The effect of ripening time on the vitamin content of soft Craft cheeses made from unpasteurised goat milk

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Abstract

Healthy eating has always been, is and will be one of the priority areas for the development of science and practice in the field of public health. Food products that have a positive effect on health include Craft soft cheeses made from unpasteurised goat milk. Expanding their range on the world market and in Ukraine, in particular, involves assessing quality, biological value, and developing authenticity criteria. For this purpose, brine Feta cheese and Chevre cheese with white noble mould were made from unpasteurised goat milk on one of the goat eco-farms in Ukraine. The content of retinol, tocopherol and riboflavin in the cheeses was determined during the ripening period. It was found that the ripening period did not affect the content of retinol in Feta and Chevre cheeses. The level of tocopherol in Chevre cheese remained constant during 40 days of ripening, and in Feta cheese, it decreased by 11.56% at the 18th and 30th months of ripening. The concentration of riboflavin in both cheeses increased with age: in Feta cheese at the 30th month of ripening – by 42.38%, and in Chevre cheese at the 40th day of ripening – by 28.91% compared to the initial value. A strong direct linear dependence of the content of riboflavin in the dry matter of Chevre cheese on the ripening period was revealed ($r = 0.768 \pm 0.128$, $P<0.01$). The obtained data give reason to consider brine Feta cheese and cheese with noble white mould Chevre as sources of retinol, tocopherol and riboflavin for the human body, which in combination with other characteristics of their microbial, fatty acid, mineral and microstructural composition can be a criterion for determining quality, biological value and authenticity.

Keywords: retinol, tocopherol, riboflavin, Feta cheese, Chevre cheese.

Introduction

Dairy products are not only nutritious, but also dietary products that are an important source of vitamins for the human body (Sharma et al., 2024; Davydovych et al., 2025a, 2025c).). Vitamins are biologically active compounds that catalyse a number of biochemical reactions of metabolism in the tissues of the body, and provide the processes of growth, development and regeneration of tissues. Among the most important vitamins is retinol (vitamin A), which ensures the functioning of the organs of vision, reproduction, as well as cell differentiation. Tocopherol (vitamin E) is considered one of the strongest antioxidants that slows down the ageing and apoptosis of cells. Riboflavin belongs to the water-soluble vitamins of group B and is a precursor of flavin nucleotides, which function as coenzymes in many redox reactions in body tissues (Ruchala et al., 2022). Despite the insignificant concentration of vitamins in the diet, their deficiency significantly affects human health, which requires their constant intake with food products. Considering the content of these vitamins in dairy products, it can be assumed that they cover more than 10% of the daily human need for vitamins A, E and B_2.

The most valuable dairy products for the human diet are cheeses, especially craft cheeses, made from unpasteurised goat milk, which have original aromatic and taste characteristics (Awad and Abdou, 2024; Sadvari et al., 2024a, 2024b). Today's high consumer awareness increases the demand for high-quality, natural dairy products (Sobaih and Abdelaziz, 2022; Zampelas, 2023), in particular, craft goat cheeses made with minimal technological processing. The production of such cheeses is of particular importance for the ecology and economy of local communities, since small farms, on the one hand, reduce the waste load on the ecosystem, and on the other hand, contribute to the creation of jobs in rural areas and the development of its infrastructure (Bal-Prylypko et al., 2023, 2024). Consumers have the opportunity to provide themselves with local food products that are produced according to the traditions and technologies of a particular region and reflect its history and culture (Lapidakis and Fragkiadakis, 2022). Another factor in favour of craft Cheese production is a gastronomic tourism that is gaining popularity and ensuring a corresponding interest in craft products (Pappa and Kondyli, 2023).

Currently, along with the high demand for hard cheeses, the demand for soft cheeses is also growing significantly, particularly brine cheeses such as Feta (Katsouri et al., 2022) and cheeses with white noble mould, such as Camembert or Brie. Feta cheese and Feta-like cheeses are brined white soft cheeses made from goat or sheep milk, but technologies are now known that use cow and buffalo milk, as well as their blends (Hamdy et al., 2020; Hammam et al., 2021). Camembert-type cheeses are characterised by a superficial ripening of the rind, which is formed by the growth *of*

Penicillium candidum, as well as yeast: *Geotrichum candidum, Kluyveromyces* spp. and *Debaryomyces hansenii,* which grow on the surface of the wheels. In such cheeses, numerous physicochemical, microbiological and biochemical processes occur, which contribute to the transformation of the crumbly cheese into a soft, viscous, pasty or fluid (Batty et al., 2019).

