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Effect of Environmental Factors on Goat Milk and Meat Quality under Field and Farm Rearing Condition: A Review

Gitam Singh[1], R.B. Sharma[2], Khushboo Sharma[1], Alok Kumar[1], L.K. Sharma[1]

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ABSTRACT

The main objective of this study is the use of milk and meat composition data for the use of research and extension purpose. All samples were analyzed by an electronic milk analyzer, Atomic Absorption Spectrophotometer and Photo flame. Data were analyzed using the ANOVA procedure of RBD (at 5% and 1% significance levels) for the statistical analysis of all milk samples. The specific gravity, fat, calcium, phosphorus, potassium, magnesium and chloride percentage in the milk of Jakhrana as well as Jamunapari goat breeds under farm rearing conditions was significantly higher than that of field rearing conditions. As regards meat quality, the sensory quality of meat of both the breeds under field and farm conditions did not differ significantly from each other. The chemical quality of goat meat, in general, was slightly better in goats reared under field conditions than in farm conditions. All the variables *viz.* breed, season, stage of lactation and multiple births had conspicuous effects on milk quality of goats under study. However, such variations were not prominently observed in case of meat quality. In the field and farm rearing conditions, milk and meat related agencies would be able to alert farmers whenever threshold values for milk and meat quality were reached, allowing them to improve their dairy production from an economic and ecological and animal welfare point of view.

Key words: Environmental factors, Farm rearing condition, Field, Goat milk, Meat quality.

India today stands first in the area of milk production at the world level, with an annual growth rate of about 4%. The country's milk production in 2010 was estimated to be 110 million tons. A large quantity of milk produced in the country, amounting to over 46%, is being consumed as liquid milk. The production and use of animal products in the use of human diet is receiving tremendous attention (Singh *et al.,* 2012). The productive improvements among dairy animals can be made through proper management, feeding, handling, *etc.*, which may influence the expression of productive characters as per their heritability nature. Before identifying the animals for breeding and production purposes, screening of animals shall be performed on the basis of physical traits (Singh *et al.,* 2013). The goat population of our country increased from 47.14 million in the year 1951 to 124.5 million during 2005 (Singh and Sharma, 2013a) and (Singh and Sharma, 2014). The Gir breed, which is rated as a relatively better milk producer of indigenous breeds, needs exploration of its production potentiality with a view to knowing its further prospect. Improvement can be made through proper management, feeding, handling and other environmental conditions that will influence the expression of characters, but a limit of which is set by the heredity of the individual (Singh *et al.,* 2013b, Singh *et al.,* 2025e).

Goats are an integral part of livestock production and play a vital role in the socio-economic structure of the rural poor. The aim of this study was to project the importance and significance of goat milk with special reference to Indian field and farm rearing conditions. There are adverse ecological and physiological constraints in the Indian system of goat farming. Poultry farming is an ancient business in India, but scientific upkeep of poultry is very new. It has got economic, nutritional, industrial, recreational and research importance. It also plays an important role in improving the economy of the poultry owner. Various government and non-government organizations have also recognized the importance of poultry farming as an employment-generating enterprise and are engaged in motivating more and more entrepreneurs to take up this enterprise (Singh *et al.,* 2014a). Goats play a vital socio-economic role in Asian agriculture, particularly for resource-poor people living in harsh environments (Singh *et al.*, 2014b). The global goat population currently stands at 921 million, of which over 90% are found in developing countries. Asia is home to about 60% of the total world goat population and has the largest goat breed share of 26%. Goats play a vital socioeconomic role in Asian agriculture, particularly for resource-poor people living in harsh environments. Non-cattle milk accounts for approximately 15% of the total milk

[1]College of Agriculture, Madhav University, Sirohi-307 026, Rajasthan, India.
[2]Former National Co-ordintor, ICAR, New Delhi-110 011, India.

