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Microbiological quality and chemical composition of goat milk

Mikrobiologische Qualität und chemische Zusammensetzung von Ziegenmilch

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Summary

The interest in goat milk and goat milk products is increasing worldwide. Therefore, this study considers the chemical composition and microbiological quality of bulk goat milk of a medium-sized German cheese factory over a period of 15 months. Total solids, protein, fat and lactose contents of 24 samples were examined. 27 samples were analysed for the total bacterial count as well as the counts of pseudomonads, enterobacteria, lactic acid bacteria, yeasts, moulds and coagulase-positive staphylococci. Furthermore, examinations for *Bacillus cereus, Salmonella* spp. and *Listeria monocytogenes* were performed. The mean value of protein was 3.0 %, fat 3.6 %, lactose 3.7 % and total solids 10.9 %, whereby data were influenced by seasonal factors. The average total bacterial count was 6.1 lg cfu/ml, mainly formed by psychrotrophic, potentially spoilage inducing pseudomonads, but also by lactic acid bacteria, yeasts and moulds. A seasonal influence on the microbiological quality was not detectable. Chemical results show that goat milk with its high levels of lactose and protein is a valuable foodstuff. However, strict production hygiene and, with regard to psychrotrophic bacteria, the avoidance of prolonged cooled storage are necessary to guarantee an acceptable microbiological quality and stability.

Keywords: goat milk, pseudomonads, yeasts, enterobacteria, fat, protein, lactose

Zusammenfassung

Das Interesse an Ziegenmilch und Ziegenmilchprodukten ist weltweit steigend. Die 15-monatige Studie beschäftigt sich mit der chemischen Zusammensetzung und der mikrobiologischen Qualität von Ziegen-Sammelmilch in einer mittelgroßen deutschen Käserei. Die Trockenmasse-, Protein-, Fett- und Laktosegehalte von 24 Proben wurden untersucht. Bei 27 Proben wurden die Gesamtkeimzahl sowie die Keimzahlen von Pseudomonaden, Enterobakterien, Milchsäurebakterien, Hefen, Schimmelpilzen und koagulase-positive Staphylokokken bestimmt. Außerdem wurden die Proben auf *Bacillus cereus, Salmonella* spp. und *Listeria monocytogenes* untersucht. Im Durchschnitt wurden folgende Gehalte ermittelt: Protein: 3,0 %, Fett: 3,6 %, Laktose: 3,7 % und Trockenmasse: 10,9 %, wobei diese Daten jahreszeitlich beeinflusst waren. Die mittlere Gesamtkeimzahl betrug 6,1 lg KbE/ml und bestand hauptsächlich aus psychrotrophen und potenziell Verderbnis verursachenden Pseudomonaden, aber auch aus Milchsäurebakterien, Hefen und Schimmelpilzen. Ein jahreszeitlicher Einfluss auf die mikrobiologische Qualität wurde nicht festgestellt. Die chemischen Ergebnisse zeigen, dass es sich bei Ziegenmilch aufgrund des hohen Gehaltes an Protein und Laktose um ein wertvolles Lebensmittel handelt. Strikte Produktionshygiene und, mit Blick auf psychrotrophe Keime, die Vermeidung von längerer Kühllagerung sind für eine akzeptable mikrobiologische Qualität und Stabilität erforderlich.

Schlüsselwörter: Ziegenmilch, Pseudomonaden, Hefen, Enterobakterien, Fett, Protein, Laktose

Journal of Food Safety and Food Quality 69, Heft 5 (2018), Seiten 131–160

Introduction

The interest in goat milk and goat milk production is growing around the world (Guo et al., 2004; Trancoso et al., 2010; Navarro-Alarcón et al., 2011; Kumar et al., 2012; Yangilar, 2013). Annually, 801.6 million tons of milk are produced worldwide, including 18.3 million tons of goat milk (FAO, 2014). Goat milk has specific significance in countries where unfavourable climatic conditions prevail (Barbosa, 1993). 601.186 tons of the total goat milk volume are produced in America, 2.6 million tons in Europe, 4.1 million tons in Africa and 11.0 million tons in Asia (FAO, 2014). The top producers worldwide are India and Bangladesh (Trancoso et al., 2010; Barłowska et al., 2011). China has the largest goat herd with 185.8 million of globally about one billion goats (FAO, 2014). In contrast, only 16.5 million goats are kept in Europe (FAO, 2014). Leaders among Europe are France and Greece (Trancoso et al., 2010; Barłowska et al., 2011) where goat farming has specific economic significance, organisation and ancient traditions (Trancoso et al., 2010; Yangilar, 2013). According to estimations, there are currently 117 000 to 139 000 goats kept in Germany (FAO, 2014; Statistisches Bundesamt, 2016) and 37 238 t goat's milk produced (FAO, 2014).

Compared to cow milk, goat milk is better digestible (Jandal, 1996; Park et al., 2007; Navarro-Alarcón et al., 2011) and has a higher biological value and a smoother texture (Yangilar, 2013). Furthermore, it has therapeutic (Jandal, 1996; Barłowska et al., 2013) and hypoallergenic properties (Yangilar, 2013). In contrast, the higher production costs (Soryal et al., 2004), the goaty taste (Pandya and Ghodke, 2007) and a lower heat stability (Yangilar, 2013) are disadvantageous compared to bovine milk. The composition of goat milk is less constant compared to cow milk (Guo et al., 2004; Park et al., 2007; Yangilar, 2013) due to the reproduction cycle of goats, and depends on season of kidding (Kala and Prakash, 1990; Pal et al., 1996). Additionally, the chemical composition of milk is generally affected by a variety of further factors as stage of lactation (Pal et al., 1996; Antunac et al., 2001 a; Guo et al., 2001), lactation number (Kala and Prakash, 1990; Antunac et al., 2001 a), litter size (Ciappesoni et al., 2004), health status of the animals (Haenlein, 1996), daytime (Simos et al., 1991), climate (Mba et al., 1975), feeding (Morand-Fehr and Sauvant, 1980; Calderon et al., 1984; Morand-Fehr et al., 2007), breed (Antunac et al., 2001 b; Agnihotri et al., 2002) and genetical disposition (Kala and Prakash, 1990). The total solids content which consists mainly of lactose, protein and fat is inversely proportional to the milk yield of the individual animal during lactation and depends on the breed (Flamant and Morand-Fehr, 1982).

Little is known about bulk goat milk and its changes in microbiological and chemical parameters during the course of the year because most data deal with the composition and microbiological quality of single samples. Therefore, the aim of this study was to investigate the chemical (total solids, fat, protein and lactose) and microbiological (*Salmonella* spp., *Listeria monocytogenes, Bacillus cereus,* total bacterial count, counts of enterobacteria, pseudomonads, lactic acid bacteria, coagulase-positive staphylococci, yeasts and moulds) composition of bulk milk collected in a German cheese factory and its seasonal variation up to 15 months.

Materials and Methods

Sample-taking

Bulk milk samples of a German medium-sized cheese factory were collected. The goat milk originated from five regional farms keeping goats of the breeds "Bunte Deutsche Edelziege" and "Weiße Deutsche Edelziege". The goats were in various ages and lactation stages. The milk yield (215 to 2500 litres per day) and feeding systems (pasturage and feeding ad libitum in one farm, different relations between roughage and concentrate) of the five farms differed. Lambing took place from January to October with a main section in February and March. A dry period was not effected in any farm. The bulk milk had been stored in the tank of the cheese factory for three to six days before processing. Samples (24 for chemical and 27 for microbiological analysis) were taken from this tank twice a month from April 2013 to June 2014. Each sample (800 ml) was filled into sterile plastic bottles and transported to the laboratory in a cooling box.

