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Effect of Breed, Parity and Stage of Lactation on Milk Composition of Western Region Goats of India

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Abstract: Variations in daily milk yield, composition, pH and titrable acidity and stage of lactation were studied at fortnightly interval from 7th day after kidding up to 90 days of lactation in Sirohi, Marwari, Kutchi and Jakhrana breeds. The milk yield was maximum ($p<0.01$) in Jakhrana (0.770 L day^{-1}) and lowest (0.500 L day^{-1}) in Marwari breed. Similar trend was observed for fat content. Milk pH was higher ($p<0.01$) in Sirohi (6.64), followed by Jakhrana, Marwari and Kutchi. The Kutchi milk having lowest pH, had higher ($p<0.01$) titrable acidity. No significant difference was observed in other milk constituents. Parity had significant ($p<0.01$) effect on milk yield and milk pH. Animals in parity 2 and 5 yielded higher milk per day. As parity advanced, milk pH increased. Rest of the milk traits remained unaffected due to parity of the animals. In week 2 of lactation, highest milk yield was recorded and with progress of lactation period steady increase in fat content and pH was recorded but casein content declined. Though the TS content was more ($p<0.01$) in last stages of lactation, SNF, ash and TA remained unaffected.

Key words: Composition, factors, breed, parity, stage of lactation, goat milk

INTRODUCTION

Goat farming is a vital part of national economy in many countries, especially in the Mediterranean and Middle East region. It is particularly well organized in developed countries (Park *et al*., 2006) and in India, goat farming is well established but unorganized. Goats in India mainly reared by landless farmers (Prasad *et al*., 2005) and concept of commercial farming is spreading. The annual milk production from goats in India is about 2 million tones contributing 3.5% to the total milk produced in the country (FAO, 2006). India has the second largest goat population in the world with 120 million heads and has 26 well established breeds well distributed all over the country.

Goat milk is of interest due to variation in yield and composition from breed to breed. The variation in milk composition affects product yield and quality (Pal and Agnihotri, 1997). Goat milk composition is affected due to breed, season (Pal *et al*., 1997), time of milking (Pal and Agnihotri, 1997) and locations (Agnihotri *et al*., 2002). The published information on milk composition of Marwari, Sirohi and Kutchi is limited to breed differences (Pal *et al*., 1997) only. Present study was therefore, designed to study the effect of breed, parity and stage of lactation on milk yield and composition of Sirohi, Marwari, Kutchi and Jakhrana, the Western region goat breeds, raised under semi-intensive management system in the semi arid tropics. Further, milk composition of the farm and field reared Jakhrana goats were also analyzed to understand any due to method of rearing. In field condition goats are reared by grazing only.

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MATERIALS AND METHODS

Location of the Study

The study was conducted at Central Institute for Research on Goats, located in Makhdoom village of Mathura District, Utter Pradesh, India (27°10' N, 78° 002' E and 169 m above MSL). Geologically the Institute land falls under Jamuna alluvial soil category. The climate is semi-arid. Temperature ranges between 6°C in winter to as high 45°C in summer. Annual average rainfall is 750 mm and spread over a period of 50-60 days. Monsoon arrives in mid July and remains active till mid-September. Deep tube wells provide saline water.

Milk Source

Milk samples of Sirohi, Marwari, Kutchi and Jakhrana does maintained at Central Institute for Research on Goats, Makhdoom, Farah, on 7th day after kidding and there after at fortnightly intervals were collected in the morning up to 90 days of lactation. Samples collected in clean glass containers were analyzed for major milk constituents, pH and titrable acidity (TA, %lactic acid). The effect of breed, parity and stage of lactation (1-13 weeks) on milk yield and major milk constituents including TA and pH were examined. The data on milk yield and parity of dam (1-5) was collected from the available farm records. Animals were maintained under semi-intensive system with 6 h grazing and feeding seasonally available green fodder supplemented with concentrate mixture at the rate of 500 g day^{-1} (16% DCP and 72% TDN). Experiment started in 1st week of October and lasted up to first week of February due to late kidding in few animals. Field reared Jakhrana goats milk samples were collected from its home tract (Alwar district of Rajasthan State, India).

