Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2021, 11(2), 144-148, doi: 10.15421/2021_91

ORIGINAL ARTICLE

Comparative analysis of the criteria for goat milk assessment in Ukraine and France

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Received: 24.03.2021. Accepted: 24.04.2021.

The safety and quality of raw milk in Ukraine remained the biggest problem in the retooling of dairy enterprises by the newest processing lines and modern quality control systems. This research aimed to scientifically substantiate the requirements of the Ukrainian standard for goat milk, especially for indicators of acidity, density, somatic cell count, and bacterial contamination. This requires conducting a comparative analysis of the criteria for assessing the safety and quality of goat milk in Ukraine and abroad to harmonize with the relevant legal documents of the European Union; to conduct monitoring studies on the quality and safety of goat milk in France and Ukraine. The monitoring of indices of goat milk in Ukraine was conducted compared to the similar ones in the laboratory of milk LILCO (Laboratoire Interprofessionnel Laitiere du Centre Ouest - Interprofessional milk laboratory of center and west), Surgères, France. Statistical data of goat milk analyses by seasons were obtained in the laboratory LILCO. Samples of goat milk in Ukraine were taken from farms of Dnipropetrovs'k oblast, Ukraine. The most fat and protein content in goat milk were fixed during winter as in Ukraine also in LILCO, France, significant differences were determined concerning other seasons.
It was found that the existing standard does not meet the international requirements for goat milk based on the leading indicators (bacterial contamination, somatic cells, acidity, and density). The ineffectiveness of the criteria of density and acidity for goat milk assessment was substantiated because of their insignificance. It was proposed to eliminate the requirements for the density and acidity of goat milk from "Goat's milk. Raw. Specifications: DSTU 7006: 2009", to reduce the requirements for the fat and protein content, and to meet the requirements for the somatic cell count and bacterial contamination following European standards.
Keywords: goat milk, fat, protein, somatic cells, density, acidity, season.

Introduction

Economic research has highlighted that along with other factors, the increasing animal productivity and wholesale prices for meat and milk would be the essential reserves in supporting food security in the agricultural clusters (Vasylieva, 2017). Kalyankar *et al*. (2016) mark that although goats have been the most ignored domesticated species in many parts of the world, they have played an essential role in human nutrition and well-being. The goat milk and its processed specialty products are beneficial as functional foods, maintaining nourishment and health for the young and elderly, especially those who have a cow milk allergy. The relationship between goat milk protein components and allergic reaction to milk and milk intolerance is also discussed (Greppi *et al*., 2008). The use of medicinal plants in the treatment and hygiene of productive animals is deeply studied by scientists of Ukraine (Zazharskyi *et al*., 2019; Sklyarov *et al*., 2020).
Somatic cell count (much more than in cow milk) is one of the biggest problems in goat milk. Leitner *et al.* (2016) propose thresholds and cut-off levels indicating a decrease in milk quality, consequently influencing product quantity and quality. 3500×10^3 cells/ml is suggested as the cut-off level for goat milk. Brito *et al*. (2009) assess somatic cell count and other milk quality indicators (fat, protein, lactose, and total solids) for goat milk bulk tank. The influence of the herd and year-season on the milk composition and herd, milking system, and year-season on SCC were also evaluated. The average somatic cell count values of herds milked by hand and machine were 1121 and 848×10^3 cells/ml, respectively. In both groups, the somatic cell count was lower in the winter and higher in the autumn.
It is marked that somatic count contents in goat milk in the morning and evening yield of milk is different. In the evening yield of milk, the somatic cell count is 30 % higher than in the morning one. Low and fairly constant somatic cell content (15 to 63×10^3 cells/ml) is observed in the milk of primiparous goats (Fotina *et al.,* 2018). Wanniatie *et al*. (2019) compare microbiological quality

between organic and conventional goat milk in Bogor District, West Java Province, Indonesia. In conclusion, the microbiological quality of organic and conventional goat milk in Bogor was relatively similar and appropriate within the Indonesian National Standard.
This research aimed to scientifically substantiate the requirements of the Ukrainian standard for goat milk, especially for indicators of acidity, density, somatic cell count, and bacterial contamination. This requires conducting a comparative analysis of the criteria for assessing the safety and quality of goat milk in Ukraine and abroad to harmonize with the relevant legal documents of the European Union; to conduct monitoring studies on the quality and safety of goat milk in France and Ukraine.

