Sjournals
Scientific Journals
Scientific Journal of Animal Science (2013) 2(8) 215-221
ISSN 2322-1704
doi: 10.14196/sjas.v2i8.901

Contents lists available at Sjournals
Scientific Journal of Animal Science
Journal homepage: www.Sjournals.com

Original article

Factors affecting milk composition of Algerian ewe reared in central steppe area

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ARTICLE INFO

Article history:
Received 02 August 2013
Accepted 10 August 2013
Available online 26 August 2013

Keywords:
Algeria
Milk composition
Ouled Djellal sheep
Rumbi sheep
Variation

ABSTRACT

The aim of this study was to assess changes in composition of individual raw ewe's milk reared in Algerian area steppe. In total 167 milk samples from two local breeds, Ouled Djellal (75 samples) and Rumbi (92) were taken. For each ewe, we recorded the number of lactation (primiparous vs. multiparous), lactation stage (beginning, middle or end) and age. Milk samples were taken twice time from lactating period during winter and spring season. Rumbi ewe milk exhibited the highest ($p \leq 0.001$) protein, lactose, solid-non-fat and density than Ouled-Djellal ewe milk. Conversely, Ouled-Djellal manifested significantly higher ($p \leq 0.001$) fat concentration and freezing point in milk than the Rumbi. The pH value was not significantly affected by breed. The stage of lactation had significant effect on fat contents ($p \leq 0.05$) and freezing point ($p \leq 0.01$) while, other parameters studied were not significantly influenced by lactation stage. The season had a significant effect on all parameters tested except total solids. Lactose and freezing point were not significantly affected by the age of ewe. On the contrary there was an important effect of age for other parameters. Regarding the lactation number, no significant effects were found.

1. Introduction

In Algerian area steppe, the ruminant livestock are mostly represented by sheep. Sheep are operated mainly for meat production and secondarily for milk and wool. Ouled Djellal and Rumbi are the most common breed with low production but well adapted to the different natural regions (Benyoucef et al., 1995) and represents approximately 75% of the total number (Boucif et al., 2007). In this environment, Sheep milk is generally used for breast lambs in the first place, then it is consumed by the farmers as well as or transformed traditionally.

Milk is undoubtedly the first food consumed by mammals. The composition of the raw milk specifies both its nutritional quality and also its ability to technological transformation and quality of resulting products (Pirisi et al., 2001; Bencini, 2002). This composition is not stable and is subject to multiple variations. Several factors affecting the composition of sheep's milk have been reported in the literature. Some of these factors are related to the animal breed (Haenlein, 2002; Tsiplakou et al., 2006; Mierlita et al., 2011), lactation stage (Sahan et al., 2005; Kuchtik et al., 2008; Hejtmankova et al., 2012), parity (Gonzalo et al., 1994; Piras et al., 2007), lactation number (Kremer et al., 1996; Oravcova et al., 2007), age of the animal (Kremer et al., 1996; Berger et al., 2004; Abd Allah et al., 2011), udder health (Bianchi et al., 2004; Raynal-Ljutovac et al., 2007), other are related to diet (Pirisi et al., 2001; Bocquier and Caja, 2001; Bovera et al., 2003), milking practices (Nudda et al., 2002; Rassu et al., 2007; Sinapsis, 2007), season (Thomson et al., 1982; Bocquier et al., 1997; Abd Allah et al., 2011) and other factors (Sevi et al., 2003; Morand-Fehr et al., 2007). Thus, this investigation constitute the first and preliminary study carried out concerning the factors affecting milk composition of Algerian ewe reared in central steppe area.

2. Materials and methods

2.1. Sampling

Individual milk samples were collected from two local sheep breed, Ouled Djellal “OD” (n=75) and Rumbi “R” (n=92) conducted in the same herd with similar conditions regarding housing and feeding. Ewes were allowed to graze on natural pasture and feed with hay, pasture ensilage and barley when necessary. All were housed under semi-intensive mode. For each ewe, we recorded the number of lactation (primiparous vs. multiparous), lactation stage (beginning, middle or end) and age. Milk samples were taken from each ewe twice time from lactating period during winter and spring season. Milk samples were collected at the afternoon hand milking and analyzed within 24h with refrigeration overnight in terms of milk composition.