Microbiome of soft goat cheeses made from unpasteurised milk (Bustos et al., 2025) in combination with a complex of biologically active and nutritional substances is able to exert probiotic, antioxidant, anticarcinogenic and anti-inflammatory effects in tissues (Zhang et al., 2023). This classification identifies such cheeses as food products that contribute to human health by reducing the risk of metabolic disorders, as well as diseases of the digestive, nervous, and cardiovascular systems (Saleem et al., 2024).

The constant expansion of the range of craft goat cheeses requires the development of criteria for assessing not only their quality and safety, but also their authenticity and biological value (Siafaka et al., 2024). There are very few such studies in the literature, and they do not fully reveal the features of the dynamics of vitamin composition depending on the ripening period of soft cheeses made from unpasteurised goat milk.

Therefore, the study aimed to determine the content of retinol, tocopherol and riboflavin in soft Craft cheeses made from unpasteurised goat's milk: brined Feta cheese and Chevre cheese with noble white mould in the ripening process.

Materials and Methods

Determination of vitamin content in soft craft cheeses from unpasteurised goat milk was conducted from May 2023 to January 2025. The study used two batches of craft cheeses: brine Feta cheese and cheese with white noble mould, Chevre. All cheeses were made in the conditions of the Eco Farm "Zhuravka" in the Kyiv region according to the recipe described in our previous studies (Davydovych et al., 2025b). In total, the study used 5 batches of Feta cheese, each weighing 5 kg, as well as 15 wheels of Chevre cheese, each weighing 180-200 g. The cheeses were made from the milk of Anglo-Nubian goats, which use natural pastures during the growing season. Goats were milked by machine, with a frequency of twice a day.

The technological scheme for the production of brined Feta cheese consisted of the following stages: heating unpasteurised goat milk to 33 °C and the introduction of mesophilic starter culture MA 11 (Danisco France SAS, France); introduction of liquid rennet enzyme Rennet Liquid 92/8 (Pamir Service, Kyiv, Ukraine); curdling of milk and cutting of the curd; laying of the curd in a mold and separation of the whey; cutting of the cheese into triangles weighing 250-300 g and packing into containers; salting of the cheese with a 9% solution of table salt in the whey; storage of the cheese in brine for 30 months (Fig. 1a).

Chevre cheese with white noble mold is made according to the following scheme: heating unpasteurised goat milk to 32°C and adding mesophilic starter culture MA 11 (Danisco France SAS, France); introduction of AGE M-GC mould starter (*Geotrichum candidum)* and AGE M-PC (*Penicillium candidum)* (IGEA Cultures, Italy); addition of liquid rennet enzyme Rennet Liquid 92/8 (Pamir Service, Kyiv, Ukraine); milk coagulation and clot formation; whey separation; salting of cheese grains with crystalline salt; cheese wheel formation; ripening of cheese wheels on a drainage mat for 20 days in a ripening chamber; packaging of cheese wheels in parchment paper; ripening of cheese wheels in packaging for 20 days in a ripening chamber (Fig. 1b).

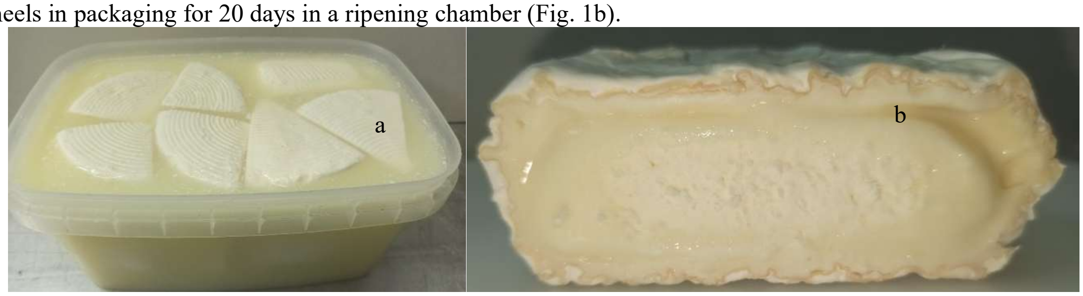

Fig. 1. Brine Feta cheese (a), cheese with white noble mould Chevre (b)

To determine the vitamin composition, samples of Feta cheese were taken on the 7th day, 18th and 30th months of ripening, 5 samples weighing 200-250 g from each batch. Samples of Chevre cheese, in the amount of 5 wheels, were taken for analysis on the 3rd, 20th, and 40th day of ripening.