Materials and methods

Data of goat milk analyses were obtained in the laboratory LILCO (Laboratoire Interprofessionnel Laitiere du Centre Ouest - Interprofessional milk laboratory of center and west), Surgères, France. Laboratory analyses 16 thousands of milk samples a day. All chemical analysis of milk in France performed using infrared spectroscopy by device MilkoScanTM FT+ and flow cytometry – by FossomaticTM FC. Microbial contamination of milk was determined by epifluorescence microscopy (FOSS Integrated Milk Testung BactoScanFC).
Samples of goat milk in Ukraine were taken from farms of Dnipropetrovs'k oblasts, Ukraine (47-70 samples depending on season). The research was conducted in the laboratory of Parasitology and Vet Expertise Department of Dnipro State Agrarian and Economic University. Physico-chemical parameters of goat's milk were determined using the utilizing ultrasonic analyzer of milk of "Ekomilk type MILKANA KAM 98-2a" (Bulgary), the somatic cell count was determined at viscometric analyzer "Somatos-M" (Russia). Also, somatic cell count was determined by the SomaCount Flow Cytometer (flow cytometry method) in the laboratory "Dairy Management Systems" of the Dnipropetrovsk regional public organization "Agricultural Consulting Service".
The data were analyzed in Statistica 6.0 (StatSoft Inc., USA). The data in the tables are presented as x ± SE (x ± standard error). The differences between the values in groups were determined using the Tukey test, where the differences were considered significant at $P < 0.05$ (with taking into account the Bonferroni correction).

Results and discussion

There is National Standards of Ukraine (DSTU) 7006:2009 "Goat's Milk. Raw. Specifications" in our country. The basic requirements for indicators of quality and safety of goat's milk following the standard and requirements in European countries are given in Table 1.
According to Regulation (EC) No. 853/2004, raw milk of other species (except cows) must comply with the following microbiological criteria: plate count at a temperature of 30°C ≤ 1500 $\times 10^3$ CFU/ml. However, if raw milk from species other than cows is intended for the manufacture of products made with raw milk by a process that does not involve any heat treatment, food business operators must take steps to ensure that the raw milk used meets the following criterion: plate count at 30°C ≤ 500 $\times 10^3$ CFU/ml.
According to the requirements of National Standards of Ukraine (DSTU) 7006:2009 "Goat's Milk. Raw. Specifications" the number of mesophilic aerobic and extra-anaerobic microorganisms of milk of the second grade (the extreme limit) corresponds to the best milk under the European regulations (Table 1).

Table 1. Requirements for physicochemical and hygienic indicators of goat milk in Ukraine (DSTU 7006:2009 "Goat's Milk. Raw. Specifications").

Indicators, unit	The norm for the grades			Requirements in France
	higher	first	second	
Density at 20 °C, kg/m^3, not less than	1028	1027	1027	Not Determined
Acidity, °T	15-18	≤ 19	≤20	Not Determined
The clean, group, not lower than	I	I	I	Not Determined
Freezing temperature, not higher than, °C	-0,520	-0,520	-0,520	recommended -0,540
Total solids, %	≥ 14,0	≥ 13,5	≥ 13,0	not determined
Fat, %	≥ 3,5	≥ 3,5	≥ 3,5	≥ 3,3
Protein, %	≥ 3,0	≥ 3,0	≥ 3,0	≥ 2,8
The number of mesophilic aerobic and extra-anaerobic microorganisms, $\times 10^3$ CFU/ml	≤ 100	100-300	300-500	≤ 500
Somatic cell count $\times 10^3$ cells/ml	≤500	≤600	≤800	≤ 1 000

By the requirements of most European countries and the USA, the best goat milk is considered with a somatic cell count ≤ 1 million/ml (Maurer et al., 2013). According to the National Standards of Ukraine (DSTU) requirements, goat's milk of the second grade should contain <800 $\times 10^3$ cells/ml. So, the somatic cell count requirements and bacterial contamination in the Ukrainian normative document are very strict. Indicators of density and acidity of goat milk are not regulated in EU countries but regulated in Ukrainian standards. Laboratory LILCO in France determines fat, protein, somatic cell count, freezing temperature, lipolysis, microbial contamination, inhibitors, IgG, butyric bacteria in the goat milk. As to fat and protein content in goat milk, French farmers are recommended: ≥ 3.3% fat and ≥ 2,8% protein, but variations are allowable over the year. The freezing point is indicated in the National Standards of Ukraine (DSTU) for goat milk is not higher than -0.520°C, but it should be determined only on suspicion of dilution of milk with water. In other cases, it is enough to measure the density of milk. Such a characteristic as lipolysis of milk is not determined at all in the routine analysis of milk in Ukraine, but this indicator is very important for cheese characteristics, so it is mandatory in the analysis of milk in France. Based on the analysis of the criteria for assessing the safety and quality of goat milk in Ukraine and abroad, it has been established that the existing normative document (DSTU) 7006:2009 "Goat's Milk. Raw. Specifications" does not meet the international requirements for goat milk, especially in somatic cell count and bacterial contamination (Regulation (EC) No. 853/2004).