Physico-chemical examination

24 samples were analysed twofold for protein, fat, lactose and total solids content after storage at 4 °C for a maximum of three days. The study was conducted from May 2013 to April 2014 based on DIN- and ISO-standards. The Kjehldahl-Method was used for the measurement of protein (Kjehldahltherm KB; titrator Vapodest 50 C. Gerhardt GmbH & Co. KG, DE) (DIN EN ISO, 2002). Fat contents were performed by the Weibull-Berntrop-Method (DIN, 1992) and by means of a Soxtherm-extraction-unit (C. Gerhardt GmbH & Co. KG, DE). Lactose was analysed using a test kit of R-biopharm and measured spectrophotometrically (Spekol 1200, Analytik Jena AG, DE) (DIN, 1982). Dry-oven-method was implemented for determination of total solids (DIN, 1988) by means of FD 240 (BINDER GmbH, DE). The pH-value was measured by means of a pH-Meter pH 340i (WTW GmbH, DE) and the electrode Sentix 61 (WTW GmbH, DE). Furthermore, the acidity was titrated with 0.25 molar sodium hydroxide solution (Honeywell Specialty Chemicals Seelze GmbH/ Riedel de Ha n, DE) following the national DIN method (DIN, 2000).

Microbiological examination

Microbiological examinations included the analysis of total bacterial count as well as the counts of lactic acid bacteria, pseudomonads, enterobacteria, coagulase-positive staphylococci, yeasts and moulds by surface plating technique, and the analysis for *Bacillus cereus, Salmonella* spp. and *Listeria monocytogenes.* In total, 27 samples were analysed within a maximum of twelve hours after sampling during the investigation period of 15 months (from April 2013 to June 2014). The following culture media were used: Plate-count-skim-milk-agar (PCM) for the total bacterial count, incubation 30 °C for 72 hours (ISO, 2013), deMan, Rogosa and Sharpe-Agar, modified pH-value: 6.5 (MRS) for lactic acid bacteria, incubation 37 °C for 72 hours (ISO, 1998), Yeast-Extract-Glucose-Chloramphenicol-Agar (YGC) for yeasts and moulds, incubation 25 °C for 96 hours (DIN, 2005), Cetrimid-Fucidin-Cephalothin-Agar (CFC) for pseudomonads, incubation 25 °C for 48 hours (VDLUFA, 1993), Baird-Parker-Agar for coagulase-positive staphylococci, incubation 37 °C for 24 hours (DIN EN ISO, 2003) and Violet-Red-Bile-Dextrose-Agar (VRBD) for enterobacteria using surface plating technique instead of pour plate

TABLE 1: *Results of chemical analysis of raw goat milk, n = 24 (May 2013–April 2014).*

g/100 ml	Average Value	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Minimum	Maximum	Relative SD
Protein	3.0	3.1	2.5	2.8	3.2	3.1	2.6	3.3	2.9	3.3	3.3	3.0	2.6	1.9	3.4	0.1
Fat	3.6	3.2	2.4	3.4	3.4	3.7	3.0	3.7	3.2	4.0	4.4	5.1	3.8	2.0	5.4	0.2
Lactose	3.7	4.3	4.1	3.7	4.2	3.7	3.3	3.1	2.9	4.0	3.7	3.9	3.3	1.9	4.4	0.2
Total solids	10.9	11.4	9.1	10.6	10.9	10.1	8.7	11.3	11.2	11.7	12.3	13.1	10.3	6.4	13.2	0.2

SD: Standard Deviation

method, incubation 37 °C, 18 hours (DIN ISO, 2009). 100 µl of suspension were applied on each of two plates for every dilution stage. Additionally, one millilitre of undiluted milk was spread on three plates for the investigation of coagulase-positive staphylococci, enterobacteria, yeasts and moulds to reach a detection limit of 1 cfu/ml. Gram stain assay, oxidase and catalase test were applied for the confirmation of the colonies. Species of the genus *Pseudomonas* were identified by biochemical reactions using Api 20 NE test (bioMérieux Deutschland GmbH, DE). The detection of *Salmonella* spp. was carried out according to DIN EN ISO (2007) and of *Listeria monocytogenes* according to DIN EN ISO (2005). Enumeration of *Bacillus cereus* was performed according to DIN EN ISO (2006).

The data are presented and discussed in logarithmised form. However, in case the available literature refers to non-logarithmised bacterial counts the data were compared with our non-logarithmised microbiological results.

Statistics

Data were evaluated by means of IBM SPSS Statistics 22 program for the investigation of Pearson-correlations, normal distribution and significant variations in the course of the investigation period. A significance level of 0.05 was assessed. Additionally, it was tested whether outside temperature or the daylight length (Anonymus, 2018 a; Anonymus, 2018 b) correlated with chemical and microbiological results of the milk by Pearson correlation. Relevant changes during the investigation period were determined by the T-Test for independent samples concerning normal distributed parameters and by the Whitney-U-Test, concerning not normal distributed parameters.

Results

Physico-chemical examination

The average pH-value of the samples was 6.7 with variations from 5.7 to 7.0, the acidity 6.3 °SH with variations from 4.9 to 7.0 °SH. In Table 1 results of the chemical analysis of raw goat milk are summarised. Total solids and fat were normal distributed in contrast to lactose and protein.

The contents (except for lactose and fat) are correlated on 5 %-level (r_{TS+fat} = 0.762; $r_{TS+protein}$ = 0.723; $r_{TS+lactose}$ = 0.412; $r_{fat+protein}$ = 0.640; $r_{protein+lactose}$ = 0.536). There could not be observed significant correlations of chemical parameters with neither the outside temperature nor the daylight length both generated by weather webpages (Anonymus, 2018 a; Anonymus, 2018 b). The winter (December 2013 to February 2014) in the region was particularly mild with temperatures frequently above 10 °C while the rest of the investigation period had the usual temperatures.

The protein, fat and total solid content were significantly higher from January to March compared to the rest of the year (t_{fat} = 3.447, P < 0.01; t_{TS} = 2.957, P < 0.01; $U_{protein}$ = -2.134, P < 0.05), whereas the lactose content varied during the year without any seasonal pattern or significant change.

TABLE 2: *Microbiological results of raw goat milk, n = 27 (April 2013–June 2014).*

lg cfu/ml	Average*	Minimum	Maximum	SD
Total bacterial count	6.1	4.3	7.5	0.9
Lactic acid bacteria	4.8	3.1	6.9	1.0
Pseudomonads	5.8	3.4	7.0	0.9
Enterobacteria	4.0	1.5	5.2	0.8
Yeasts and Moulds	4.8	3.4	6.0	0.7
Coagulase-positive staphylocci	1.9	none	2.7	1.0

*: Arithmetic average values of logarithmised bacterial counts (values below detection limit not respected); cfu: colony forming unit; none: not detected in 1 ml; SD: Standard Deviation

Microbiological examination

Arithmetic average of logarithmised bacterial counts (results below detection limit were not respected), minima, maxima and standard deviations are presented in Table 2.

Pseudomonads were the dominant flora with a mean value of 5.8 lg cfu/ml and there was a significant correlation between the total bacterial count and the number of pseudomonads (r = 0.710, p <0.01) which were identified as *Pseudomonas putida, aeruginosa* and *fluorescens.* Coagulase-positive staphylococci were detected in twelve out of 24 samples with an average value of 1.9 lg cfu/ml. *Bacillus cereus* was determined in two samples (4.3×10^1 and 0.9×10^0 MPN/ml) whereas *Listeria monocytogenes* and *Salmonella* spp. were not detected. Data correlated neither to outside temperature nor to daylight length. The bacterial counts were not normal distributed and varied widely during the investigation period (15 months). Seasonal patterns or peak values of all bacterial counts on certain investigation dates were not detectable as shown in Figures 1–6 for the total viable count, enterobacteria, pseudomonads, yeasts/ moulds, lactic acid bacteria and coagulase-positive staphylococci. Average values are also illustrated.

Discussion of chemical data

Aim of the chemical analysis was to define values of total solids, fat, protein and lactose as status quo determination in bulk milk which is used in dairy industry and to detect its seasonal compositional differences. The average values of bulk goat milk in our study were: fat: 3.6 %, lactose: 3.7 %, protein: 3.0 % and total solids: 10.9 %. The milk was obtained from five regional farms keeping goats of the high performance breeds "Bunte Deutsche Edelziege" and "Weiße Deutsche Edelziege".