Analysis of Samples

Milk samples within 2.5 h of milking were analyzed for fat, (ISI, 1977), Total Solids (TS) (Pandey, 1981), Solids-Not-Fat (SNF, by difference method), casein (Pal *et al*., 1997), ash (Kirk and Sawyer, 1991), titrable acidity (Scott, 1986) and pH (Agnihotri and Pal, 1996). Ninety-eight samples from Sirohi, 63 Marwari, 21 Kutchi and 28 Jakhrana breed-a total of 210 were analyzed. Analyses of variance followed by calculation of critical differences were done to find significant differences (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

The average daily milk yield was highest in Jakhrana (0.770 L day^{-1}) and lowest (0.500 L) in Marwari breed (Table 1). Khan and Roy (2000) reported daily average milk yield of 1.060 kg for 115 days of lactation in Jakhrana, 0.617 kg per day for 198 days of lactation in Sirohi, 0.561 kg for 196 days of lactation in Marwari and 0.557 kg for 202 days of lactation in Kutchi breeds. The average daily milk yield (0.770 L) of Jakhrana recorded in the present study is lower than reported by Khan and Roy (2000). Variability in milk yield could be attributed to year of kidding, season, parity, stage of

Table 1: Composition, pH and titrable acidity of Sirohi, Marwari, Kutchi and Jakhrana goat milk (Least Squares means±SE)

Breed	Milk yield/ day (L)	TS (%)	Fat (%)	SNF (%)	Casein (%)	Ash (%)	pH	TA (%) (Lactic acid)
Sirohi (N = 98)	0.69±0.02^{b}	11.60±0.19	3.89±0.13^{b}	7.75±0.15	3.32±0.05	0.89±0.08	6.64±0.01^{b}	0.170±0.01^{a}
Marwari (N = 63)	0.50±0.03^{a}	11.35±0.22	3.38±0.15^{a}	7.84±0.17	3.39±0.06	0.81±0.09	6.58±0.01^{a}	0.180±0.01^{ab}
Kutchi (N = 21)	0.54±0.05^{a}	11.17±0.39	3.61±0.27^{ab}	7.60±0.29	3.36±0.09	1.11±0.16	6.53±0.02^{a}	0.198±0.02^{b}
Jakhrana (N = 28)	0.77±0.04^{b}	12.06±0.34	4.39±0.24^{b}	7.69±0.26	3.50±0.08	0.76±0.14	6.59±0.02^{ab}	0.185±0.02^{ab}
Overall least± squares means SE (N = 210)	0.63±0.02	11.55±0.16	3.82±0.11	7.72±0.12	3.39±0.04	0.89±0.07	6.58±0.01	0.185±0.01

Means within columns sharing a common superscript letter are not significantly different at p<0.01

Table 2: Milk composition of goat breeds reared in different countries (adapted from Albenzio *et al*., 2006)

Country	Breed	Total solids (%)	Fat (%)	Crude protein (%)	Casein (%)	Lactose (%)	Ash (%)
United Kingdom	British Saanen	11.6	3.48	2.61	2.3	4.3	0.80
United Kingdom	Nubian	–	4.94	3.60	–	4.51	–
France	Alpine	–	3.38	3.08	2.33	–	–
Greece	Native (Capra prisca)	14.8	5.63	3.77	3.05	4.76	0.73
Spain	Murciano–Granadina	–	–	4.09	3.21	–	–
Italy	Sardinian	–	5.1	3.9	–	–	0.71

lactation, feeding, management and changed environment. The fat content, milk pH and titrable acidity differed significantly ($p<0.01$) and Jakhrana milk had highest fat (4.39%), which was comparable with 3.89% fat in Sirohi but higher than Kutchi (3.61%) and Marwari (3.38%). The fat content of Jakhrana is comparable with Jamunapari (4.38%) but lower than Barbari (4.82) breed (Agnihotri, 2002). Only Jakhrana and Sirohi had milk fat comparable with European (3.7%) goats (Table 2). Milk TS of western region breeds are comparable to that of British Saanen but the casein content were higher and similar to that of Greece and Spain breeds (Albenzio *et al*., 2006). All the 4 breeds studied had lower milk fat than in African goats where it ranges from 5.32-7.78 % (Devendra and Burns, 1983). In general fat content in milk of Sirohi, Kutchi and Marwari was lower than reported by Pal *et al*. (1996). Unlike our study where Sirohi revealed higher ($p<0.01$) fat, they recorded higher fat in Marwari. Kutchi had the lowest fat content. Fat content varies due to breed, parity, stage of lactation, time of milking, location, feeding and management of the animals (Agnihotri *et al*., 2002). The TS, SNF and casein contents in Jakhrana milk were higher and ash content was the lowest but differences among the breeds were non-significant. Casein content that ranged from 3.32% in Sirohi to 3.5% in Jakhrana was almost in the same range as reported by Agnihotri and Pal (1996). Overall mean TS, SNF and ash content in goat milk are in general agreement with the findings of Agnihotri (2002) who also reported overall mean TS, SNF and ash contents of 11.24, 7.25, 0.79% , respectively in mixed milk of Western region goat breeds. The non-significant difference in ash content of milk from 4 breeds is in agreement with the findings of Agnihotri (2002). Agnihotri *et al*. (2002) also did not observe marked difference in mineral composition of milk obtained from different breeds/locations.