In France, every farmer is interested in product quality improvement because it affects the price of milk. LILCO – one of 16 laboratories for control of milk quality in France. LILCO serves more than five thousands farmers who get milk from cows and goats. Laboratory analyses the milk from the herd of each farmer three times a month. Based on the milk analysis laboratory results, the price that the dairy company has to pay to the farmer.
There are statistical data of LILCO by seasons (Table 2).

Table 2. Indicators of goat milk by seasons (statistical report data) in LILCO, France, (x ± SE).

Indicators, unit	Seasons			
	spring	summer	autumn	winter
Fat, %	3.85±0.08a	3.40 ± 0,09b	3.92 ± 0.13a	4.35 ±0.08c
Protein, %	3.31 ± 0.07a	3.16 ± 0.09a	3.58 ±0.08b	3.70 ± 0.06b
Freezing temperature, °C	-0.549 ± 0.001	-0.549 ± 0.001	-0.549 ± 0.001	-0.549±0.001
Somatic cell count, $\times 10^3$ cells/ml (flow cytometry method)	1594 ± 338	2046 ± 304	2698 ± 419	2361 ±545
bacterial contamination $\times 10^3$ CFU/ml	19.8 ± 1.1	20.7 ± 1.5	24.5 ± 1.8	28.2 ±2.4

Note: different letters within the line correspond to the selections, which had significant differences between one another according to the results of Tukey's test ($P < 0.05$) with Bonferroni correction.

In winter, the fat in the milk samples was significantly more than in spring, summer, and autumn by 0.5%, 0.95%, and 0.43%, respectively ($P < 0.05$). In winter, the protein in goat milk was also significantly more than in spring and summer by 0.39% and 0.54%, respectively ($P < 0.05$). There are no significant differences between somatic cell count by seasons in France because this parameter is very variable. However, indexes in autumn and winter are more than in spring by 69.3% and 48.1%, respectively. The fat content in the goat milk in winter in Ukraine (Table 3) was significantly more than in spring, summer and autumn by 1.68%, 1.62%, and 1.11%, respectively ($P < 0.05$).

Table 3. Indicators of goat milk by seasons in Ukraine, M ± m.

Indicators, unit	Season, samples			
	spring, n = 57	summer, n = 70	autumn, n = 55	winter, n = 47
Fat, %	3.40±0.20a	3.46 ± 0.12a	3.97 ± 0.17a	5.08 ±0.21b
Protein, %	3.12 ± 0.03a	2.83 ± 0.03b	3.14 ± 0.03ac	3.25 ± 0.05c
Freezing temperature, °C	-0.555 ± 0.005a	-0.540 ± 0.003b	-0.553 ± 0.004a	-0.551 ± 0.009ab
Somatic cell count, $\times 10^3$ cells/ml (viscosimetric method)	631 ± 104	697 ± 81	817 ± 159	647 ± 169
Somatic cell count, $\times 10^3$ cells/ml (flow cytometry method, n = 76	1079 ±323			

Note: different letters within the line correspond to the selections, which had significant differences between one another according to the results of Tukey's test ($P < 0.05$) with Bonferroni correction.

In winter, the protein in goat milk was also significantly more than in spring and summer by 0.13% and 0.42%, respectively ($P < 0.05$). Indicators of fat and protein in goat milk are drastically reduced in the summer and spring; therefore the requirements in the Ukrainian normative document of 3.5 and 3.0% respectively are not substantiated. The lowest index of freezing temperature in the goat milk was observed in spring, the highest – in the summer – -0.540 ± 0.003 oC ($P < 0.05$). These indexes of somatic cell count (even by viscosimetric method) do not correspond to the "higher" grade of goat's milk following "Goat's milk. Raw. Specifications: DSTU 7006: 2009" – up to 500×10^3 cells/cm^3.
Unfortunately, it was not possible to explore the somatic cell count in Ukraine by flow cytometry method seasonally, but the common index shows that this method is more accurate than the viscosimetric method. The exact somatic cell count in goat's milk should be determined only by direct microscopic or fluoroptoelectronic counting.
The most fat and protein content were fixed during winter as in Ukraine also in LILCO, France (Tables 2 and 3). It could be explained not a big amount of goat milk in winter but more concentrated.
According to the French laboratory, the freezing temperature of goat milk is -0.549°C, according to the requirements of the Ukrainian standard - not higher than -0.52°C.
According to our research in Ukraine, the indicators of acidity in goat milk vary from 14 to 27 °T. The lowest index of acidity in goat milk was observed in the spring - 17.3±2.7 °T, and the highest – in the winter (22.7 ± 4.3 °T). By the requirements, the density of goat's milk is 1027-1029 kg/m^3, which corresponds to 27–29 °A. According to our research, the density varied from 25.6 to 35.4 °A. Significant fluctuations in the indexes of acidity, density, and somatic cell count of goat milk during the year were noted. Information on chemical composition and its seasonal variety of bull-collected goat milk is limited.
In a study conducted by Souza G. et al., all the milk components in 913 samples of bulk milk from 7 herds significantly changed depending on the season and herds. The average fat content in this study was 3.44%, with a minimum value of 3.15% and a maximum value of 3.87% (Souza et al., 2009). The highest protein was in summer (Guo et al., 2001). The mean values of fat in the milk of Tswana goats 4.40% (Aganga et al., 2002). Content of protein in the milk of Saanen and Alpine goats from 27.0 to 29.2 g/kg (on average 2.8%), and fat content equal to 30.2–34.1 g/kg (on average 3.2%) (Maurer et al., 2013). According to the other

