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Exploring potential of goat based dairy farming in India and way forward

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ABSTRACT

The aim of this review is to highlight the significance of goat milk along with potential and prospects of dairy goat development in the country. India occupies the first position in goat milk production in the world. In the last few years, commercial dairy goat production in India gained momentum due to spread of knowledge about therapeutic, nutraceutical and medicinal benefits of goat milk and its product, and their export potential. India possesses vast caprine resources with 37 goat breeds distributed in different bio-climates with varied nutritive value, however, some goat breeds native to north and north-western region namely Beetal, Jamunapari, Jakhrana, Surti and Zalawadi are considered as Indian dairy breed with 150 to 500 litre milk yields. The reported milk yield of Indian dairy goat is far below their potential, since they are primarily raised for mutton and also due to energy-deficient diet. Attempts so far made were scarce and limited for milk improvement of dairy goats and in creating infrastructure for goat milk processing and marketing. Use of potential sire/semen and infrastructural support for a secured market for goat milk and products is necessary to enhance dairy goat productivity and profitability. To cater the demand for goat milk in southern, eastern and hilly regions, suitable dairy breeds need to be developed along with increasing the genetic potential of existing breeds. Development of the goat dairy sector will require focused efforts to encourage entrepreneurship to set as many as possible commercial dairy farms by involving private sector through appropriate policy support and incentives.

Keywords: Breed, Dairy goat, Functional food, Goat milk, Human nutrition, Nutraceutical, Reverse selection, Therapeutic

Goat in India is largely reared for chevon production and contributes largely to the livelihood of resource-poor households specifically in climatically disadvantageous regions, where crop production is always at risk (Singh *et al.* 2013). Goat farming is less capital intensive and thus suitable for a large number of rural populations. Goat with their multi-facet utility for meat, milk, skin, wool, hair and manure, etc. contributes about 9% of livestock GDP. Goats in India are predominately (>90%) reared under extensive management on community rangeland under low input and output production system. The goat population of India is 148.88 million (2nd highest after China) which has been increasing by 3.5% annually from 2007 to 2019 (DAHD 2019) despite ~56% slaughter and ~15% mortality, thus, it has become one of the most inclusive species of livestock. Indian goat breeds are distributed in different ecologies and are good performers in their habitat under optimum feeding and bear a great degree of resistance to disease and climatic fluctuations. Productivity of indigenous goats is lower than their actual genetic potential, and attributed to low input system, lack of suitable breed and region-specific structural goat improvement programme, poor adoption of technologies, depletion of grazing resources and an unorganized market (Singh *et al.* 2018). Milk from cattle and buffaloes and their products have been synonymous with the concept of the dairy industry and contribute >94% of total global milk production. However, milk from minor dairy animals such as goat, sheep, camels, mithun, donkey and yak also contribute to the significant amount and, in recent past, these species milk has been recognised for specific health benefits unique to that species. Goat occupies an important place among minor dairy species not only due to quantity, but due to therapeutic properties, their contribution to specific ecologies and export potential (Haenlein 2001, Park *et al.* 2007, Barlowska *et al.* 2011, Yangilar 2013, Verrucka *et al*. 2019, Verma *et al*. 2020).

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World scenario of goat milk production

World-wide goat milk in 2018 has surpassed 18.71 million tonnes (FAOSTAT 2018) and India with 6.17 million tonnes of milk is contributing 33% of global goat milk production. India, Sudan, Bangladesh, Pakistan, and France are the major goat milk producing countries with 53.12% global goat milk production. However, the average

milk yield per head is only a quarter (26%) of that for (762 vs 2901 g/d) Europe (Liang and Pinaengkoum 2019). The European goat sector is specialized in industrial cheese making. Most of the dairy goats originated in Europe constitute 5% of world's goat population and produce >21% of goat milk in world (FAOSTAT 2013). Switzerland led in the development of the world's highest milk yielding dairy goat breeds, namely Alpine, Saanen, Toggenburg and Oberhasli. The milk yield of European goat breeds ranges from 1500-3000 litres per lactation in 220-280 days lactation period. However, maximum milk by individual Alpine, Nubian, Saanen and Toggenburg goat was recorded as up to 2916, 2700, 2064 and 3620 kg in 305 days lactation period, respectively (Boichard *et al.* 1989, Serradilla 2001, Dubeuf *et al.* 2004, Goetsch *et al.* 2011). Increasing milk yields for direct consumption and for processing into butter, yogurt and cheeses are major selection aim in the development of dairy goats in Europe and America.