2.2. Analytical procedure

The pH values were measured using a pH-meter (Hanna H211, Hanna Instrument, Portugal) previously calibrated. Density was performed by using Quevenne lactometer, according the method described by AOAC (1998) and Milk freezing point by using a cryoscope (model 403, advanced Instruments, Norwood, NA). Total solids (TS) content was determined according to the method of AOAC (1998) by drying at 103±2°C. Fat, protein and lactose were determined by infrared analysis using a Milkoscan apparatus (FT 120, FossElectric, Hilleroed, Denmark). Solid-non-fat (SNF) was calculated as the difference between the total solids and fat content.

2.3. Statistical analysis

The statistical analysis was performed using STATISTICA software, v. 6.0 for Windows (StatSoft Inc., Tulsa, OK, USA). The general linear model used is described by the following equation:

$Y_{ijklm} = \mu + B_i + P_j + LS_k + A_l + S_m + \theta_{ijklmn}$

Where Yijklm is the considered parameter

μ: overall mean

B_i: fixed effect of breed (i= Rumbi and Ouled-Djellal ewes)

P_j: fixed effect of parity (j= primiparous and multiparous)

LS_k: fixed effect of stage of lactation (k= beginning, middle and end)

A_l: fixed effect of age (l= 1,2,3,4 and 5 being ≤2, ≤3 and >2, ≤4 and >3, ≤5 and >4, >6 years, respectively)

S_m: fixed effect of season (m= winter and spring)

θ_{ijklmn}: error.

The significant differences between means were calculated by one-way Analysis of Variance (ANOVA) using Tukey range test and probability level was either 95 or 99%.

3. Results and discussion

3.1. Average composition

Table 1 report the mean and standard deviations of chemical composition of individual milk samples collected. These contents are not constant and vary depending on breed, stage of lactation, age and season. The average composition of the 167 samples of ewe's milk used in this study was 5.10±1.21% protein, 6.02±3.48% fat and 4.76±0.72% lactose. These values were found lower than those reported by several authors for sheep milk in various countries: Baltadjieva et al. (1982) in Bulgaria and Greece, Pavic et al. (2002) in Croatia, Sahan et al. (2005) in Türkiye and Rouissi et al. (2006) in Tunisia except for lactose who seems to be higher. The content of TS (16.91±3.55%) and SNF (10.90±1.44%) were also lower than those reported previously. The physico-chemical characteristics, expressed by the freezing point, density and pH shows the following averages -0.58 ° C, 1036.78 and 6.76 respectively. These data are somewhat similar to those mentioned by many workers (Pavic et al., 2002; Park et al., 2007; Kuchtik et al., 2008 and Hilali et al., 2011).

3.2. Factors of variation

3.2.1. Effect of breed

The results in Table 1 confirm the hypothesis put forward by several authors on the effect of breed on the composition of sheep milk. Rumbi ewe milk exhibited the highest ($p \leq 0.001$) protein (5.41 vs. 4.71%), lactose (4.93 vs. 4.54%) and solid-non-fat (11.43 vs. 10.24 %) than Ouled-Djellal ewe milk. Conversely, OD manifested significantly higher ($p \leq 0.001$) fat concentration in milk (6.83 vs. 5.35%) than the R. On the other hand, OD ewes yielded more milk than R ewes (data not shown). This variation includes negative correlation between milk yield and composition (Haenlein, 2002). Many researchers have shown the effect of breed on milk composition, although reports are somewhat contradicting and disparate. Abd Allah et al. (2011) found that breed had a significant effect only on fat and SNF when comparing Rahmani and Chios Egyptian ewes. Jaramillo et al. (2008) observed a significant difference in the concentration of fat and lactose from two Spanish ewe breeds (Guirra and Manchega). However, Mierlita et al. (2011) reported that breed of ewe had no significant effect on protein, fat and TS contents for Spanca and Turcana Romanian ewes. Also, Tsiplakou et al. (2008) did not found any effect of breed on fat, protein and lactose concentration of the four sheep breeds (Awassi, Lacaune, Friesland and Chios) kept under the same management in Greece. If it is recognized that fat and protein concentration in milk show a positive correlation with cheese yield (Barron et al., 2001), breeds selected for dairy production tend to have a lower concentration of milk components (Flamant and Morand-Fehr, 1982; Berger et al., 2004). Then Bencini (2001) concluded that, with high milk production, the total amount of cheese produced from the milk can be higher, but the relative yield of cheese from each liter of milk will be lower. So the East Friesian which is considered one of the best milking sheep in the world, it has, however, one of the lowest fat and protein contents, 5.5-6.5% and 5% respectively (Berger, 2004).