The literature survey showed that most publications deal with goat milk samples of individual animals or single

Journal of Food Safety and Food Quality 69, Heft 5 (2018), Seiten 131–160

farms and investigation periods shorter than six months, which limits the comparability to our results and the informative value. Additionally, most data refer to milk of native, genetically unimproved breeds which are not strictly comparable to high performance breeds such as "Bunte Deutsche Edelziege" and "Weiße Deutsche Edelziege".

Our research contributes, thus, to the knowledge about the composition of bulk goat milk samples taken directly before processing in the course of more than one year.

Mayer and Fiechter (2012), for example, investigated milk of the same two breeds (15 animals per breed) over a period of eight months and fat and protein contents were similar to our values.

Nonetheless, Devendra (1972), Mba et al. (1975), Anifantakis and Kandarakis (1980), Mariani et al. (1987), Sung et al. (1999), Soryal et al. (2004) and Barłowska et al. (2013) referred total solid, fat and protein values comparable to ours for the high performance breeds British Alpine, Alpine, Saanen, Toggenburg and Polish Colour improved breed. The total solid values reported by Guo et al. (2001) and Morgan et al. (2003; French enterprises) are also similar to our data and were measured several times (Guo: n = 50, during one year; Morgan: n = 19, from February to October) in bulk milk samples of more than one farm keeping animals of the breeds Saanen, Nubian, LaMancha, Alpine and Toggenburg.

Most authors (e. g. Devendra, 1972; Mba et al., 1975; Anifantakis and Kandarakis, 1980; Mariani et al., 1987; Guo et al., 2001; Mayer and Fiechter, 2012; Barłowska et al., 2013) reported higher lactose contents above 4 % which is also reflected in the total solid content. Lower values and comparable to ours could be explained by subclinical mastitis/ higher somatic cell counts (Silanikove et al., 2014, Ying et al. 2002), feeding/lower feed intake (Morand-Fehr et al., 2007), breeds (Kala and Prakash, 1990, Antunac et al., 2001 a), genetical disposition (Kala and Prakash, 1990) and stage of lactation (Antunac et al., 2001 a).

In contrast to all aforementioned results, native, genetically not improved breeds, e.g. West African dwarf (18.2 %, Mba et al., 1975), Red Sokoto (15.9 %, Mba et al., 1975) as well as Indigenous breed, (14.8 %, Anifantakis and Kandarakis, 1980) reach lower milk yields but seem to produce milk which is much higher in total solid contents compared to high performance breeds (Mba et al., 1975; Anifantakis and Kandarakis, 1980; Barłowska et al., 2013). These breed differences probably explain the higher total solid contents

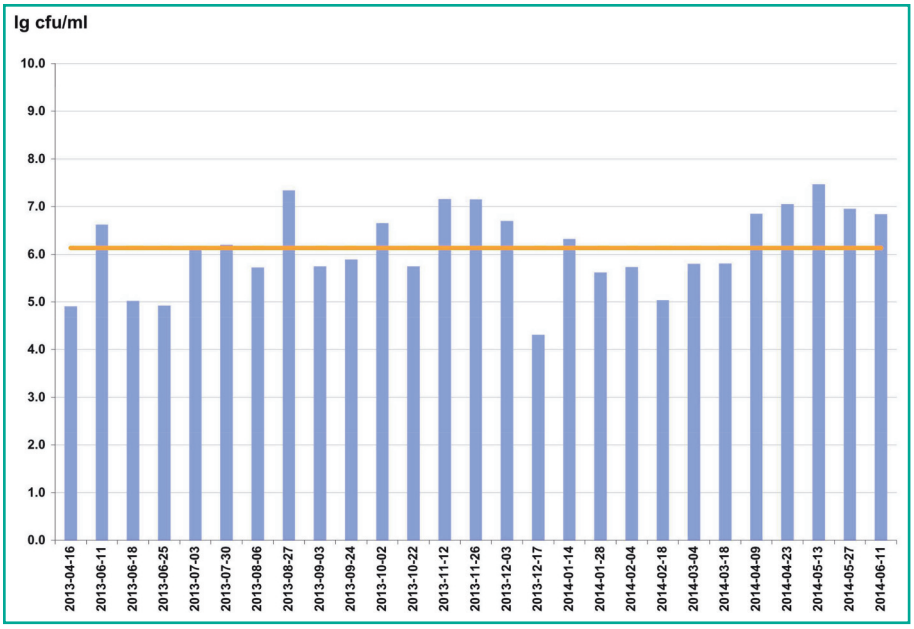

FIGURE 1: *Total bacterial count, orange line: arithmetic mean value 6.1 lg cfu/ml, x-axis: date of sampling (n = 27).*

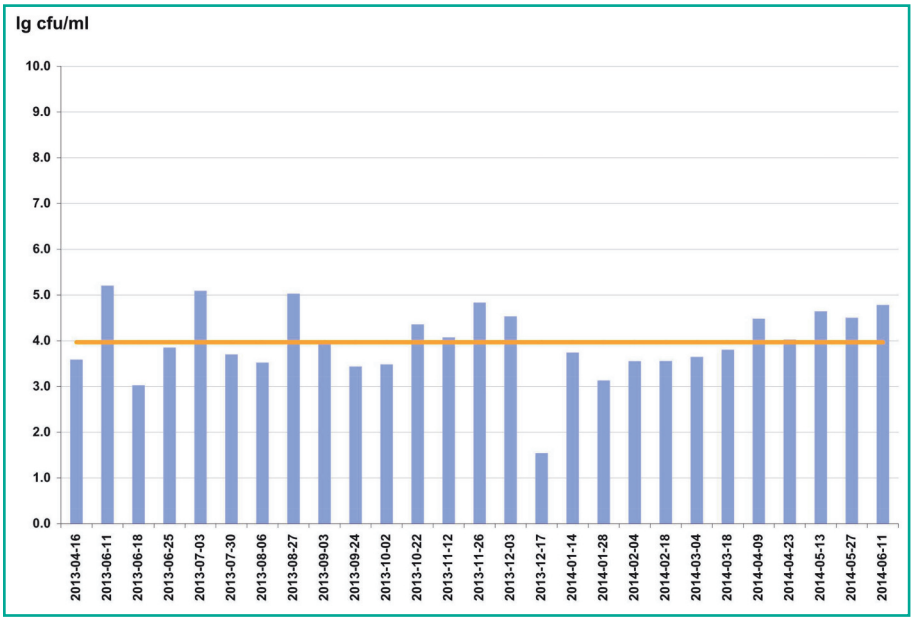

FIGURE 2: *Enterobacteria, orange line: arithmetic mean value 4.0 lg cfu/ml, x-axis: date of sampling (n = 27).*

(above twelve percent) reported by numerous authors for native breeds in comparison to our study (Uusi-Rauva et al., 1970; Agrawal and Bhattacharyya, 1978; Qureshi et al.,1981; Ghosh et al., 1982; Boros, 1986; Simos et al.,1991; Majee et al.,1994; Hadjipanayiotou, 1995; Aganga et al., 2002; Morgan et al., 2003 in Greek and Portuguese enterprises; Prasad et al., 2005; Kondyli et al.; 2012; Mestawet et al., 2012).

Relating to seasonal influences our study showed significantly higher protein, fat and total solids values from January to March compared to the rest of the year. An explanation for that fact might be related to the reproduction cycle of goats. The highest total solids, protein and fat contents are attained directly before lambing which is also described by Kala and Prakash (1990), Aganga et al. (2002), Kuchtík and Sedláčková (2003) and Rudovsky

(2008). The total solid content of bulk goat milk referred by Guo et al. (2001) reached its maximum in January, i.e. in late lactation similar to our study. The climatic conditions were comparable to ours.

In contrast, Boros (1986) reported the lowest protein and fat values in mid lactation and higher values in early and late lactation and Agnihotri et al. (2002) and Kondyli et al. (2012) found no significant changes in the chemical composition in dependence on lactation stage.