Indian scenario of dairy goat production

India occupies the first position in global goat milk production (6.09 million tonnes) and in India goat is 3rd (3% of total milk) largest milk contributing species (DAHD 2019). The top five goat milk producing states are Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat and Maharashtra accounting for 79.5% of total goat milk production. However, the proportional increase in milking goat over the period is less compared to the total goat population. In India, milk production of goats is likely to be more than in the official statistics, because the large amounts of milk is unreported due to home consumption and un-recorded marketing. Milk productivity, however, remains static over the year i.e. about 0.46 kg/day/goat for the last decade. The estimated global dairy goat population was 218 million in the 2017 and there has been a continuous increase (Miller and Lu 2019). However, in India, there is a decline in the dairy goat population (DAHD 2019). Milk obtained from Indian goats is relatively rich in health-promoting substances like phenolic compound, fat soluble vitamins, unsaturated fatty acid, medium chain fatty acids, bioactive peptides as these animals are raised predominately on community pasture unlike their European counterparts who maintain goats on diet rich in concentrate (Kondyli and Katsiari 2002, Lucas *et al.* 2008, Shingfield *et al.* 2008, Goetsch *et al.* 2011, Zervas and Tsiplakou 2011). At present, goat milk marketing structure does not exist and milk in countryside is being sold at very low price (₹ 25-35 per litre) which made dairy goat farming uneconomic. However, dairy goat farming may grow very fast in organized manner by providing reasonable price (₹ 60/litre) of goat milk to farmers. It may make commercial dairy goat farming at par or better than commercial goat meat production (Table 2).

Goat resources of India

India is home to 148.88 million goats with 37 recognized breeds and contributes 6.38 million tonnes (3%) milk and 1.09 million tonnes meat (13.53%). The 20th livestock census showed a 10.1% increase in population over 19th livestock census. Rajasthan, West Bengal, Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra are major goat population states accounting for 20.84, 16.28, 14.48, 12.82, 11.06 and 10.60%, respectively (DAHD 2019). These 37 goat breeds in India have been developed in different regions to cater to the multi-facet needs of people in different regions of the country. The milk composition of different breeds varies significantly and also influenced by bio climates (Verma *et al.* 2022). These goat breeds are good performer in their habitat under adequate feeding and bear a great degree of resistance to disease and climates. However, some breeds, native to north-west region are good in milk, i.e. 150-500 litres milk in 160-225 days lactation (Beetal, Jamunapari, Jakhrana, Surti, Gohilwadi, Zalawadi) and classified as Indian dairy breeds (Singh *et al.* 2018). The average milk yield of the Indian dairy breed is about 150 litres, however, about 8-10% goats are producing 250-500 litres of milk per lactation. These dairy goats are also good in prolificacy (40 to 60% multiple births) and possess large variation for lactation period (150 to 220 days) and growth performance (28 to 52 kg live body weight at 12 months of age). These breeds may also be used as candidate breeds for grading up of large number of non-descript goats according to agro-climatic suitability. The dual purpose breeds such as Barbari, Sirohi, Mehsana, Kutcchi, Sojat, Gujari, Malabari and Sangamneri etc. also possess good potential for milk (100-175 litres/lactation (Singh *et al*. 2018). However, lack of structured genetic improvement, faulty breeding practices and market has put most of Indian dairy goats (Beetal, Jakhrana, Jamunapari and Surti) under the endangered category (Singh and Singh 2012).

The goat breeds of India on their lactation performance are briefly grouped as (Rai *et.al* 2005, Singh *et al.* 2008, Singh and Chauhan 2021).

Milch (dairy) Breeds (Milk and Meat): Beetal, Jakhrana, Jamunapari, Surti, Zalawadi and Gohilwadi with 150-500 litres milk in 150-200 days lactation period.