The pH value of milk varied from 6.53-6.64, which is closer to values reported by Agnihotri *et al*. (2002). The Sirohi milk had comparable pH with Jakhrana but higher ($p<0.01$) than Marwari, Kutchi. Contrary to our results, Agnihotri (2002) did not observe significant difference in pH of milk from Jamunapari, Barbari and mixed milk of Western region breeds. However, Pal *et al*. (1996) reported type of breed significantly ($p<0.05$) influenced milk pH and Kutchi had higher pH than Marwari and Sirohi. Such variability might be due to breed, stage of lactation, health of the animal, as well as level of bacterial contamination in raw goat milk (Agnihotri and Pal, 1996). Titrable acidity in milk varied from 0.170 to 0.198% (lactic acid) with overall mean percent of 0.185. Kutchi revealed higher ($p<0.01$) TA than Sirohi. The Marwari and Jakhrana had almost similar TA. Titrable acidity ranging from 0.15 to 0.21% has been reported in goat milk. Jamunapari and Barbari milk has higher TA than Western region breed's milk (Agnihotri *et al*., 2002). Agnihotri and Prasad (1993) mentioned that although pH of goat milk did not vary much, TA was fairly high (0.18%) in Black Bengal milk. The milk samples of Kutchi that had lowest SNF (7.60%) also had lowest pH (6.53). Joshi and Vedanayakam (1967) reported that lower the SNF content in goat milk, lower was the buffering capacity resulting in poor keeping quality of goat milk.

The Jakhrana, Sirohi and Kutchi milk met the Prevention of Food Adulteration Act (PFA, 1976) standards for fat but Marwari milk failed to meet the prescribed minimum limits. Milk from four breeds failed to meet SNF standards. According to PFA rules (Saini and Khan, 1986) goat milk in UP should not have less than 3.5% fat and 9.0% SNF. Although prescribed minimum limits for fat might work but SNF limit was unrealistic being on higher side. Majority of the samples did not cross SNF content beyond 8.0% (Table 1, 3 and 4) in this study.

Table 3: Effect of parity on composition, pH and TA of goat milk (Least squares means±SE)

Breed	Milk yield/ day (L)	TS (%)	Fat (%)	SNF (%)	Casein (%)	Ash (%)	pH	TA (%) (Lactic acid)
1 (N = 70)	556.70±26.52^{a}	11.28±0.22	3.75±0.15	7.53±0.16	3.42±0.05	0.95±0.09	6.54±0.01^{a}	0.19±0.03
2 (N = 49)	637.25±30.88^{ab}	11.92±0.25	3.90±0.17	7.85±0.19	3.46±0.06	0.99±0.10	6.59±0.01^{bc}	0.18±0.04
3 (N = 42)	575.94±35.22^{a}	11.05±0.29	3.45±0.19	7.59±0.22	3.34±0.07	0.81±0.12	6.57±0.01^{ab}	0.18±0.04
4 (N = 35)	602.00±32.00^{a}	11.78±0.31	4.09±0.21	7.71±0.22	3.30±0.08	0.87±0.13	6.59±0.02^{ab}	0.18±0.04
5 (N = 14)	750.49±58.41^{b}	11.74±0.47	3.88±0.33	7.91±0.36	3.42±0.12	0.86±0.20	6.65±0.02^{c}	0.18±0.04

Means within columns sharing a common superscript letter are not significantly different at p<0.01

Table 4: Least squares means of daily milk yield (L), concentration (g L^{-1}) of milk constituents, pH and titrable acidity (%, lactic acid) at different stages of lactation in goats