The lactose content either declined continuously (Kala and Prakash, 1990) or remained fairly constant with variations during the whole production cycle as in our study (Boros, 1986, Zeng and Escobar, 1995, Kuchtík and Sedláčková, 2003).

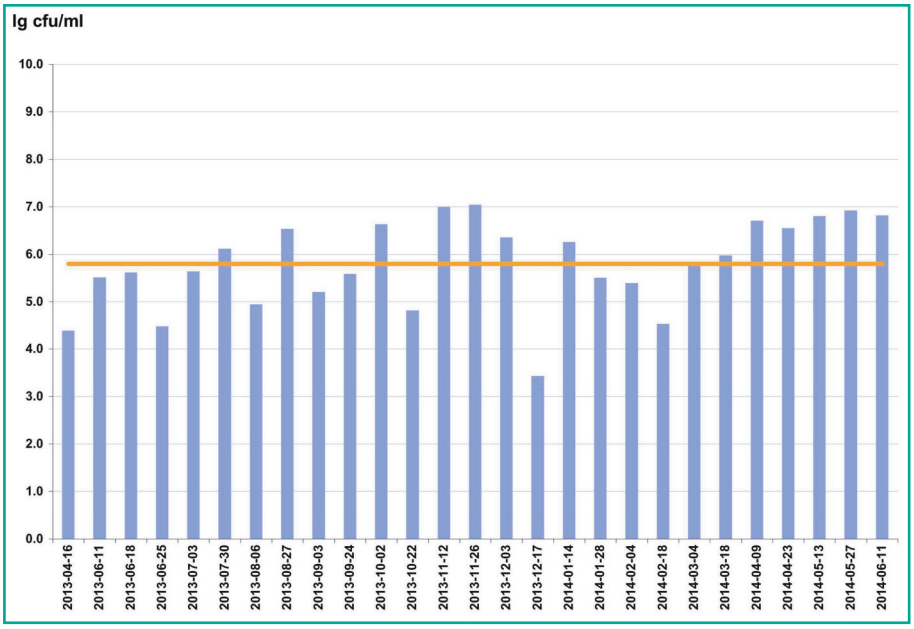

FIGURE 3: *Pseudomonads, orange line: arithmetic mean value 5.8 lg cfu/ml, x-axis: date of sampling (n = 27).*

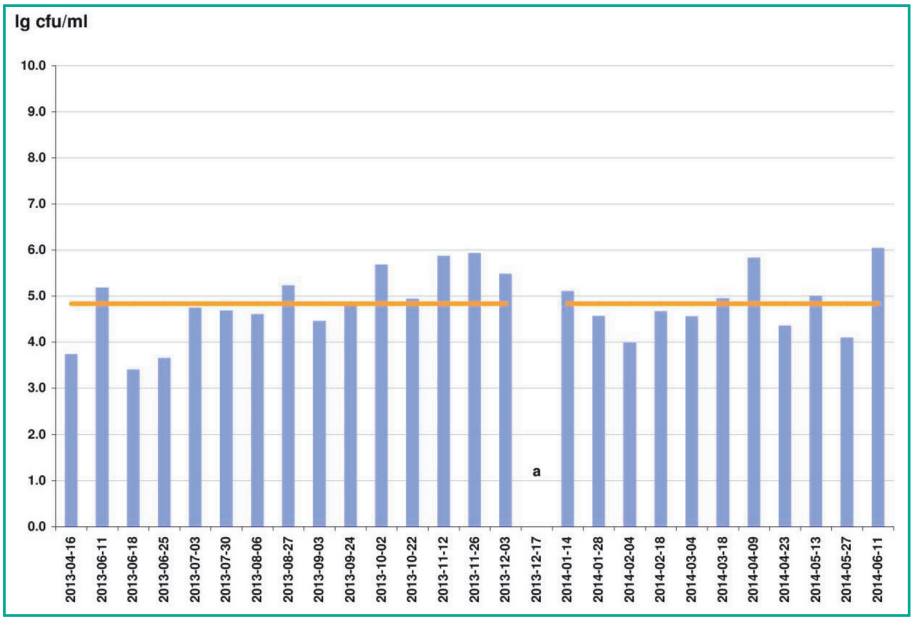

FIGURE 4: *Yeasts and Moulds, orange line: arithmetic mean value 4.8 lg cfu/ml, x-axis: date of sampling (n = 26), a: not determined.*

Discussion of microbiological data

Our long-term study results provide information on the general microbiological condition and presence of potentially pathogenic bacteria (*Salmonella* spp., *Listeria monocytogenes, Bacillus cereus,* coagulase-positive staphylococci) of raw bulk goat milk.

The pathogens *Salmonella* spp. and *Listeria monocytogenes* were not detected in any sample in accordance with data from Foschino et al. (2002), Morgan et al. (2003) and Cavicchioli et al. (2015). Also in monitoring-analysis, only 0.3 % of raw goat and sheep milk cheeses were tested positively for *Salmonella* spp. in 2015 (Bundesinstitut für Risikobewertung, 2018). Gonzales-Barron et al. (2017), on the other hand, reported a detection rate of *Salmonella* spp. of 1.4 to 2.4 % (meta-analysis of the available literature). Regarding listeriosis, which are primarily foodborne and often connected to dairy products (Büla et al., 1995; Koch et al., 2010; Delhalle et al., 2012), an evidence of *Listeria monocytogenes* in 2 to 4 % of raw goat milk samples was described (Gaya et al., 1996; Abou-Eleinin et al., 2000; Jamali et al., 2013; Gonzales-Barron et al., 2017). In Germany, by contrast, only 0.3 % of raw goat and sheep milk cheeses and 1.9 % of bulk milk samples were tested positively for *Listeria monocytogenes* in 2015 (Bundesinstitut für Risikobewertung, 2018). Since Listeria is inactivated by pasteurisation, recontamination during the subsequent process steps is often the cause of positive detection in the end product, e.g. cheese. *Bacillus cereus* is frequently found in environment and can lead to spoilage and food intoxications. Thermoresistant spores in raw milk are the major source of *Bacillus cereus* in pasteurised milk (Lin et al., 1998). In our investigations *Bacillus cereus* was determined in only two raw milk samples and in very low numbers. However, according to Liu et al. (2018) *Bacillus cereus* was detected in 36.1 % of the investigated goat milk powder infant formula. Most foodborne outbreaks were linked to bacterial counts of above 10^5 cfu/g in foodstuff (EFSA, 2016).

Staphylococcus aureus ranks to the most frequent agents of subclinical and clinical mastitis of small ruminants (Bergonier et al., 2003, Kunz et al., 2011) and therefore dairy equipment should be regularly checked and renewed.. Food intoxications are caused by heat stable staphylococcal enterotoxins which can be formed in foodstuff at bacterial counts of 5 to 6 lg cfu/g or ml (Bundesinstitut für Risikobewertung, 2010). According to Regulation (EC) No. 2073/2005, an examination for staphylococcal enterotoxins is mandatory in case of detection of more than 10^5 cfu/g coagulase-positive staphylococci in cheeses, milk powder and whey powder. Cases of intoxication are frequently

Journal of Food Safety and Food Quality 69, Heft 5 (2018), Seiten 131–160

linked to milk products (Hennekinne et al., 2012) after contamination during production or by usage of milk from infected udders (Scherrer et al., 2004).

Hahn et al. (1992) and Muehlherr et al. (2003) reported 32 % of goat bulk milk samples to be positive for *Staphylococcus aureus*. Scherrer et al. (2004) referred to detection of staphylococcal enterotoxin genes, mainly SEC gene, in approximately two thirds of the investigated isolates obtained from bulk goat milk samples. In our study, coagulase-positive staphylococci were detected in even 48 % of the milk samples but in number far below 10^5 cfu/ml and thus comparable to other studies (French samples referred by Morgan et al., 2003; Callon et al., 2007; Álvarez-Suárez et al., 2015).