Corresponding Author: Gitam Singh, College of Agriculture, Madhav University, Sirohi-307 026, Rajasthan, India.
Email: gitam.singh@madhavuniversity.edu.in
ORCID: 0000-0002-0097-9699

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consumption by humans worldwide (Singh *et al.,* 2014c). Goats are more often poorly managed and this is attributed to their ability to survive under harsh conditions and also because most people in rural areas rear goats for their subsistence purposes to support their families. This benefit is often not shown in national statistics because of informal trading and slaughtering (Singh *et al.,* 2014d). The milk is naturally homogenized since it lacks the protein agglutinin. The milk also has a more similar makeup (percentage of fats, *etc*.) to human milk than cow's milk. For these reasons, goat milk may be recommended for infants and people who have difficulty digesting cow's milk (Singh *et al.,* 2014e). Goat meat, being a high-quality protein source, is the choicest meat in the domestic market. It is leaner than other red meats and its fat has desirable fatty acids. The goat was domesticated as early as 6-7 BC, as evidenced by archaeological remains collected in western Asia (Singh *et al.,* 2014f). The major population of India is primarily dependent on an agricultural-based system for their daily life, including goat keeping that constitutes an important rural business of small marginal farmers and landless laborers (Singh *et al.,* 2014 g). Reproductive management of an animal is governed through a number of parameters, *viz.* age at first conception, age at first calving, first gestation length, *etc*. However, this study is limited to studying the reproductive management in terms of the age of the animal at first calving (Singh *et al.,* 2014h). Goats, which were known as "wet nurses of infants" in the United Kingdom and "poor man's cow" in India, were the first animals to be domesticated. Goat milk contains less lactose than cow's milk, so it is less likely to trigger lactose intolerance (Singh and Sharma, 2015). Goat meat, being a high-quality protein source, is the choicest meat in the domestic market. It is leaner than other red meats and its fat has desirable fatty acids. The goat was domesticated as early as 6-7 BC, as evidenced by archaeological remains collected in western Asia. It has since played a significant socioeconomic role in the evolvement of human civilization around the world (Singh and Sharma, 2015a). Pearl millet was recognized as a main source of energy for livestock and is fed at critical times, such as during lactation, illness and for weight gain. Farmers felt that grass is more useful to fill the animals' stomachs and would therefore come before crop stover as a feed. Farmers preferred Deda over Kona because it has more biomass (Singh and Sharma, 2015b). This explains why goat farmers seldom consider the possibilities of increasing production through either crossbreeding or artificial insemination. A very important aspect in this regard is the awareness of risk by resource-poor farmers and their emphasis on minimizing it (Singh and Sharma, 2016). Goats, being a multipurpose animal, produce meat, milk, skin, fiber and manure. The country is endowed with a large and biologically diverse population of goats. (Singh and Sharma, 2016a). The nutritional value of milk is closely related to its composition, which is affected by factors such as breed, diet, stage of lactation, season, *etc*. Goat milk has more calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg) and chloride (Cl) and less sodium (Na) and sulfur (S) content than cow milk (Singh and Sharma, 2016b). Livestock production is the backbone of Indian agriculture, contributing 7% to national GDP and being a source of employment and livelihood for 70% of the population in rural areas. India ranks first in terms of milk production (129.7 million tons); however, the productivity is quite low, mainly because of the scarcity of feeds and fodders (Singh *et al.,* 2017). Animals reared in intensive production systems consume a considerable amount of protein and other nitrogen-containing substances in their diets (Singh *et al.,* 2017a). Small ruminants have a large impact on the economy and food supply of people in subtropical and tropical countries. This benefit is often not shown in national statistics because of informal trading and slaughtering (Singh and Sharma, 2017b). Jamnapari (or Jamunapari) is a breed of goat originating from the Indian subcontinent. Since 1953 they have been imported to Indonesia (popular as Etawa goats and their mixture with a local goat called "PE," *peranakan Etawa,* or Etawa mix), where they have been a great success. It is bred for both milk and meat. The name is derived from the rivers Yamuna, Jamuna (West Bengal) and Jamuna (Bangladesh) of India and Bangladesh. There is a great variation in coat color, but the typical coat is white with small tan patches on the head and neck. The typical character of the breed is a highly convex nose line with a tuft of hair, yielding a parrot mouth appearance (Singh *et al.,* 2017c). The consequence of domestication was a change in the phenotypic characteristics of wild goats, which resulted in the development of a multiplicity of goat breeds or types. These breeds or types were distributed across the world as a result of the migration and translocation of humans, usually due to changing climatic conditions and natural resources (Singh and Sharma, 2017d). Goats play a vital socio-economic role in Asian agriculture, particularly for resource-poor people living in harsh environments. Non-cattle milk accounts for approximately 15% of the total milk consumption by humans worldwide. Asia contributes approximately 59% to world goat milk production (Singh *et al.,* 2018). There is a large commercial chicken industry that provides us with eggs and meat. A major constraint to poultry production is the high value placed upon crop production rather than livestock production. Over recent decades the poultry industry has made tremendous adjustments to meet the increasing demand for an inexpensive and safe supply of meat and eggs (Singh, 2019). India is endowed with a significant share of the world's livestock population, growing steadily and continuously. Buffalo are predominantly animals of poor countries with a very high density of livestock and human population and with poor feed resources. In tropical and subtropical regions, dairy cattle usually depend exclusively on native or introduced pastures as their only source of nutrients and in particular, during critical periods of the