All cheese samples were analysed for the content of retinol (vitamin A), tocopherol (vitamin E) and riboflavin (vitamin B_2). The content of retinol and tocopherol in cheeses was determined using the phototocolorimetric method, the study was performed on a photoelectric photometer KFK-3-01 ("Zomz", Sergiev-Posad, Russia). The content of riboflavin in cheeses was determined using the fluorometric method on the analyser Fluorat-02-2M (FNVF AP "Lumex", Russia). For the vitamin analysis of cheeses, reagents from the Thermo Fisher Scientific company (USA) were used.

Statistical processing of the obtained data was performed using one-way analysis of variance. Individual indicators of soft cheeses were subjected to correlation and regression analysis. Comparison of the vitamin composition of Feta and Chevre cheeses was carried out within each name in the range of ripening period. The studies used Microsoft Excel 2016 and XLSTAT (Addinsoft, Paris & France, 2017). The data in the tables are presented as x ± SD (mean ± standard deviation), the difference between the indicators was considered significant at $P<0.05$ using the Tukey test with Bonferroni correction.

Results

The retinol content in Feta cheese from unpasteurised goat milk did not change during the ripening process, however, the tocopherol concentration decreased with increasing ripening time, in particular by 11.56% at the 18th month and remained at this level until the 30th month of ripening compared to 7-day cheese (Table 1).

Table 1. Vitamin composition of brined Feta cheese, x ± SD, mg/kg

Vitamin name	Cheese ripening period		
	7 days	18 months	30 months
Retinol	5.06 ± 0.65^{a}	5.96 ± 0.46^{a}	5.80 ± 0.43^{a}
Tocopherol	2.25 ± 0.11^{a}	1.99 ± 0.06^{b}	1.98 ± 0.13^{b}
Riboflavin	2.10 ± 0.33^{a}	2.08 ± 0.26^{a}	2.99 ± 0.30^{b}

Note: different superscript letters indicate a significant difference between values in a row of the table ($P < 0.05$) using the Tukey test with Bonferroni correction

Among the B vitamins, riboflavin is of particular importance, the concentration of which in Feta cheese fluctuated at the same level from the 7th day to the 18th month of ripening, and at the age of 30 months, its increase by 42.38% compared to the initial value was detected.

Table 2. Vitamin composition of dry matter of brined Feta cheese, x ± SD, mg/kg

Vitamin name	Cheese ripening period		
	7 days	18 months	30 months
Retinol	9.22 ± 1.39^{a}	10.57 ± 0.99^{a}	10.52 ± 0.68^{a}
Tocopherol	4.09 ± 0.27^{a}	3.53 ± 0.15^{b}	3.59 ± 0.20^{b}
Riboflavin	3.82 ± 0.70^{a}	3.68 ± 0.47^{a}	5.43 ± 0.63^{b}

Note: different superscript letters indicate a significant difference between values in a row of the table ($P < 0.05$) using the Tukey test with Bonferroni correction

The content of vitamin A in the dry matter of Feta cheese did not depend on the period of its ripening, and the content of tocopherol decreased starting from the 18th month by 13.69% and remained at this level until the 30th month (Table 2).

The concentration of riboflavin in the dry matter of Feta cheese from the 7th day to the 18th month of ripening did not significantly change, and at the 30th month it was characterised by an increase of 42.15% (Table 2).

The vitamin composition of Chevre cheese was characterised by some features during the ripening period. The content of retinol and tocopherol in this cheese remained constant throughout the entire ripening period (Table 3). At the same time, the content of riboflavin in the cheese from 3 days to 20 days of age remained stable, and on the 40th day of ripening, an increase in its content by 42.77% was found.

Table 3. Vitamin composition of Chevre cheese, x ± SD, mg/kg

Vitamin name	Cheese ripening period, days		
	3	20	40
Retinol	5.45 ± 0.38^{a}	6.05 ± 0.37^{a}	6.04 ± 0.35^{a}
Tocopherol	2.19 ± 0.08^{a}	2.24 ± 0.12^{a}	2.25 ± 0.11^{a}
Riboflavin	1.73 ± 0.16^{a}	1.88 ± 0.14^{a}	2.47 ± 0.28^{b}

Note: different superscript letters indicate a significant difference between values in a row of the table ($P < 0.05$) using the Tukey test with Bonferroni correction

The dynamics of retinol and tocopherol in the dry matter of Chevre cheese developed in a similar way (Table 4). The riboflavin content in Chevre cheese from the 3rd to the 20th day of ripening was at the same level, and on the 40th day it exceeded the similar indicator of the 3-day cheese by 28.91%.