Dual Purpose Breeds (Milk and Meat): Barbari, Sirohi, Sojat. Gujari, Karauli Marwari, Kuttchi, Mehsana, Kahmi, Rohil Khandi, Sangamneri, Osmanabadi, Malabari and Berari with 100-145 litres milk in 90-160 days lactation period.

Meat Purpose Breeds: Black Bengal, Terresa, Assam Hill, Sumi-Ne, Kodi-Adu, Kana-Adu, Salem-black, Black Attapady, Konkan Kanyal, Bidri, Nandi-Dugra, Pantja, Ganjam with 20-45 litres milk in 40-75 days lactation period.

Other Dual Purpose Breeds (Meat and Fibre): Chegu, Changthangi, Gaddi and Bhakarwali with 20-45 litres milk in 50-75 days lactation besides 200-350 g fibre/year.

Importance of goat milk

The protein, fat, solid not fat and total solids contents are much higher in sheep, cow and buffalo's milk as compared

Table 1. Milk composition of different dairy animals

Parameter	Sheep	Goat	Buffalo	Cow	Camel
Protein (%)	4.50-6.60	2.80- 3.70	4.38	3.20-4.00	3.26
Fat (%)	(5.30-9.30) 6.99	(3.40-4.50) 4.07	7.73	(3.40-4.50) 4.09	3.80
Lactose (%)	3.90-4.90	3.90-4.80	4.79	4.60-4.90	4.30
Solid not fats (%)	12.00	8.90	9.50	9.00	10.36
Water (%)	82	83.20	83.18	87.80	86.50
Total solid (%)	18.50	12.50	18.00	13.80	14.00

(*Source:* Kapadiya *et al.* 2016 and Giambra *et al.* 2014)

to goats (Table 1). However, goat milk composition differs from other species due to genetic polymorphism which resulted in variation in amino acid configuration that led to alteration in protein chain making the goat milk unique and beneficial for human health (Verma and Rout 2022). Unique nutritive and health properties of goat milk have been briefly described (Jandal 1996, Haenlein 2004, Park *et al.* 2007, Al-Wabel 2008, Silanikove *et al.* 2010, Ribeiro and Ribeiro 2010, Barlowska *et al.* 2011).

Importance of goat milk with unique features for human health

Goat milk is more alkaline and cow milk is slightly acidic. Goat milk has a stronger goaty flavour than sheep and cow milk. The fat globule size in goat milk is much smaller, make it in homogenized state with naturally improved digestibility. Goat milk forms a finer curd than cow milk following acidification, which mimics the conditions in the stomach, making it more readily digested. Goat milk contains a higher proportion of medium-chain fatty acids, i.e. caproic, caprylic and capric which are known for anti-bacterial, antiviral, inhibit development and dissolve cholesterol deposits, and absorbed rapidly from the intestine (Shingfield *et al.* 2008). Goat milk contains 4-5 times higher oligosaccharides than cow milk and 10 times higher than sheep milk and is associated with prebiotic and anti-infective, anti-inflammatory properties and stimulates gut bifidobacterium and lactobacilli (Martinez *et al.* 2005, Boehm and Stahl 2007). Goat milk is a rich source of conjugated linoleic acid (CLA), which helps in reducing oxidative stress, atherosclerosis, improves blood lipids profile and protects the growth of tumours of mammary