The average values found in this study were: total bacterial count: 6.1 lg cfu/ml, lactic acid bacteria: 4.8 lg cfu/ml, pseudomonads: 5.8 lg cfu/ml, yeasts and moulds: 4.8 lg cfu/ml, enterobacteria: 4.0 lg cfu/ml.

Kondyli et al. (2012) and Barbosa and Miranda (1986) referred total bacterial counts (6.1 lg cfu/ml and 2.0 x 10^6 cfu/ml, respectively) comparable to our values for goat milk stored in bulk.

Morgan et al. (2003) compared the microbiological quality of goat milk in Portugal, France and Greece. The samples of Portuguese and Greek goat milk with their mostly extensive keeping showed a much higher total bacterial count (average from 1.4 to 6.4 x 10^7 cfu/ml) and number of coliforms and coagulase-positive staphylococci compared to the results of French milk originating from farms with intensive farming and milking conditions (average total bacterial count: from 2.7 x 10^4 to 1.9 x 10^5 cfu/ml) indicating the importance of production and transport hygiene. Our total bacterial count (average) and obviously also hygiene conditions to which the milk was exposed are in between while those for coagulase-positive staphylococci as potentially pathogenic germs are more in line with those of the French samples (average from 2.5 to 3.0 x 10^2 cfu/ml).

Álvare -Suárez et al. (2015), Muehlherr et al. (2003) and Yamazi et al. (2013), on the other hand, reported total bacterial counts of bulk goat milk which were about one lg-level lower (4.7–5.0 lg cfu/ml) compared to our data. Foschino et al. (2002) published an average total bacterial count which was even approximately two lg-levels lower compared to our study (5.0 x 10^4 cfu/ml) but coincides with studies of Park and Humphrey (1986) (2.5 x 10^4 cfu/ml), Park (1991) (3.9 x 10^4 cfu/ml) and Kyozaire et al. (2005) (from 1.6 to 4.8 x 10^4 cfu/ml). Espie and Mullan (1987) and Zeng and Escobar (1996) determined three times lower values (6.5 x 10^3 cfu/ml and 3.0 lg cfu/ml, respectively). The higher bacterial counts in our study might be explainable by deterioration of milking, transport or storage hygiene; the average value was in 48.1 % above the criterion for raw milk of other species destined for the production of heat treated products (bacterial count at 30 °C as geometric mean of two months with not less than two sample collections per month: ≤1 500 000 cfu/ml) according to Regulation (EC) No. 853/2004, Annex III, Section IX, Chapter 1, III, 3.a, ii).

Zeng et al. (2007) for example referred also an increase from 4 lg cfu/ml to 5 lg cfu/ml within six days of storage of raw refrigerated Alpine bulk goat milk correlating with an increase of psychrotrophic bacteria. The majority of the

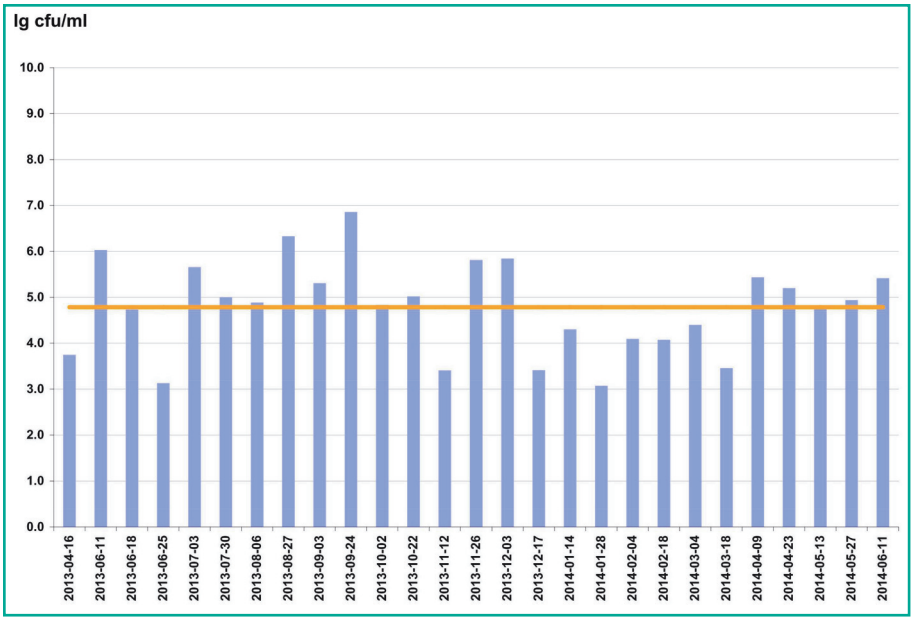

FIGURE 5: *Lactic acid bacteria, orange line: arithmetic mean value 4.8 lg cfu/ml, x-axis: date of sampling (n = 27).*

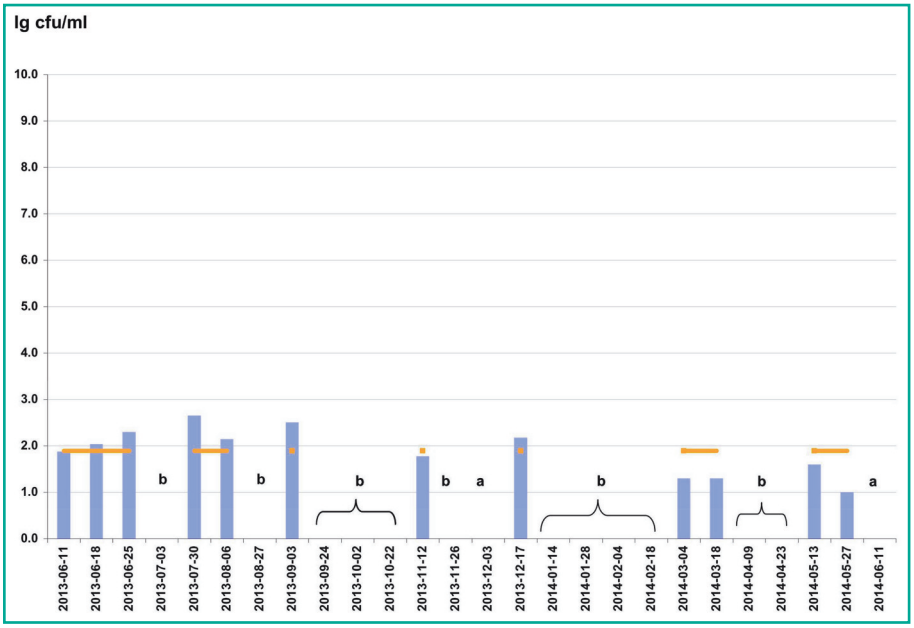

FIGURE 6: *Coagulase-positive staphylococci, orange line: arithmetic mean value 1.9 lg cfu/ml, x-axis: date of sampling (n = 25), a: not determined, b: Coagulase-positive staphylococci not detected in 1 ml.*

total bacterial count in the study of Tirard-Collet et al. (1991) consisted of psychrotrophs (3.3 to 5.4 lg cfu/ml) as in our study. Prolonged refrigerated storage of approximately four days led to selection of this flora according to data reported by von Neubeck et al. (2015) and Stoeckel et al. (2016 a) and could be a reason for the higher total bacterial count and the majority of pseudomonads in our study after storage of max. six days. Pseudomonads are psychrotrophic bacteria, frequently found in raw milk (von Neubeck et al., 2015) and able to produce heat resistant proteolytic enzymes (Baur et al., 2015; Glück et al., 2016) which could lead to spoilage of milk and products (Scatamburlo et al., 2015; Stoeckel et al., 2016 a). Short distribution channels and storage periods at farm (Stoeckel et al., 2016 b) as well as processing and strict production hygiene help to reduce the amount of pseudomonads and to ensure an acceptable product quality and stability.

The average count of lactic acid bacteria is comparable to the value 5.0 x 10^5 cfu/ml published by Barbosa and Miranda (1986) and the number of yeasts/ moulds to the count 2.5 x 10^5 cfu/ml referred by Foschino et al. (2002). The amount of enterobacteria is similar to the values 3.5 and 3.7 lg cfu/ml, respectively, published by Yamazi et al. (2013) and Kondyli et al. (2012).