Regarding the physical characteristics of milk, R had significantly ($p \leq 0.001$) higher milk density (1039.26) than the OD (1033.73) and weak freezing point (-0.60 vs. -0.55 °C). The pH value was not significantly affected by breed. The same finding was observed with density (Rouissi et al., 2006), pH (Rouissi et al., 2006 and Abd Allah et al., 2011). A contrary, Martini and Caroli (2003) reported that breed of ewe had a significant ($p<0.001$) effect on pH value. According to Mathieu (1998), the pH of milk depends on its richness in certain constituents, particularly phosphates, citrates and casein.

3.2.2. Effect of stage of lactation

Changes in physico-chemical characteristics of ewe's milk during the stage of lactation are shown in table 1. Fat percentage increase significantly ($p \leq 0.05$) as lactation progressed. Similar observations had been made by Pavic et al. (2002), Bianchi et al. (2004) and Kuchtik et al. (2008). This increase was 36.8% between beginning and end lactation period; which is in agreement with percentage (37.6%) reported by Gonzalo et al. (1994) between d 45 and 150 postpartum. Also, the stage of lactation had significant effect on freezing point ($p \leq 0.01$). Its value at the end of lactation period was significantly lower with regard to the mid lactation.

Table 1
Factors affecting milk composition.

Factor of variation	Means ±sd								
	Effectif	Protein (%)	Fat (%)	Lactose (%)	TS (%)	SNF (%)	Freezing point (°C)	Density	pH
Overall mean	167	5.10±1.21	6.02±3.48	4.76±0.72	16.91±3.55	10.90±1.44	-0.58±0.07	1036.78±8.16	6.76±0.20
Breed of ewe		***	***	***	ns	***	***	***	ns
Rumbi	92	5.41±1.26	5.35±3.67	4.93±0.71	16.78±3.75	11.43±1.52	-0.60±0.06	1039.26±9.43	6.77±0.21
Ouled-Djellal	75	4.71±1.04	6.83±3.07	4.54±0.67	17.07±3.32	10.24±1.31	-0.55±0.07	1033.73±4.82	6.74±0.19
Parity		ns	ns	ns	ns	ns	ns	ns	ns
Primiparous	14	5.07±1.19	5.91±3.88	4.52±0.69	16.47±3.60	10.56±1.25	-0.57±0.07	1035.27±5.56	6.67±0.16
Multiparous	153	5.10±1.22	6.03±3.46	4.78±0.72	16.95±3.56	10.93±1.57	-0.59±0.07	1036.92±8.37	6.77±0.20
Stage of lactation		ns	*	ns	ns	ns	**	ns	ns
Beginning	97	$5.19±1.30^{a}$	$5.42±3.49^{a}$	4.82±0.74	16.48±3.76	11.06±1.66	$-0.60±0.06^{a}$	1037.95±9.58	6.77±0.02
Middle	49	$5.11±1.10^{ab}$	$6.59±3.05^{b}$	4.63±0.77	17.39±3.18	10.80±1.36	$-0.55±0.07^{b}$	1035.65±5.13	6.75±0.20
End	21	$4.60±0.98^{b}$	$7.42±3.90^{b}$	4.73±0.46	17.78±3.22	10.36±1.27	$-0.65±0.02^{a}$	1033.99±5.69	6.76±0.17
Age (years)		*	**	ns	**	**	ns	*	***
≤2	35	$4.74±1.05^{a}$	$6.08±2.87^{a}$	$4.53±0.52^{a}$	$16.31±2.81^{a}$	$10.23±1.03^{a}$	$-0.55±0.06^{a}$	$1034.10±4.11^{a}$	$6.68±0.13^{a}$
≤3 and >2	44	$5.21±1.08^{ab}$	$4.16±2.65^{b}$	$5.04±0.83^{b}$	$15.49±2.87^{ac}$	$11.34±1.43^{bc}$	$-0.59±0.05^{bc}$	$1038.87±5.33^{bc}$	$6.82±0.19^{bc}$
≤4 and >3	42	$4.99±1.23^{a}$	$7.01±3.94^{a}$	$4.66±0.67^{a}$	$17.70±3.93^{bad}$	$10.69±1.54^{a}$	$-0.57±0.09^{abc}$	$1035.14±5.95^{a}$	$6.74±0.19^{ad}$
≤5 and >4	15	$4.65±0.99^{a}$	$6.83±2.92^{a}$	$4.65±0.36^{ab}$	$17.15±2.48^{ae}$	$10.32±1.06^{a}$	$-0.58±0.04^{abd}$	$1034.06±4.40^{ad}$	$6.71±0.15^{ae}$
>6	31	$5.70±1.44^{b}$	$6.84±3.89^{a}$	$4.80±0.83^{ab}$	$18.42±4.30^{be}$	$11.58±1.94^{c}$	$-0.61±0.08^{cd}$	$1040.37±14.71^{dc}$	$6.81±0.27^{cde}$
Season		***	**	***	ns	***		***	***
Winter	73	6.30±0.75	5.19±3.14	4.47±0.63	17.07±3.48	11.89±1.44	-0.58±0.07	1040.69±9.88	6.82±0.22
Spring	94	4.16±0.44	6.66±3.62	4.98±0.71	16.78±3.63	10.12±1.13	/	1033.74±4.71	6.71±0.17