Table 4. Vitamin composition of dry matter of Chevre cheese, x ± SD, mg/kg

Vitamin name	Cheese ripening period, days		
	3	20	40
Retinol	13.26 ± 0.90^{a}	14.73 ± 0.94^{a}	13.36 ± 1.21^{a}
Tocopherol	5.35 ± 0.21^{a}	5.44 ± 0.32^{a}	4.97 ± 0.37^{a}
Riboflavin	4.22 ± 0.36^{a}	4.59 ± 0.38^{a}	5.44 ± 0.58^{b}

Note: different superscript letters indicate a significant difference between values in a row of the table ($P < 0.05$) using the Tukey test with Bonferroni correction

Correlation and regression analysis showed a strong direct linear dependence of the riboflavin content in the dry matter of Chevre cheese on the ripening period ($r = 0.768 \pm 0.128$, $P<0.01$) (Fig. 2).

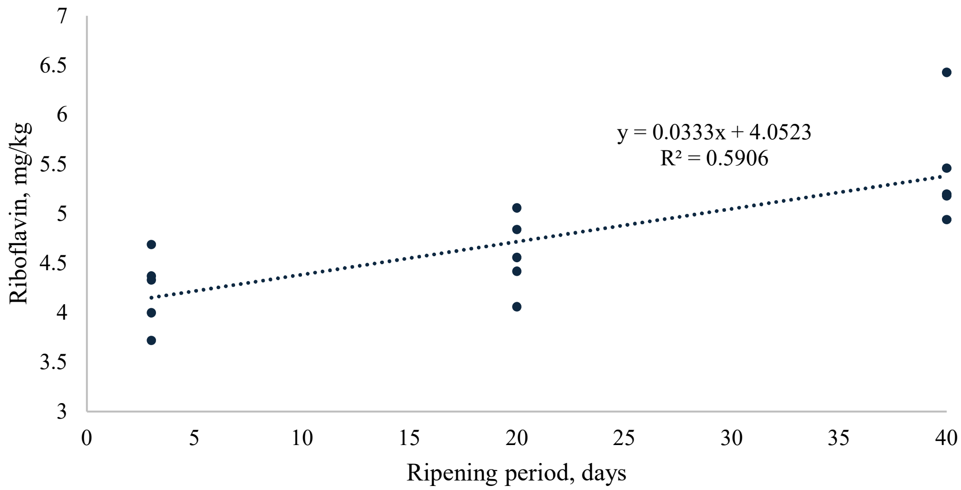

Fig. 2. Dependence of riboflavin content in dry matter of Chevre cheese on ripening period, n =15

Discussion

The vitamin composition of dairy products, in particular cheeses, is of considerable importance in covering their deficiency, especially in population groups that require functional nutrition. As for vitamin A, its deficiency is noted worldwide and represents a significant public health problem (Bora, 2022). The determination of retinol content in brine Feta cheese and Chevre cheese with white noble mould revealed that its concentration did not depend on the term of their ripening. The presence of salt in brine Feta cheese also did not affect the dynamics of the concentration of this vitamin. However, in another study (do Oriente et al., 2020) showed that the salt content in goat cheese significantly increased the level of vitamin A to 3.87 ng/ml, compared to unsalted cheese, where the retinol content reached 1.27 ng/ml. The authors of this study believe that the salt level determines the degree of vitamin A retention in cheese, which does not contradict the results of our study. In addition, the ability of the cheese microbiome to synthesise some vitamins is also determined by the bacteriostatic ability of salt (Bansal and Mishra, 2020). In two studies of the vitamin composition of Roja Mallorquina cheese made from sheep's milk (Gutiérrez-Peña et al., 2021), as well as Feta cheese made from goat milk (Kondyli et al., 2016), showed an inverse dependence of retinol content on their ripening period. At the same time, in the dry matter of fresh Roja Mallorquina cheese contained 3.76 mg/kg of retinol compared to 2.34 mg/kg in ripened, which does not coincide with the dynamics of this vitamin obtained in the cheeses of our study. Tocopherol content in dry matter of Roja Mallorquina cheese at the end of ripening decreased from 3.62 mg/kg to 0.33 mg/kg (Gutiérrez-Peña et al., 2021). This pattern was confirmed when analysing the dynamics of tocopherol content in goat Feta cheese with a ripening period of 60 days (Kondyli et al., 2016) and in our study in Feta cheese with a ripening period of 30 months, but this was not typical for Chevre cheese with a short ripening period. It should be noted that in our study, the absolute values of retinol and tocopherol content in goat cheeses Feta and Chevre were higher than in sheep cheese Roja Mallorquina.