data, the protein content in milk of the British Saanen goat is 2.6%, of Nubian in Great Britain – 3.6%, Alpine and Saanen in France – 3.2%, and fat content of 3.5%, 4.9%, and 3.6%, respectively (Yangilar, 2013). In our previous studies, a significant increase of fat and protein content in goat's milk was recorded after improving the diet (Zazharska et al., 2018). Also, it was proven that bacterial contamination of milk in Ukraine according to European requirements (up to 100 $\times 10^3$ CFU/ml) is possible only when rapid cooling to 4oC and storing in the cooling tank (Zazharska, 2016).
The freezing temperature of regular goat milk should be below -0.534 °C (Fulton C. 2012). According to Maurer et al. (2013) (Switzerland), freezing temperature of goat milk is <-0.540 °C.
Based on the obtained results, the analysis of statistical data from France and literary sources, the following requirements were suggested (Table 4).

Table 4. Proposed requirements for physico-chemical and hygienic indicators of goat milk in Ukraine.

Indicators, unit	**The norm for the grades**		
	higher	**first**	**second**
Freezing temperature, °C	-0.540	-0.540	-0.540
Fat, %	≥ 3.3%	≥ 3.3%	≥ 3.3%
Protein, %	≥ 2.8%	≥ 2.8%	≥ 2.8%
The number of mesophilic aerobic and extra-anaerobic microorganisms, $\times 10^3$ CFU/ml	≤ 100	≤ 500	≤ 1500 (only for the products with heat treatment)
Somatic cell count, $\times 10^3$ cells/ml (flow cytometry method or direct microscopy)	< 1000	< 1000	< 1500
Somatic cell count, $\times 10^3$ cells/ml (viscosimetric method)	< 500	< 600	< 800

We propose not to regulate the acidity and density of goat's milk due to the large fluctuations of these indicators in healthy goats. The freezing temperature is the most accurate indicator of milk dilution with water and not the density index.
For high-quality goat milk, the criterion of microbial contamination ≤ 100 $\times 10^3$ CFU/ml is proposed that corresponds to the "extra" grade of cow's milk, which means the highest hygienic quality and higher payment to the farmer.
The criteria for the somatic cell count in DSTU 7006: 2009 should be specified with the obligatory indication of the measurement method - "viscosimetric" and " flow cytometry method or direct microscopy ". The distribution of the somatic cell count by the grades proposed based on the own results and studies of foreign researchers.

Conclusion

The most fat and protein content in goat milk were fixed during winter as in Ukraine also in LILCO, France, significant differences were determined concerning other seasons. It was established that the somatic cell count in the milk of healthy goats much exceeds the index given in DSTU 7006: 2009 "Goat's milk. Raw. Specifications". It was proposed to eliminate the requirements for the density and acidity of goat milk from DSTU, reduce the requirements for the fat and protein content, and meet the requirements for the somatic cell count and bacterial contamination according to European standards.
Changes to the standard "Goat's milk. Raw. Specifications: DSTU 7006: 2009" has been developed and proposed for Technical Committee 158 "Animal husbandry: technology, tribal affairs, and reproduction" in Ukraine.

Acknowledgments

The authors highly acknowledged the LILCO (Laboratoire Interprofessionnel Laitier du Centre Ouest – Interprofessional milk laboratory of center and west), Surger, France; the laboratory "Dairy Management Systems" of the Dnipropetrovsk regional public organization "Agricultural Advisory Service", for providing research facilities to carry out some part of this work.

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Citation:

Zazharska, N., Fotina, T., Yatsenko, I., Tarasenko, L., Biben, I., Zazharskyi, V., Brygadyrenko, V., Sklyarov, P. (2021). Comparative analysis of the criteria for goat milk assessment in Ukraine and France. Ukrainian Journal of Ecology, 11 (2), 144-148.