Table 2. Production economics of milch and dual purpose goat breeds

Breed	Beetal	Jamunapari	Jakhrana	Surti	Zalawadi	Barbari	Sirohi
Item							
Price of yearlings	15000	15000	12000	12000	12000	10000	10000
Age at first kidding (m)	20	20	18	18	18	15	16
Kidding interval (m)	11	11	11	9	10	8	10
Litter size (%)	1.4	1.3	1.5	1.5	1.4	1.6	1.2
Kid mortality (%)	5	5	5	5	5	5	5
12 month body weight (kg)	28	28	26	23	26	23	28
Lactation period (days)	160	160	160	140	140	140	130
Milk yield for sale (L)	90	100	100	70	80	80	70
Litter size*	1.4	1.3	1.5	1.5	1.4	1.6	1.2
Body wt/ kidding/year at 12 M	37.24	34.58	37.05	31.35	34.58	34.96	29.64
Income from sale of kids (₹ 400/ kg BW)	15680	14560	15600	13800	14560	14720	13440
Income from sale of milk (₹ 60/l)	5400	6000	6000	4200	4800	4800	4200
Total feed (Concentrate-kg)	227.5	227.5	227.5	171.5	210.5	164.5	202
Conc. cost (₹ 16 per kg)	3640	3640	3640	2744	3368	2632	3232
Dry fodder requirement (kg)	990	990	990	990	990	990	990
Green fodder requirement (kg)	330	330	330	330	330	330	330
Health input (₹)	500	500	500	500	500	500	500
Feed requirement (up to 12 M)	92.25	92.25	92.25	83.25	92.25	83.25	92.25
Conc. cost (₹ 16 per kg)	1476	1476	1476	1332	1476	1332	1476
Dry fodder requirement	432	432	432	432	432	432	432
Green fodder requirement	144	144	144	144	144	144	144
One labour for 40 females and its followers @ ₹ 9000 per month.	2700	2700	2700	2700	2700	2700	2700
Total input costs (₹)	10212	10212	10212	9172	9940	9900	8304
Total output (₹)	21080	20560	21600	18000	19360	19520	17640
Net profit (₹)	10868	10348	11388	8828	9420	9620	9336

gland and skin. Goat milk contains less lactose than cow milk (4.1 % vs 5.0 %). The size of casein micelles in goat milk is higher (100- 200 nm vs 60- 80 nm) than in cow milk. The concentration of α_{s1}- casein in goat milk is low, whereas high for β-casein than that of cow milk, which helps in easy digestion and reduce allergycity.

Goat milk contains more calcium, phosphorus and potassium than cow and human milk. Goat milk contains a range of free amino acids (Taurine, glycine and glutamic acid etc.) that may be utilized directly by the intestine. Taurine is high in goat milk, being 20–40 folds higher than cow milk (Mehaia and Al-Kanhal 1992), and involved in bile salt formation, osmoregulation, antioxidation, calcium transport in the central nervous system, regulation of blood pressure and alleviation other cardiovascular ailments (Redmond *et al.* 1998, Militante and Lombardini 2002). The goat milk-based infant formula contains a level of nucleotides similar to human milk, which facilitate maturity in the immune system of the milk-fed offspring (Boehm and Stahl 2007). Goat milk nucleotides are also involved in lipoprotein metabolism, which increase in high-density lipoprotein (HDL) concentration and synthesis of apolipoprotein A1 and Apo A1 V in pre-term infants as well as long-chain polyunsaturated fatty acid (PUFA) in neonates (Schallera *et al.* 2007). Goat colostrum and milk are rich in polyamines (Ploszaj *et al.* 1997) and shown to be important for optimal growth, gastrointestinal tract (GIT) cell function, maturation of GIT enzymes (Pegg and Mc Cann 1982) and in reducing the incidence of food allergy (Dandrifosse *et al.* 2000). Goat milk enhanced the memory scores (dementia) by significantly decreasing in acetylcholinesterase activity, serum total cholesterol, oxidative stress, and malondialdehyde level (Kaura *et al.* 2022). Goat milk from pasture is naturally enriched in fat-soluble vitamins, unsaturated fatty acids and CLA, medium-chain fatty acids in comparison to goats fed concentrate-forage diets (Kondyli and Katsiari 2002).