It is important to compare the accumulation of retinol in cheeses made from unpasteurised milk of small ruminants. In this respect, soft goat cheeses Feta and Chevre outperformed similar indicators of Italian cheeses, in particular soft sheep cheese Vastedda della Valle del Belìce (PDO), which, with a ripening period of 20 days, contained 2.5-2.7 mg/kg of retinol, and semi-hard goat cheese Caprino Nicastrese of similar age – 2.9-4.1 mg/kg of this vitamin (Di Trana et al., 2022). In the study (Lodianov et al., 2021) found a slightly lower retinol content (1.2-1.4 mg/kg) in Feta cheese than in our study, but the tocopherol content was within 1.8 mg/kg, which was close to our data. In the same study, the riboflavin content in Feta cheese reached 8.4-8.5 mg/kg, which exceeded the similar values obtained in our studies of both soft cheeses.

The main source of riboflavin in cheeses is animal milk, but it is known that during the ripening of cheeses, their autochthonous microflora provides lipolysis, proteolysis and synthesis of individual vitamins (Vázquez-García and Martín-del-Campo, 2023). Despite the high solubility of B vitamins in milk whey, which causes their significant loss during whey removal from cheese grains, lactic acid bacteria of the genera Lactococcus and Streptococcus are able to synthesise vitamins B_2 and B_6 (Ferroukhi et al., 2022). It has been proven that *Limosilactobacillus reuteri* in the presence of yeast bacteria *Streptococcus thermophilus,* capable of synthesising up to 18.36 µg/ml of riboflavin (Spacova et al., 2022). For some strains of *Lactococcus cremoris, L. lactis, Limosilactobacillus fermentum* is also characterised by this property (Langa et al., 2024). This is confirmed by our results of studies of goat cheeses Feta and Chevre, in which the level of riboflavin increased during the ripening process, which occurred, probably, due to microbial synthesis.

The differences in the vitamin composition of Feta and Chevre cheeses made from unpasteurized goat milk and other cheeses, which are described in a number of studies cited above, may be associated with the different composition of their microbiome (Davydovych et al. 2025b; Sadvari et al. 2025), as well as the chemical composition of the raw milk (Nguyen, 2022), breed and species characteristics of ruminants, the composition of their feeding ration (Guzmán et al., 2024; Król et al., 2020), the production season (Mylostyvyi et al., 2023; Necula et al., 2024; Oliynyk et al., 2025), as well as the technology and recipe for making cheeses (Gherghina et al., 2021; Iakubchak, et al. 2024; Savchenko et al., 2024). Thus, it can be assumed that Feta and Chevre cheeses made from unpasteurised goat milk have certain features of the accumulation of vitamins, in particular retinol, tocopherol, and riboflavin, which can be taken into account when determining their authenticity and biological value.

Conclusions

The retinol content in soft Feta and Chevre cheeses made from unpasteurised goat milk did not depend on the ripening period. The tocopherol concentration in Chevre cheese throughout the ripening period was characterised by high stability. With an increase in the ripening period to 18 months, the tocopherol content in brine Feta cheese decreased by 11.56%, remaining at this level until the 30th month. The riboflavin content in Feta cheese from 7 days to 18 months of age and in Chevre cheese from 3 days to 20 days of age did not undergo significant changes. In Feta cheese at the age of 30 months, an increase in the content of vitamin B_2 by 42.38% was found, and in cheese Chevre on the 40th day revealed an increase in its level by 42.77%. It was proven that there is a strong direct linear dependence of the content of riboflavin in the dry matter of Chevre cheese on the ripening period (r = 0.768 ± 0.128, P<0.01). The dynamics of the vitamin composition of the dry matter of brine Feta cheese and cheese with white noble mould Chevre retained the patterns of changes characteristic of cheeses of natural moisture. The obtained results of the vitamin analysis of goat cheeses from unpasteurised milk, Feta and Chevre, confirm their high biological value and can be a justification for determining the criteria for authenticity in combination with other biological and physicochemical characteristics.

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