ns: not significant, *: P< 0.05, **: P< 0.01, ***: P< 0.001, a,b,c: P< 0.05.

Pavic et al. (2002) showed the same trend but with lower values. Other parameters studied were not significantly influenced by lactation stage. This observation is in agreement or in disagreement, regards the parameter considered, with various previous findings. Thus, Sahan et al. (2005) report significant lactational effects on the contents of dry matter ($p<0.01$), pH and density ($p<0.05$), not on protein, lactose and non-fat dry matter of Awassi ewe's milk. However, Bianchi et al. (2004) showed significant effect of lactation stage on lactose, protein but not on pH. While Gonzalo et al. (1994), Pavic et al. (2002) and Kuchtik et al. (2008) found that the stage of lactation had a significant influence on all analyzed parameters. On the other hand, Hejtmankova et al. (2012) report that, the contents of total protein as well as acid whey proteins in ovine milk were dependent on the period of lactation.

3.2.3. Effect of age and parity

The composition of milk depending on age and parity of ewes is summarized in table 1. Lactose and freezing point were not significantly affected by the age of ewe. On the contrary there was an important effect of age for all of the other parameters. Fat and SNF were the most affected. The highest values were recorded at the age of 4 years for Fat and more than 6 years for SNF. The lowest ones were observed respectively at the age of 3 years and 2 years old. Among other things, the older ewes (> 6 years) produce milk which is richer in term of protein, TS, density and less acid than milk produced by maiden ewes (less than 3 years). Our result contrast with the results reported by Abd Allah et al. (2011) who found no significant effect of ewe's age on the chemical components (TS, SNF, protein and pH) analyzed except fat %; where the fat percentage is lower in older ewes compared with that of younger ewes. By contrast, Corbett (1968) in Bencini (2001) reported that the concentration of fat is higher in older than younger ewes. Similarly, Hassan (1995) found no significant effect of age of ewe on TS and SNF but also on fat. Lateif et al. (1989) reported the significant effect of the age of ewe on protein percent which agrees with our finding. According to Kremer et al. (1996), only fat content was affected by age not protein, lactose and SNF contents.

Regarding the lactation number, no significant effects were found for all parameters studied which corresponds with the results reported by Piras et al. (2007) and contrast with the results reported by Gonzalo et al. (1994) for which, parity had a significant effect on the fat content but not on the protein content. Also, the concentration of TS increases with parity (Berger et al., 2004). Bencini (2001) report that there are contrasting literature reports on the effect of parity on milk composition and it is not possible to distinguish between age and parity of ewe. As documented, it seems that our results and those found in the literature are disparate and sometimes contradictory.

3.2.4. Effect of season

Results in table 1 show the influence of the season on the variables studied. Protein, lactose, SNF, density and pH have been found to increase in winter; while fat was reduced significantly. Reduction of fat can be explained by reduction of milk C4 to C16 fatty acids (Haenlein, 2002). The effect of season on milk composition may be direct by length of day (Bocquier et al., 1997) not by high temperature (Thomson et al., 1982) or indirect by its effect on food for sheep fed primarily pasture (Pulina et al., 1993). The effect of season on pH, protein, SNF contents recorded in this study were supported by Abd Allah et al. (2011) but were not for fat and TS percentage.

4. Conclusion

This study showed that all parameters were affected by breed (except pH), season (except TS) and age of ewe (except lactose and freezing point). However, no significant effect was observed of lactation number while, the stage of lactation had significant effect only on fat contents and freezing point. On the other hand, our results and those found in the literature are disparate and sometimes contradictory.

Acknowledgement

This study was supported by Algerian Ministry of higher education and scientific research (research project of CNEPRU, code: F02820100030).

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