year, such as the winter or dry season, the animals cannot fulfill their nutrient requirements because forage is either scarce or of low quality (Singh, 2019a and Singh *et al.,* 2025c). Milk-secreting tissues and various ducts throughout the udder can be damaged by bacterial toxins and sometimes permanent damage to the udder occurs. Severe acute cases can be fatal, but even in cows that recover; there may be consequences for the rest of the lactation and subsequent lactations (Singh and Singh, 2020). Livestock has become an integral part of all interventions aimed at reducing rural poverty and enhancing food and nutrition security. The dairy livestock owners who raise cattle and buffaloes are yet ignorant of scientific management practices (Singh and Somvanshi, 2020a).

The goat is thought to have been the earliest domesticated ruminant and, of all the species of domesticated animals except the dog, has the widest ecological range. Originating in Asia, goats have spread over all the continents and inhabit almost all climatic zones from the Arctic Circle to the equator (Singh, 2024). Man, animal and nature are in a symbiotic relationship for their survival and sustenance. The balance maintained among the three for several millennia has been disturbed by the overexploitation of natural resources to meet the demands of the increasing population of men and animals (Singh *et al.,* 2024a). The nutritional value of milk is closely related to its composition, which is affected by factors such as breed, diet, stage of lactation and season. Goat milk has more calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg) and chloride (Cl) and less sodium (Na) and sulfur (S) compared to cow milk (Singh *et al.,* 2024b) and (Singh *et al.,* 2025a). Minerals are required by dairy animals for their metabolic functions, growth, milk production, reproduction and health.

Animals cannot synthesize minerals inside their bodies and usually, feeds and fodders fed to the dairy animals do not provide all the minerals in the required quantity (Singh *et al.,* 2024c). The goat is thought to have been the earliest domesticated ruminant and, of all the species of domesticated animals except the dog, has the widest ecological range (Singh *et al.,* 2024d). The productive improvements among dairy animals can be made through proper management, feeding, handling, *etc.*, which may influence the expression of productive characters as per their heritability nature (Singh *et al.,* 2024e). The production and use of animal products in the use of human diet is receiving tremendous attention. (Singh *et al.,* 2025; Singh *et al.,* 2025b and Singh *et al.,* 2025d).

Milk quality

Breeds

The specific gravity of Jakhrana goat milk was significantly ($p<0.05$) higher than that of Jamunapari goat under field and farm rearing conditions. The fat percentage in the milk of Jakhrana as well as Jamunapari goat breeds under farm rearing conditions was significantly ($p<0.05$ and $p<0.01$) higher than that under field rearing conditions. The protein per cent in field conditions was significantly ($p<0.01$) greater than that of farm rearing goat milk in both the breeds. The overall average lactose per cent in both breed's milk under field and farm rearing conditions was found to be 4.43±0.014 for all 1215 samples. The statistical analysis revealed that the lactose content in field conditions was significantly higher ($p<0.05$) than that of farm rearing conditions in Jakhrana as well as Jamunapari goats. The overall average ash content in both breed's milk under field and farm rearing conditions of all samples was found to be 0.745±0.007 per cent. The ash content in the milk of Jakhrana or Jamunapari goats under field conditions was significantly ($p<0.05$ and $p<0.01$) greater than that of farm rearing conditions.