Finally, the bacteriological quality of goat milk is variable and dependent on genetic, environmental and farming factors (Yangilar, 2013). However, reflecting the seasonal factors, no influence on the bacterial counts could be shown, in agreement with Callon et al. (2007) who described the microbial community of raw milk as stable during one year. In contrast, Zee et al. (1986) and Tirard-Collet et al. (1991) reported higher total bacterial counts in the summer period, while Eglezos et al. (2008) and Álvareź-Suárez et al. (2015) measured lower values.

Conclusion

The results prove that goat milk with its superior amounts of total solids is a valuable foodstuff. However, the seasonal variability of the total solid, fat and protein contents is disadvantageous for usage.

The microbiological quality of the milk is very good in relation to the occurrence of pathogenic bacteria. Nevertheless, the total bacterial count which consisted mainly of pseudomonads was in 48.1 % above the legal requirements (Regulation (EC) No. 853/2004). Prolonged storage periods before processing up to six days resulted probably in an accumulation of pseudomonads. This problem could be defused by accelerated processing. Regarding the legal limits concerning the total bacterial count and the possible spoilage triggered by pseudomonads, the main focus is on the reduction of these bacteria, which can only be achieved by strict hygiene measures and shortened storage periods in tank.

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Conflict of interest

We hereby declare that we are not in any conflict of interest.

References

Abou-Eleinin A-AM, Ryser ET, Donnelly CW (2000): Incidence and seasonal variation of *Listeria* species in bulk tank goat's milk. J Food Prot 63 (9): 1208–1213.

Aganga AA, Armateifio JO, Nkile N (2002): Effect of stage of lactation on nutrient composition of Tswana sheep and goat's milk. J Food Compost Anal 15 (5): 533–543.

Agnihotri MK, Singh NAWAB, Babji Y (2002): Milk composition of goats reared under field condition. Indian J Anim Sci 72 (11): 1019–1021.

Agrawal KP, Bhattacharyya NK (1978): Yield and composition of milk in Black Bengal, Barbari and Black Bengal x Barbari nannies. Indian J Anim Sci 48 (12): 882–886.

Álvareź-Suárez M-E, Otero A, García-López M-L, Santos JA (2015): Microbiological examination of bulk tank goat's milk in the Castilla y Léon Region in Northern Spain. J Food Prot 78 (12): 2227–2232.

Anifantakis EM, Kandarakis JG (1980): Contribution to the study of the composition of goat's milk. Milchwissenschaft 35 (10): 617–619.

Anonymus (2018a): Weather webpage www.sunrise-and-sunset.com/de/deutschland/leipzig, accessed on 06.05.2018.

Anonymus (2018b): Weather webpage www.wetterkontor.de/de/wetter/deutschland/monatswerte-station.asp; accessed on 06.05.2018.

Antunac N, Samaržija D, Havranek JL, Pavić V, Mioč B (2001a): Effect of stage and number of lactation on the chemical composition of goat milk. Czech J Anim Sci 46 (12): 448–453.

Antunac N, Havranek JL, Samaržija D (2001b): Effect of breed on chemical composition of goat milk. Czech J Anim Sci 46 (6): 268–274.

Barbosa M, Miranda R (1986): Physico-chemical and microbiological characteristics of goat milk in Portugal. IDF-Bulletin 202: 84–89.

Barbosa M (1993): Goat's milk research in Portugal. Lait 73: 425–429.

Barłowska J, Szwajkowska M, Litwińczuk Z, Król J (2011): Nutritional value and technological suitability of milk from various animal species used for dairy production. Compr Rev Food Sc Food Saf 10: 291–302.

Barłowska J, Litwińczuk Z, Wolanciuk A, Szmatoła T (2013): Chemical composition and selected parameters of technological suitability of caprine milk produced in organic and conventional farms. Ital J Food Sci 25: 105–108.

Baur C, Krewinkel M, Kranz B, von Neubeck M, Wenning M, Scherer S, Stoeckel M, Hinrichs J, Stressler T, Fischer L (2015): Quantification of the proteolytic and lipolytic activity of microorganisms isolated from raw milk. Int Dairy J 49: 23–29.

Bergonier D, De Crémoux R, Rupp R, Lagriffoul G, Berthelot X (2003): Mastitis of dairy small ruminants. Vet Res 34: 689–716.

Boros V (1986): Influence of the lactation period on variations in the levels of certain components of bulked goat's milk. IDF-Bulletin 202: 81–83.

Bundesinstitut für Risikobewertung (2010): Fortbildung für den Öffentlichen Gesundheitsdienst 2010, Abstracts. 67–68.

Bundesinstitut für Risikobewertung (2018): Erreger von Zoonosen in Deutschland im Jahr 2015. BfR-Wissenschaft 01/2018: 1–252.

Journal of Food Safety and Food Quality 69, Heft 5 (2018), Seiten 131–160

Büla CJ, Bille J, Glauser MP (1995): An Epidemic of Food-Borne Listeriosis in Western Switzerland: Description of 57 Cases Involving Adults. Clin Inf Dis 20: 66–72.

Calderon I, De Peters EJ, Smith NE, Franke AA (1984): Composition of Goat's Milk: Changes Within Milking and Effects of a High Concentrate Diet. J Dairy Sci 67 (9): 1905–1911.

Callon C, Duthoit F, Delbès C, Ferrand M, Le Frileux Y, De Crémoux R, Montel M-C (2007): Stability of microbial communities in goat milk during a lactation year: Molecular approaches. Syst Appl Microbiol 30: 547–560.

Cavicchioli VQ, Scatamburlo TM, Yamazi AK, Pieri FA, Nero LA (2015): Occurrence of *Salmonella, Listeria monocytogenes,* and enterotoxigenic *Staphylococcus* in goat milk from small and medium-sized farms located in Minas Gerais State, Brazil. J Dairy Sci 98 (12): 8386–8390.

Ciappesoni G, Přibyl J, Milerski M, Mareš V (2004): Factors affecting goat milk yield and its composition. Czech J Anim Sci 49 (11): 465–473.

Delhalle L, Ellouze M, Yde M, Clinquart A, Daube G, Korsak N (2012): Retrospective analysis of a *Listeria monocytogenes* contamination episode in raw milk goat cheese using quantitative microbial risk assessment tools. J Food Prot 75 (12): 2122–2135.

Devendra C (1972): The composition of milk of British Alpine and Anglo-Nubian goats imported into Trinidad. J Dairy Res 39: 381–385.

DIN (1982): DIN 10344. Bestimmung des Lactose- und Galactosegehaltes von Milch und Milchprodukten; Enzymatisches Verfahren, Beuth-Verlag.

DIN (1988): DIN 10348. Bestimmung des Trockenmassegehaltes von Milch und Sahne (Rahm); Referenzverfahren, Beuth-Verlag.

DIN (1992): DIN 10342. Bestimmung des Fettgehaltes von Milch und Milchprodukten nach dem gravimetrischen Weibull-Berntrop-Verfahren, Beuth-Verlag.

DIN (2000): DIN 10316. Bestimmung des Säuregrades von Milch und flüssigen Milchprodukten, nach Soxhlet-Henkel, Beuth-Verlag.

DIN (2005): DIN 10186. Mikrobiologische Milchuntersuchung – Bestimmung der Anzahl von Hefen und Schimmelpilzen – Referenzverfahren, Beuth-Verlag.

DIN EN ISO (2002): DIN EN ISO 8968-1. Milch – Bestimmung des Stickstoffgehaltes – Teil 1: Kjeldahl-Verfahren, Beuth-Verlag.

DIN EN ISO (2003): DIN EN ISO 6888-1. Mikrobiologie von Lebensmitteln und Futtermitteln – Horizontales Verfahren für die Zählung von koagulase-positiven Staphylokokken (*Staphylococcus aureus* und andere Species) – Teil 1: Verfahren mit Baird-Parker-Agar, Beuth-Verlag.