Value added products from goat milk

There are several reports related to goat milk products in human nutrition (Haenlein 2004, Park 2005, Scintu and Piredda 2007, Rutherfurd *et al.* 2008, Muehlhoffg *et al.* 2013, Verma *et al.* 2020). Different goat milk products like dry whole milk, dried granulated milk, condensed goat milk, fruit yogurt, cheeses, butter and butter oil, cultured goat cream butter, ice cream, whey protein concentrate (WPC), evaporated milk, traditional Indian products and Turkish butter known as Yayik have been reported (Chilliard *et al.* 2006, Pandya and Ghodke 2007). An increase in demand has been observed for goat milk cheese processed with *Feruloyl Esterase* (FE) producing strain CRL1446, which could result in increased intestinal FE activity and consequently the bioavailability of antioxidant ferulic acid in the gut, thus protect against oxidative stress-related disorders. Besides above, several cosmetic beauty products such as creams, body lotion, shampoos, after-shave lotions and hair conditioners made up of goat milk are in high demand in western countries (Ribeiro and Ribeiro 2010). The characteristics fatty acids caproic and caprylic acids present in goat milk fat also help in enhancing skin permeability, thus being used as a vehicle for several cosmetics (Mahjour *et al.* 1993 and Wongpayapkul *et al.* 2006).

Hygienic goat milk production

Hygienic milk production from dairy goats is of utmost importance for getting all benefits in development of goat dairy industry. Good milking practices are recommended which include regular examination of somatic/bacterial count to prevent and monitor mastitis, cleaning of udder and teats before milking, cleaning of milk collection utensil, washing of hands of milk men, fast milking and most importantly cleaning of goat sheds and proper health of goat. Hygienic milk production has the potential to tolerate technological treatment and to prepare the product for the greater satisfaction of consumers in terms of nutritional and sensory attributes. Thus milk should not have objectionable favours and free from pathogenic bacteria, antibiotic, insecticide, herbicide compounds and contains minimum limits of all nutrients (Park 2010)

Prospects of dairy goat farming in India

A nutritional composition such as type of fat and fatty acids, saturated, unsaturated, omega-3, conjugated and trans-fatty acids in milk and milk products draws minute consumers' attention in the recent time. Goat milk is considered natural functional food because of a higher amount of lactose-derived oligosaccharides, short and medium-chain fatty acids (MCFA), richness in conjugated and branched-chain fatty acids, higher calcium, zinc and vitamin A levels (Albenzio *et al.* 2016). Niche market is rapidly growing in India for preparing ayurveda medicine, pharmaceutical and therapeutic products, cheese, milk powder, immunity booster and other value-added products (Singh *et al.* 2017). Thus, many commercial avenues have been emerging to use goat milk to produce novel dairy products and ingredients such as flavored milk, probiotic yogurt, cheeses, ice-cream and bioactive peptides, and creating opportunities in rural development, employment and sustainable income generation (Park *et al.* 2007, Degen 2007, Pulina *et al.* 2018). Milk peptides from goat are regarded as highly prominent components for health-promoting pharmaceutical applications. India with the highest milk production and huge genetic diversity could be a mega centre of goat milk-based industries and may produce diversified products. The heritability for milk production and lactation traits is moderate to high (0.3 to 0.6), thus huge scope exist for sustainable genetic improvement (Prakash *et al.* 1971, Singh and Singh 1974 and Annual Report 2021).

Issues and concerns in dairy goat development

Certain areas of dairy goat farming development in India have concerns and need focused attention, long-term planning and a holistic approach to improvise milk

productivity.

(1) *Feeding and nutrition* is a key to high milk producing dairy goats to allow expression of their genetic potential for milk production. The dry matter (DM) requirement of goats varied 3 to 4% of their body weight. However, the DM requirements in lactating dairy goats are more 4 to 7% (Morand *et al.* 2007, Goetsch *et al*. 2011, Singh *et al.* 2018). Whereas, in reality, >90% of goat keepers do not offer concentrate to lactating goats, moreover remain unconcerned about level of productivity. Unbalanced diets also adversely affect the composition of milk (Lu *et al.* 2005). High milk-producing goats are quite often encountered with hypocalcaemia, lactation ketosis, udder edema, mastitis and other metabolic disturbances and attributed mainly to the unbalanced diet. Therefore, goats from late quarter of pregnancy should be provided high energy ration to obtain milk for extended period. Ration rich in protein and energy promote milk fat and microbial protein synthesis.