The overall average total solids percentage of all 1215 samples was found to be 13.15±0.035. The total solids in Jakhrana goats was significantly ($p<0.05$) higher in field rearing condition where as in case of Jamunapari goats was slightly higher in field rearing condition. The SNF percentage was significantly ($p<0.01$) higher in field rearing conditions in both breeds than that of farm rearing conditions (Singh and Sharma, 2013).

The overall average calcium per cent in all above samples and conditions was 0.1455±0.0019. Calcium content of Jakhrana or Jamunapari goat breed milk under field conditions were significantly ($p<0.05$) lower than that of farm rearing conditions. The overall average phosphorus content in both breed's milk under field and farm rearing conditions of all 1215 samples was found to be 0.1233±0.0010 per cent. The phosphorus content in the milk of Jakhrana goat breeds under field rearing conditions was lower than that of farm rearing conditions. The overall average potassium per cent of all 1215 samples was found to be 0.111±0.00085. The potassium content was higher in farm rearing conditions than field rearing conditions but this difference was, however, insignificant. The overall average magnesium per cent of all above 1215 samples under field and farm rearing conditions was 0.01455±0.00015. The magnesium content was significantly ($p<0.01$) higher in farm rearing conditions than in field rearing conditions. The chloride content was significantly ($p<0.05$ and $p<0.01$) higher in farm rearing samples than that of field rearing samples of both breeds. The selenium percent in the milk of Jakhrana as well as Jamunapari goat breed under field rearing conditions was significantly ($p<0.01$) greater than that of farm rearing conditions (Singh and Sharma, 2016).

Seasons

The specific gravity was higher in summer seasons and lower in rainy seasons in both breeds of goat under field and farm rearing conditions. The fat content was significantly greater in farm samples than field rearing samples in all seasons. The higher fat percent was recorded in rainy season in milk samples of both breeds. The protein content under field conditions in Jakhrana as well as Jamunapari goat breeds in all seasons was significantly ($p<0.05$) higher than that of farm rearing conditions. The overall average

lactose per cent in all above 1215 samples was found to be 4.433±0.014. Significant variation in lactose content under field and farm rearing conditions was observed in both breeds. The overall average ash content of above all breeds and field and farm rearing conditions in all above seasons was 0.745±0.009 per cent. The ash content was higher in winter season and lower in summer season in both breeds under field as well as farm rearing conditions. The overall average total solids percentage of all above 1215 samples of milk was found to be 13.15±0.037. Total solids content was significantly ($p<0.05$ and $p<0.01$) greater in field samples than in farm rearing samples in all seasons. The SNF content was significantly ($p<0.01$) greater in field rearing samples than farm rearing samples in all seasons (Singh *et al.,* 2014).

The overall average calcium percentage of all above 1215 samples of milk was 0.146±0.0019. Significant variation in calcium content under field and farm rearing conditions was observed in both breeds. The overall average phosphorus content of all above 1215 samples of milk was found to be 0.123±0.00105. Phosphorus content was highest in winter seasons and lowest in summer seasons in both breeds of goat milk under field and farm rearing conditions. The overall average potassium content of all above 1215 samples of milk was found to be 0.111±0.0009 per cent. Potassium content was significantly ($p<0.05$) greater in farm samples than field rearing samples in all seasons but this variation was insignificant. The overall average magnesium content of all above 1215 samples of milk was 0.0146±0.00015 percent. Magnesium content under field rearing conditions in Jakhrana as well as Jamunapari breed milk in all seasons was significantly ($p<0.01$) lower than that of farm rearing samples. The overall average chloride content of all above samples of milk was 0.106±0.0006 per cent. Significant variation in chloride content under field and farm rearing conditions was observed in milk of both breeds. Selenium content was significantly ($p<0.01$) greater in field samples than farm rearing samples in all seasons (Singh and Sharma, 2014).