DIN EN ISO (2005): DIN EN ISO 11290-1. Mikrobiologie von Lebensmitteln und Futtermitteln – Horizontales Verfahren für den Nachweis und die Zählung von *Listeria monocytogenes* – Teil 1: Nachweisverfahren, Beuth-Verlag.

DIN EN ISO (2006): DIN EN ISO 21871. Mikrobiologie von Lebensmitteln und Futtermitteln – Horizontales Verfahren zur Bestimmung niedriger Zahlen von präsumtivem *Bacillus cereus* – Verfahren der wahrscheinlichsten Keimzahl (MPN) und Nachweisverfahren, Beuth-Verlag.

DIN EN ISO (2007): DIN EN ISO 6579. Mikrobiologie von Lebensmitteln und Futtermitteln – Horizontales Verfahren zum Nachweis von *Salmonella* spp., Beuth-Verlag.

DIN ISO (2009): DIN ISO 21528-2. Untersuchung von Lebensmitteln – Horizontales Verfahren zum Nachweis und zur Zählung von Enterobacteriaceae in Lebensmitteln – Teil 2: Koloniezählverfahren, Beuth-Verlag.

EFSA Panel on Biological Hazards (2016): Risks for public health related to the presence of *Bacillus cereus* and other *Bacillus* spp. Including *Bacillus thuringiensis* in foodstuffs. EFSA Journal 14 (7): Article 4524.

Eglezos S, Huang B, Dykes GA, Fegan N, Bell K, Stuttard E (2008): A survey of the microbiological quality of frozen unpasteurised goats' milk in Queensland, Australia. Aust. J Dairy Techn 63 (3): 79–81.

Espie WE, Mullan WMA (1987): Microbiological aspects of the quality of goat milk in Northern Ireland. Milchwissenschaft. 42 (12): 762–764.

FAO Statistics Devision (2014): FAOSTAT, http://www.fao.org/faostat/en/#home, last accessed on 06.05.2018.

Flamant JC, Morand-Fehr P (1982): Milk production in sheep and goats. World Animal Science Series (Sheep and Goat Production) 26: 275–295.

Foschino R, Invernizzi A, Barucco R, Stradiotti K (2002): Microbial composition, including the incidence of pathogens, of goat milk from the Bergamo region of Italy during a lactation year. J Dairy Res 69: 213–225.

Gaya P, Saralegui C, Medina M, Nuñez M (1996): Occurrence of *Listeria monocytogenes* and other *Listeria* spp. in raw caprine milk. J Dairy Sci 79 (11): 1936–1941.

Ghosh TK, Bhattacharyya B, Sinha R, Moitra DN (1982): Effect of lactation length on composition of milk in Black Bengal does. Indian J Dairy Sci 35 (4): 433-435.

Glück C, Rentschler E, Krewinkel M, Merz M, von Neubeck M, Wenning M, Scherer S, Stoeckel M, Hinrichs J, Stressler T, Fischer L (2016): Thermostability of peptidases secreted by microorganisms associated with raw milk. Int Dairy J 56: 186–197.

Gonzales-Barron U, Gonçalves-Tenório A, Rodriguez V, Cadavez V (2017): Foodborne pathogens in raw milk and cheese of sheep and goat origin: a meta-analysis approach. Curr Opin Food Sci 18: 7–13.

Guo MR, Dixon PH, Park YW, Gilmore JA, Kindstedt PS (2001): Seasonal changes in the chemical composition of commingled goat milk. J Dairy Sci Supplement: E79–E83.

Guo M, Park YW, Dixon PH, Gilmore JA, Kindstedt PS (2004): Relationship between the yield of cheese (Chevre) and chemical composition of goat milk. Small Rumin Res 52 (1-2): 103-107.

Hadjipanayiotou M (1995): Composition of ewe, goat and cow milk and of colostrum of ewes and goats. Small Rumin Res 18 (3): 255–262.

Haenlein, GFW (1996): Nutritional value of dairy products of ewe and goat milk. In: Anifantakis, E.M. (ed.) Proceedings of the IDF/CIRVAL seminar on production and utilization of ewe and goat milk. October 19–21, Crete, Greece, 1995, Brussels, Belgium. International Dairy Federation, 159–178.

Hahn G, Kirchhoff H, Hammer P, Ubben EH, Heeschen W (1992): Bacteriological findings and their evaluation in milk and related products from goats and sheep. Arch Lebensmittelhyg 43 (4): 89–93.

Hennekinne J-A, De Buyser M-L, Dragacci S (2012): *Staphylococcus aureus* and its food poisoning toxins: characterization and outbreak investigation. FEMS Microbiol Rev 36 (4): 815–836.

ISO (1998): ISO 15214. Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of mesophilic lactic acid bacteria – Colony-count technique at 30 °C, Beuth-Verlag.

ISO (2013): ISO 4833-2. Microbiology of the food chain – Horizontal method for the enumeration of microorganisms – Part 2: Colony count at 30 degrees C by the surface plating technique, Beuth-Verlag.

Jamali H, Radmehr B, Thong KL (2013): Prevalence, characterisation, and antimicrobial resistance of *Listeria* species and *Listeria monocytogenes* isolates from raw milk in farm bulk tanks. Food Control 34: 121–125.

Jandal JM (1996): Comparative aspects of goat and sheep milk. Small Rumin Res 22 (2): 177–185.

Kala SN, Prakash B (1990): Genetic and phenotypic parameters of milk yield and milk composition in two Indian goat breeds. Small Rumin Res 3 (5): 475–484.

Koch J, Dworak R, Prager R, Becker B, Brockmann S, Wicke A, Wichmann-Schauer H, Hof H, Werber D, Stark K (2010): Large listeriosis outbreak linked to cheese made from pasteurized milk, Germany, 2006–2007. Foodborne Pathog Dis 7 (12): 1581–1584.

Kondyli E, Svarnas C, Samelis J, Katsiari MC (2012): Chemical composition and microbiological quality of ewe and goat milk of native Greek breeds. Small Rumin Res 103 (2-3): 194–199.

Kuchtík J, Sedláčková H (2003): Composition and properties of milk in White Short-haired goats on the third lactation. Czech J Anim Sci 48 (12): 540–550.

Kumar S, Kumar B, Kumar R, Kumar S, Khatkar SK, Kanawjia SK (2012): Nutritional features of goat milk-A review. Indian J Dairy Sci 65 (4): 266–273.

Kunz F, Corti S, Giezendanner N, Stephan R, Wittenbrink MM, Zweifel C (2011): Antibiotikaresistenz von *Staphylococcus aureus* und Koagulase-negativen Staphylokokken isoliert aus Mastitismilchproben von Schafen und Ziegen. Schweiz Arch Tierheilk 153 (2): 63–69.

Kyozaire JK, Veary CM, Petzer I-M, Donkin EF (2005): Microbiological quality of goat's milk obtained under different production systems. J S Afr Vet Assoc 76 (2): 69–73.

Lin S, Schraft H, Odumeru JA, Griffiths MW (1998): Identification of contamination sources of *Bacillus cereus* in pasteurized milk. Int J Food Microbiol 43: 159-171.

Liu Y, Ge W, Zhang J, Li X, Wu X, Li T, Zhang X, Wang X (2018): Detection of *Bacillus cereus* sensu lato from environments associated with goat milk powdered infant formula production facilities. Int Dairy J 83: 10–16.

Majee J, Bandyopadhyay AK, Ghatak PK (1994): Physico-chemical properties of Black Bengal goat milk. J Dairy Foods Home Sci 13 (2): 119–122.

Mariani P, Corriani F, Fossa E, Pecorari M (1987): Composizione chimica, ripartizione delle frazioni azotate e caratteristiche di coagulazione del latte di capra durante un ciclo di produzione. Sci Tecn Latt Cas 38 (1): 7–30.

Mayer HK, Fiechter G (2012): Physicochemical characteristics of goat's milk in Austria – seasonal variations and differences between six breeds. Dairy Sci Technol 92:167-177

Mba AU, Boyo BS, Oyenuga VA (1975): Studies on the milk composition of West African Dwarf, Red Sokoto and Saanen goats at different stages of lactation. J Dairy Res 42: 217–226.