(2) Availability of *high potential and pure-bred bucks* is another major constraint as most of the elite males are either castrated or sold before their replacement and inferior males are left to serve the females. The lesser availability of purebred bucks of high genetic merit (Devendra 2001, Singh and Rai 2006, Singh *et al.* 2009) have put many flocks in the process of reverse selection. Sufficient number of breeding males are necessary which simultaneously also increase the genetic potential of non-descript goats for milk and other economic important traits.

(3) *Health inputs* (deworming and vaccination) are negligible leading to 15-30% goats' mortality. Non-availability of cold chain, poor support services, and ignorance of farmers for protective health measures are important reasons.

(4) Adequate and *proper housing* is not being provided (overcrowded, unhygienic, sharing with other small and large ruminants even human being) to goats, making them weak, less productive and also sick.

(5) *Marketing of goat milk and goat products* is highly unorganized, inadequate, seasonal and confined to certain pockets in metros, whereas goat farms are concentrated in rural areas and no mechanism exist for the goat milk collection and processing.

(6) Well-organized cow milk sectors with good infrastructure for milk transport, processing and services can benefit goat dairy producers as long as consumer demand and supportive policies are in right place.

(7) Goat farmers by and large are resource-poor and not aware with the concurrent scientific advancement therefore, capacity building and credit support to them is utmost important for dairy development.

Challenges in dairy goat farming

Goat in India has a huge scope for milk productivity enhancement, however, they are heavily constrained by their inadequate production management, health care, selection and marketing (Degen 2007, Devendra and Liang 2012, Singh *et al.* 2013, Singh *et al.* 2017, Eknaes *et al.* 2017, Singh and Chauhan 2017, Goetsch 2018 and Hegde 2020). The major challenges in dairy goat sub-sector are:

1. Regulations on uncontrolled sale or castration of elite buck during festive seasons.
2. Small and medium flocks are unwilling to keep bucks.
3. Perfection in artificial insemination with frozen semen technology.
4. Establishment of buck mother farms of dairy breeds.
5. Reduction in feed and fodder costs through technological innovations.
6. Development of dairy goat (3.0 litres milk/day) across the agro-climatic zones.
7. Shifting of goat-based dairy farming from extensive to semi-intensive management.
8. Flock Registration Scheme to identify and multiply elite animals with proper record keeping.

Strategy and road map for the development of goat based dairy farming

The following points may be considered while improving milk potential of goat breeds.

Breed and area specific breeding policy, action plan and management practices: Nucleus schemes may be a better strategy for genetic improvement of dairy goat because flock sizes are small, animal identification and data recording are limited, small number of bucks utilized for breeding. The nucleus flock should be kept open or closed depending upon flock size and land use policy. The open flock may bring faster genetic improvement under which elite male and female may be regularly introduced from farmers flock. Buck with higher genetic potential can also be provided to the farmers after using at nucleus flock. It will raise potential of milk production and also bring improvement in genetic variability in field and farms. Seed unit (*Multiplier flocks*), semen bank and high milk producing breeds/farms needs to be developed and supported in different regions to cater buck's demand for sustainable dairy farming.

Both proven (tested buck) and untested juvenile buck based on relative's information (pedigree selection) may be simultaneously used. Progeny-proven buck may be extensively utilized through artificial insemination. Breeding objectives, breeding practices and package of management practices for each dairy breed for different agro-climatic conditions may be clearly described. Following breeding practices should also be described in dairy breeds considering their body size, (i) Minimum female body weight at first service, (ii) Minimum female age at first service, (iii) Post-partum service period, (iv) Lactation period, (v) Selection of buck (sire line) for the desired nutrient content in milk.

Package of management practices should be described to care different management system, i.e. (i) Backyard system (Extensive system), (ii) Small holder goat production (Extensive system), (iii) Small holder (Semi-

intensive production system), (iv) Small holder (Intensive production system), (v) Medium to large flock on Extensive production system, (vi) Medium to large flock on Semi-intensive production system, (vii) Large flock on Intensive production system.

