:168, Ankara, Türkiye, 2006.

Şenel E., Atamer M., Öztekin FŞ. The oxidative and lipolytic stability of Yayık butter produced from different species of mammals milk (cow, sheep, goat) yoghurt. Food Chemistry 2011; 127: 333-339.

Şenel E., Atamer M. Yayik butter profiles from different species of mammals' milk, processing and ımpact on active components in food. Preedy, V.R.(ed.) Processing and Impact on Active Components in Food. Elsevier Science & Technology 2014; Chapter 26: 215-221.

Tahmas Kahyaoğlu D. İnek, koyun ve keçi sütlerinden üretilen tereyağlarında depolama süresince uçucu bileşikler, oksidasyon stabilitesi ve diğer bazı kalite kriterlerinin belirlenmesi. Atatürk Üniversitesi Fen Bilimleri Enstitüsü Gıda Mühendisliği ABD Doktora Tezi, sayfa no:206, Erzurum, Türkiye, 2014.

Tahmas Kahyaoğlu D., Çakmakçı S. Comparative study on some properties and oxidation stability during storage of butter produced from different animals' milk. Gıda 2018; 43(2): 283-293.

Yılmazer M., Seçilmiş H. Bazı serbest yağ asitlerinin metanolik HCL ortamında türevlendirilmesindeki koşulların incelenmesi. III. Ulusal Analitik Kimya Kongresi, 2006, sayfa no:25, Çanakkale.

TUIK. Süt ve Süt Ürünleri 2022 Verileri. 2022. https://data.tuik.gov.tr/Bulten/Index?p=Sut-ve-Sut-Urunleri-Uretimi-Aralik-2022-49484 . Erişim Tarihi: 05.04.2023.

Uraz T. Saanen ve Kilis keçisi melezlerinin F1 döllerinde sütlerin bileşimi ile süt yağının fiziksel ve kimyasal konstantları üzerine araştırmalar. Ankara Üniversitesi Ziraat Fakültesi Yayınları Bilimsel Araştırmalar ve İncelemeler 1972; 477: 278; Ankara.

Valle JAB., Valle RDCSC., Bierhalz ACK., Bezerra FM., Hernandez AL., Lis Arias MJ. Chitosan microcapsules: Methods of the production and use in the textile finishing. Journal of Applied Polymer Science 2021; 138: 50482.

Vinceković M., Jurić S., Marijan M., Viskić M., Vlahoviček-Kahlina K., Maslov Bandić L. Encapsulation of herb extracts (aromatic and medicinal herbs). In: Galanakis, C.M. (ed.) Aromatic herbs in food: bioactive compounds, processing and applications. Academic Press (Elsevier), Cambridge 2021; 263-322.

Vinceković M., Jurić S. Application of encapsulation technology in the Agri-Food Sector. In: Jambrak, R.A. (ed.) Nonthermal Processing in Agri-Food-Bio Sciences. Cham: Springer International Publishing 2022; 469-490.

Vos P., Faas MM., Spasojevic M., Sikkema J. Encapsulation for preservation of functionality and targeted delivery of bioactive food components. International Dairy Journal 2010; 20(4): 292-302.

Walstra P., Jenness R. Biosynthesis and secretion of milk. In Walstra, P., Jenness R., (eds.) Dairy Chemistry and Physics. John and Wiley & Sons: New York, NY, 1984; 12-26.