Mestawet TA, Girma A, Ådnøy T, Devold TG, Narvhus JA, Vegarud GE (2012): Milk production, composition and variation at different lactation stages of four goat breeds in Ethiopia, Small Rumin Res 105 (1–3): 176–181.

Morand-Fehr P, Sauvant D (1980): Composition and yield of goat milk as affected by nutritional manipulation. J Dairy Sci 63: 1671–1680.

Morand-Fehr P, Fedele V, Decandia M, Le Frileux Y (2007): Influence of farming and feeding systems on composition and quality of goat and sheep milk. Small Rumin Res 68 (1–2): 20–34.

Morgan F, Massouras T, Barbosa M, Roseira L, Ravasco F, Kandarakis I, Bonnin V, Fistakoris M, Anifantakis E, Jaubert G, Raynal-Ljutavac K (2003): Characteristics of goat milk collected from small and medium enterprises in Greece, Portugal and France. Small Rumin Res 47 (1): 39–49.

Muehlherr JE, Zweifel C, Corti S, Blanco JE, Stephan R (2003): Microbiological Quality of Raw Goat's and Ewe's Bulk-Tank Milk in Switzerland. J Dairy Sci 86: 3849–3856.

Navarro-Alarcón M, Cabrera-Vique C, Ruiz-López MD, Olalla M, Artacho R, Giménez R, Quintana V, Bergillos T (2011): Levels of Se, Zn, Mg and Ca in commercial goat and cow milk fermented products: Relationship with their chemical composition and probiotic starter culture. Food Chem 129: 1126–1131.

von Neubeck M, Baur C, Krewinkel M, Stoeckel M, Kranz B, Stressler T, Fischer L, Hinrichs J, Scherer S, Wenning M (2015): Biodiversity of refrigerated raw milk microbiota and their enzymatic spoilage potential. Int J Food Microbiol 211: 57–65.

Pal UK, Saxena VK, Agnihotri MK, Roy R (1996): Effect of season, parity and stage of lactation on the composition of Jamnunapari goats' milk. International J Anim Sci 11: 245–248.

Pandya AJ, Ghodke KM (2007): Goat and sheep milk products other than cheeses and yoghurt. Small Rumin Res 68 (1–2): 193–206.

Park YW, Humphrey RD (1986): Bacterial cell counts in goat milk and their correlations with somatic cell counts, percent fat, and protein. J Dairy Sci 69: 32–37.

Park YW (1991): Interrelationships between somatic cell counts, electrical conductivity, bacteria counts, percent fat and protein in goat milk. Small Rumin Res 5 (4): 367–375.

Park YW, Juárez M, Ramos M, Haenlein GFW (2007): Physico-chemical characteristics of gost and sheep milk. Small Rumin Res 68 (1–2): 88–113.

Prasad H, Tewari HA, Sengar OPS (2005): Milk yield and composition of the beetal breed and their crosses with Jamunapari, Barbari and Black Bengal breeds of goat. Small Rumin Res 58 (2): 195–199

Qureshi HA, Deshpande KS, Bonde HS (1981): Studies on chemical composition of goat milk. Indian Vet J 58: 212–214.

Rudovsky A (2008): Untersuchungen zum Einfluss des Durchmelkens und der Verlängerung der Ablammperiode auf die Reproduktionsleistung und die Milchzusammensetzung bei Ziegen. Leipzig, Germany, Veterinärmedizinische Fakultät, diss.

Scatamburlo TM, Yamazi AK, Cavicchioli VQ, Pieri FA, Nero LA (2015): Spoilage potential of *Pseudomonas* species isolated from goat milk. J Dairy Sci 98 (2): 759–764.

Scherrer D, Corti S, Muehlherr JE, Zweifel C, Stephan R (2004): Phenotypic and genotypic characteristics of *Staphylococcus aureus* isolates from raw bulk-tank milk samples of goats and sheep. Vet Microbiol 101: 101–107.

Silanikove N, Merin U, Shapiro F, Leitner G (2014): Subclinical mastitis in goats is associated with upregulation of nitric oxide-derived oxidative stress that causes reduction of milk antioxidative properties and impairment of its quality. J Dairy Sci 97 (6): 3449–3455.

Simos E, Voutsinas LP, Pappas CP (1991): Composition of milk of native Greek goats in the region of Metsovo. Small Rumin Res 4 (1): 47–60.

Soryal KA, Zeng SS, Min BR, Hart SP, Beyene FA (2004): Effect of feeding systems on composition of goat milk and yield of Domiati cheese. Small Rumin Res 54 (1–2): 121–129.

Statistisches Bundesamt (2016): Destatis Webpage: https://www.destatis.de/DE/ZahlenFakten/WirtschaftsbereicheLandForstwirtschaftFischerei/TiereundtierischeErzeugung/Tabellen/BetriebeZiegenBestand.html; accessed on 06.05.2018.

Stoeckel M, Lidolt M, Achberger V, Glück C, Krewinkel M, Stressler T, von Neubeck M, Wenning M, Scherer S, Fischer L, Hinrichs J (2016a): Growth of *Pseudomonas weihenstephanensis, Pseudomonas proteolytica* and *Pseudomonas* sp. in raw milk: Impact of residual heat-stable enzyme activity on stability of UHT milk during shelf-life. Int Dairy J 59: 20–28.

Stoeckel M, Lidolt M, Stressler T, Fischer L, Wenning M, Hinrichs J (2016b): Heat stability of indigenous milk plasmin and proteases from *Pseudomonas:* A challenge in the production of ultra-high temperature milk products. Int Dairy J 61: 250–261.

Sung YY, Wu TI, Wang PH (1999): Evaluation of milk quality of Alpine, Nubian, Saanen and Toggenburg breeds in Taiwan. Small Rumin Res 33 (1): 17–23.

Journal of Food Safety and Food Quality 69, Heft 5 (2018), Seiten 131–160

Tirard-Collet P, Zee JA, Carmichael L, Simard RE (1991): A study of the microbiological quality of goat milk in Quebec. J Food Prot 54 (4): 263–266.

Trancoso IM, Trancoso MA, Martins APL, Roseiro LB (2010): Chemical composition and mineral content of goat milk from four indigenous Portuguese breeds in relation to one foreign breed. Int J Dairy Technol 63 (4): 516–522.

Uusi-Rauva E, Ali-Yrkkó S, Antila M (1970): Die Zusammensetzung der finnischen Ziegenmilch. Suomen Kemistilehti B 43: 178-182.

VDLUFA method book (1993): Volume VI, M 7.12.2. Determination of pseudomonads, method for the enumeration of colonies with C-F-C-Selective Agar.

Yamazi AK, Moreira TS, Cavicchioli VQ, Burin RCK, Nero LA (2013): Long cold storage influences the microbiological quality of raw goat milk. Small Rumin Res 113 (1): 205–210.

Yangilar F (2013): As a potentially functional food: goats' milk and products. Food Nutr Res 1 (4): 68–81.

Ying C, Wang H-T, Hsu J-T (2002): Relationship of somatic cell count, physical, chemical and enzymatic properties to the bacterial standard plate count in dairy goat milk. Livest Prod Sci 74: 63–77.

Zee JA, Tirard-Collet P, Lavigne C, Simard RE (1986): Nutritional and microbiological qualities of raw and pasteurized goats' milk. J Food Prot 49: 853–854.

Zeng SS, Escobar EN (1995): Effect of parity and milk production on somatic cell count, standard plate count and composition of goat milk. Small Rumin Res 17 (3): 269–274.

Zeng SS, Escobar EN (1996): Effect of breed and milking method on somatic cell count, standard plate count and composition of goat milk. Small Rumin Res 19 (2): 169–175.

Zeng SS, Chen SS, Bah B, Tesfai K (2007): Effect of extended storage on microbiological quality, somatic cell count, and composition of raw goat milk on a farm. J Food Prot 70 (5): 1281–1285.

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