Stage of lactation (in weeks)	Milk yield	TS	Fat	SNF	Casein	Ash	pH	TA
1	0.74^{d}	116. 96^{abc}	39.83^{Ab}	77.19	35.87^{b}	8.15	6.52^{a}	0.19
2	0.80^{d}	110.73^{ab}	33.36^{a}	77.66	33.97^{ab}	10.32	6.56^{Ab}	0.18
4	0.74^{d}	107.31^{a}	34.43^{Ab}	73.21	34.49^{ab}	10.60	6.57^{Ab}	0.18
6	0.65^{cd}	113. 30^{abc}	35.79^{Ab}	77.95	34.13^{ab}	8.18	6.58^{Ab}	0.17
8	0.58^{bc}	123. 35^{c}	39.54^{Ab}	81.02	33.37^{a}	8.38	6.65^{c}	0.17
10	0.46^{Ab}	116.80^{abc}	41.51^{Ab}	75.60	33.57^{ab}	8.55	6.62^{bc}	0.19
13	0.39^{A}	120.47^{bc}	42.71^{B}	77.72	32.13^{a}	8.46	6.61^{bc}	0.19
Mean	0.60	115.07	37.50	77.10	33.80	8.90	6.59	0.18
SE	14.38	0.12	0.08	0.09	0.03	0.05	0.01	0.01
CV%	34.50	14.74	30.96	16.55	12.50	79.38	1.33	13.24

Number of observations for each stage of lactation is 30. Means within columns sharing a common superscript letter are not significantly different at p<0.05 (capital letters) and p<0.01 (small letters). SE: Standard Error; CV %: Critical Variation %

Milk yield and pH were affected due to dam's parity (Table 3). The changes in TS, fat, SNF, casein, ash and TA were not significant. Animals of parity 5 yielded higher (p<0.01) milk (750.49 mL) per day followed by animals of parity 2. The pH was interdependent on milk yield. Maximum milk pH (6.65) was recorded in parity 5 having maximum milk yield. Minimum yield was recorded in the first parity. In Jamunapari goats maintained under organized farm conditions, Pal *et al*. (1996) also did not observe the effect of parity on various milk constituents except casein content, which was affected due to parity of dams.

The highest milk (0.800 L day^{-1}) yield was recorded in week two of lactation which started declining (p<0.01) after week six reaching as low as 0.390 L day^{-1} on week 13 of lactation. In Jamunapari goats daily milk yield is affected due to season, parity and stage of lactation (Pal *et al*., 1996). The TS and fat contents were high in early lactation, declined as the lactation period advanced followed by a steady increase in last stages. Fat and protein in goats' milk are high in early lactation, much lower thereafter until they rise again markedly at the end of lactation, when yields are low (Anifantakis and Kandarakis, 1980). Fat contents in goat milk changed from 2.70% in mid-lactation to 4.60% during the last week 42 of lactation (Voutsinas *et al*., 1990). In Barbari and Jamunapari goats, as the lactation period advanced milk fat and TS increased (Kala and Prakash, 1990). The SNF, ash and TA were not affected much due stage of lactation. The pH was dependent on stage of lactation and was low (6.52) in early stage and showed a steady increase reaching to the level of 6.65 in week 8 followed by gradual decline of pH 6.61 in week 13 (Table 4). Decrease in pH with progress of lactation may be attributed to increase in milk components like casein and phosphates that contribute to the natural acidity of fresh milk (Singh and Sengar, 1990). Casein content declined (p<0.05) from 35.87 g in first week to 32.13 in week 13 of lactation. Similar to this study Pal *et al*. (1996) also observed linear decrease in casein content of Jamunapari milk from week 2 to week 14, there after a gradual increase up to end of lactation (week 22) with decreasing milk yield was noticed.

Results of the study indicated that Jakhrana was better milk yielder with higher fat and pH. The milk composition of Jakhrana goats at their home tract was collected, analysed and compared with farm samples (Table 5). Next highest milk was observed in Sirohi goats. The Marwari and Kutchi had

Table 5: Major milk constituents of Jakhrana goats reared under farm and field condition

Traits	Field (N = 20)	Farm (N = 28)	Significance
Water (%)	86.29±0.32	87.94±0.36	NS
TS (%)	13.71±0.37	12.06±0.34	NS
Fat (%)	05.31±0.22	04.39±0.24	NS
SNF (%)	08.41±0.35	07.69±0.26	NS
Ash (%)	00.73±0.08	00.76±0.24	NS

NS: Not significant (p>0.05)

almost similar milk yield. Daily milk yield in parity 5 of animals was maximum and animals of first parity yielded minimum milk. The maximum milk pH was recorded when milk yield in parity 5 was maximum. Highest milk yield was recorded in week 2 of lactation. As the lactation period advanced, fat content and pH value revealed a steady increase and casein content declined. Marwari milk failed to meet the PFA standards of both 3.5% fat and 9.0% SNF whereas milk from all the breeds did not meet the PFA standard for SNF in Uttar Pradesh.

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