Stages of lactation

The overall average specific gravity of above all stages of lactation in 1215 milk samples was 1.0295±0.00038. The specific gravity was significantly ($p<0.01$) greater in farm samples than field rearing samples in all lactation stages. Fat content was significantly ($p<0.01$) greater in farm samples as compared to field samples in all above stages of lactation. The overall average protein per cent of all above 1215 samples in all stage of lactation was also worked and found to be 3.205±0.031. Protein content was significantly ($p<0.01$) higher in field rearing condition than farm in all stage of lactation. The overall average lactose content in all above milk was 4.433±0.014 per cent. The variations in lactose percent under field and farm rearing animals was found significantly ($p<0.01$ and $p<0.05$) in all above stage of lactation in both breeds samples. The overall average ash percentage of all above 1215 milk samples was 0.745±0.009. Ash content was significantly ($p<0.01$) greater in field samples than farm rearing samples in all lactation stages. Total solids content was significantly ($p<0.05$ and $p<0.01$) greater in field rearing samples as compared to farm animal in all above stage of lactation in both breed samples except late lactation of Jakhrana goat breed. The overall average SNF content in all above samples in all stages was 8.38±0.053 per cent. Solids-not-fat content was significantly ($p<0.01$) more in field rearing conditions than farm in all stage of lactation in both breeds animal. The overall average calcium content was 0.146±0.0019 per cent in all above 1215 samples.

The difference in calcium percent under field and farm rearing conditions in all above stage of lactation was significant ($p<0.05$) in both breeds' samples. The overall average phosphorus content of above all stage of lactation in above 1215 samples of milk was 0.1233±0.0010 per cent. Phosphorus content was significantly ($p<0.05$) greater in farm samples than field rearing samples in early and middle stage of lactation but some was insignificance in case of late lactation stage. Potassium content was slightly higher in farm rearing samples than that of field rearing samples in all stage of lactation in both breed samples but it was insignificant. Magnesium content in milk was significantly ($p<0.01$) higher in farm rearing conditions than that of field rearing condition in all above stage of lactation in both breed samples. The overall average chloride content in all above samples was 0.1055±0.00059. Variation in chloride content in milk under field and farm rearing animals was significant ($p<0.01$) in all stage of lactation in both breeds of goat. The overall average selenium content in the milk of all above 1215 samples in the all above stage of lactation was a 0.01667±0.000058. Selenium content was significantly ($p<0.01$) greater in field samples than in farm rearing samples in all stages of lactations (Singh *et al.,* 2014).

Multiple births

The overall average specific gravity of all above 1215 samples of milk in all above births was 1.0295±0.00038. The specific gravity content was significantly ($p<0.05$) greater in farm samples than in field rearing samples in all births. The overall average fat per cent of all samples of milk for multiple birth effect was 4.76±0.046. Fat content was significantly greater in farm samples than in field rearing animal in all multiple births. The overall average protein percentage of all above 1215 samples of milk was 3.205±0.031. Protein content was significantly ($p<0.01$) greater in field samples than in farm rearing animal in all multiple births. Significant variation in lactose content under field and farm rearing conditions was observed in all above multiple births except triplet's birth in Jamunapari goat breed. The overall average Ash per cent in all birth of above 1215 samples of milk was 0.745±0.0090 per cent. Ash content was significantly ($p<0.05$ and $p<0.01$) greater in field samples than farm rearing samples in all births. Total solids content was significantly ($p<0.01$) greater in field

rearing animas than farm rearing samples in all multiple births. The overall average SNF percentage of all above milk samples in all above birth was 8.38±0.053. SNF content was significantly ($p<0.01$) greater in field samples than that in farm rearing samples in all births (Singh *et al*., 2014). The overall average calcium content of all above samples in all rearing and births was 0.1455±0.0019 per cent. Significant variation in calcium content under field and farm rearing conditions was observed in all above multiple births ($p<0.01$) except triplets in Jamunapari goats. The overall average phosphorus percentage of all above 1215 milk samples in all above births was 0.1233±0.0011. Phosphorus content was significantly ($p<0.05$) greater in farm samples than in field rearing samples in all multiple births. The overall average potassium percentage of all above 1215 milk samples was 0.111±0.0008. Potassium content was greater in farm rearing samples than field rearing animal in all multiple births but this variation was in significant. The overall average magnesium percentage of all above samples of milk in all births and rearing conditions was 0.01455±0.00015. Magnesium content was significantly (1%) much higher in farm rearing samples than that of field samples in all multiple births. The difference in chloride percentage under field and farm rearing conditions was observed highly significant ($p<0.01$) in all above multiple births. The overall average selenium percentage of all above samples of milk in all births was 0.01667±0.000058. Selenium content was significantly ($p<0.01$) greater in field samples than farm rearing samples in all multiple births (Singh *et al.,* 2014).