Development of dairy goat breeds in India: Beetal, Jamunapari, Jakhrana, Surti, Zalawadi and Gohilwadi are known as dairy goat breeds of India. These goat breeds have the potential to produce 3.0 to 5.0 litres milk/day or 300 to 500 litres in 180-225 days lactation period. However, at present 8-10% goats of above-listed breeds are only able to produce 300-400 litres milk in lactation. Therefore, breeding and selection programme has to be re-defined and re-designed for dairy breeds along with package of management, use of newer approaches to predict precise breeding value of sires to improve efficiency and profitability of goat milk production. Sire lines for milk yield have to be developed for different breeds in different regions. However, programme could be initiated with one or two dairy goat breeds where a relatively better follow up action and market is available. Initially, milch breed may be made part of such dairy development programme and subsequently, high potential dual-purpose breeds may also be made part of programme as large size flocks are predominately available of such dual-purpose breeds such as Barbari, Sangamneri, Malabari, Sirohi, Marwari, Mehsana, Sojat, Gujari etc.

Production gap should be minimized by adopting supplementary concentrate feeding, breeding practices, health cover, housing and other critical production items.

To whom begin with: Higher success at the beginning may be obtained in North-western region as most dairy and dual-purpose breeds belong to this region. Progressive farmers with dairy goat farm at different cities across the country may be included and supported in this programme. However, dairy programme may also be simultaneously initiated with communities involved in dairy goat farming such as Rabbari, Bharwad in Saurashtra (Gujarat), Raibari, Raika, Gujars, Meenas' in Rajasthan, Gujar and Gaddi in hilly tracts in Laddakh, Jammu & Kashmir, Himachal and Uttarakhand. The milk obtained from these flocks is largely organic, may be rich in nutrient content and fetch higher price.

Milk collection from flocks: Since maximum goat farmers (>80%) are keeping small flock (2-10 female), milk production is seasonal and surplus milk may also be in less quantity (5 to 10 litres/goat farm), therefore structure for goat milk collection, their storage, processing and marketing has to be created for strong beginning. It is one of the *big challenges* and involvement of private partners, NGOs etc. is desired to establish village-level milk cooperative societies.

Development of goat market and value addition of goat milk: India is the largest goat milk producer but milk production and collection is highly unstructured. Increased consumer awareness about its nutritional and medicinal properties and value addition of goat milk as functional food with therapeutic and medicinal values may encourage for higher price. State level milk procurement federations may be involved in goat milk procurement.

Support and services: More than 70% of income from goat farming comes from the sale of kids because no goat milk market/value chains exist in India. Maximum farmers are poor and compelled to sell their high yielding goats in need, which is resulting in loss of high merit male and females without replacement and a situation may arise with "No Selection" or "Reverse Selection". Milk yield from goat and their composition are also dependent upon diversified feed-fodder resources therefore; the development of fodder resources and pastures has to be strengthened to attract high valued cheese market (retinol, xanthophyll, α-tocopherol, CLA and other important bio-active lipids). Demand for goat milk is emerging in hot-humid southern and eastern cities, however, these regions do not have dairy goat breed. With the increased awareness and adoption of technologies over periods, experiment may be initiated for synthetic dairy goat breed development for these regions. More research is required to validate health benefit claims from goat milk. Research is also required for isolation and characterization of bioactive components in goat milk.

Conclusion

In recent past, demand of goat milk has emerged due to its usage in making a lot of nutraceutical and pharmaceutical supplement besides in making many processed or functional food. It has created huge opportunity for farmers to become an entrepreneur and earn manifold, simultaneously providing a lot of raw materials for dairy industries and varying degrees of satisfaction to consumers. Development of goat based dairy sector will require focused efforts on genetic improvement of dairy breed and policy support to commercial farms to encourage entrepreneurs to invest in this sector. The production gap should be minimized by promoting adoption of supplementary/strategic feeding, capacity building, technological interventions, incentives and credit to farmers. Milk procurement, processing and marketing are other important issues in goat dairy development and may be solved through appropriate policy support, incentives and involving state-level milk production federation in goat milk procurement and value addition. The role and scope of dairy goat is going to be much more important in nutritional and livelihood security, and manufacturing a wide range of products for domestic and export markets. More research is required to validate health claims from goat milk and characterization of bioactive components in goat milk to attract industries and consumers at larger scale.

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