Meat quality

Organoleptic evaluation

The colour/ appearance score in field condition did not differ significantly from farm rearing goat meat in both breeds. Flavor in the meat of Jakhrana as well as Jamunapari goat breeds did not elicit significant difference under field and farm rearing conditions. The overall average juiciness in above goat breeds of field and farm rearing conditions was 6.58±0.05. Juiciness was significantly higher in field rearing samples than that of farm rearing samples of Jamunapari goat breeds and juiciness was higher in field rearing samples than that of farm rearing samples not significant in Jakhrana goats. Saltiness in the meat of Jakhrana goat breeds under farm rearing conditions was lower than that of field rearing conditions but this difference was insignificant but in case of Jamunapari goat breed, saltiness significantly ($p<0.01$) higher in field rearing conditions than farm rearing conditions. The overall acceptability of meat of both breeds under field or farm conditions was almost same and comparable (Singh and Sharma, 2016).

Breeds

The moisture percentage of Jakhrana goat meat under field and farm rearing conditions was found to be 75.69±0.17 and 75.57±0.15, respectively with an average of 75.63±0.16 per cent. Similarly moisture per cent in the meat of Jamunapari goat breeds under above conditions was found to be 75.69±0.175 and 75.57±0.165, respectively with average of 75.631±0.18 per cent. The moisture and protein percentage of Jakhrana and Jamunapari goat breed meat under field rearing conditions was slightly more than farm rearing samples but this variation was insignificant. The Jamunapari goat meat contained significantly ($p<0.05$) higher fat percent in field rearing samples than farm but this was not true in case of Jakhrana goat breed meat. Ash content under field rearing goats in either Jakhrana or Jamunapari breeds meat was found significantly ($p<0.05$) lower than that of farm rearing samples (Singh and Sharma, 2016).

Seasons

The moisture content in Jakhrana goat meat under field and farm rearing condition in different seasons *i.e*. summer, rainy and winter was found to be 75.26±0.16 and 75.11±0.15, 75.25±0.14 and 75.18±0.12 and 76.57±0.21 and 76.42±0.20 per cent, respectively. Similarly in case of Jamunapari goat breed meat under field and farm rearing condition in aforesaid seasons was found to be 75.28±0.14 and 75.11±0.19, 75.38±0.16 and 75.25±0.17 and 76.43±0.22 and 76.34±0.21 per cent, respectively. The moisture content was higher in field rearing samples as compared to farm samples in both breed goats but such variation was insignificant. No significant difference was observed in fat percentage under field and farm rearing animals in both the breeds under different seasons. Lowest protein content was found in winter season whereas highest in rainy seasons in meat of both breeds under field and farm rearing conditions. Ash content in goat meat was higher in field rearing conditions than farm rearing conditions in both breeds of goat in all seasons; however, it was statistically insignificant (Singh *et al.,* 2017).

CONCLUSION

The specific gravity, fat, calcium, phosphorus, potassium, magnesium and chloride percentage in the milk of Jakhrana as well as Jamunapari goat breeds under farm rearing conditions was significantly higher than that of field rearing conditions. As regards meat quality, the sensory quality of meat of both the breeds under field and farm conditions did not differ significantly from each other. The chemical quality of goat meat, in general, was slightly better in goats reared under field conditions than in farm conditions. All the variables *viz*. breed, season, stage of lactation and multiple births had conspicuous effects on milk quality of goats under study. However, such variations were not prominently observed in case of meat quality.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent

the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

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