



Production Potential, Nutritive Value and Nutraceutical Effects of Goat Milk

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Abstract | Goat is the choice of a poor farmer because they can easily adaptable, least cost in farming and low agriculture land. There are more than 500 different goat breeds in the world. Among these many are popular for their milk production potential and known as dairy goats. The most famous dairy goat breeds of Pakistan are Kamori, Beetal and Pateri. Kamori is considered as the cow of the poor farmer as it is good in milk production. The goat milk is well known for its unique characteristics to include an alternative for cow milk allergen people, easily digestible for infant, buffer capacity and higher content of mineral zinc, iron and magnesium. Caprine milk shows the therapeutic effects of various conditions such as anaemia, asthma, stomach ulcer, constipation, insomnia and neurotic indigestion. Novel angiotensin-converting enzyme inhibitory proteins released by gastric pepsin of goat milk caseins and whey proteins have been proved as a potent candidate against hypertension and associated diseases. Goat milk also utilized for preparing value-added milk products to include cheese, butter, paneer, ghee and ice cream. This review was designed to focus on the goat population, milk yield, milk products, nutraceutical effects and characteristics of goat milk.

Keywords | *Capra hircus*; Goat Population; Milk Production; Therapeutics Properties; Milk Products.

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INTRODUCTION

Goats (*Capra hircus*) are the first small domesticated ruminants that have been serving mankind longer than other ruminants and used for dual purpose, milk and meat since 2500 B.C (Dubeuf and Boyazoglu, 2009; Mirzaei, 2012). Goats are spread throughout the globe due to their capability to adapt in different environmental conditions. Worldwide, their population is about 617 million from which 97.3% found in the developing countries i.e., Asia 65.9%, Africa 27.4%, Europe 3.5% and America 3.0%. Among these, 191 million goat populations are used for dairy purpose (FAO, 2012). It has been estimated that there is 78.2 million goat population in Pakistan and their milk production is about 965 thousand tonnes (Pakistan Economic Survey, 2019-20). Pakistan ranked third in goat producing all over the world (Hasan et al., 2016). Goats are also considered as fastest growing small ruminants in

Pakistan. They have a major contribution to various families in rural areas as the old saying; the goat is the cow of poor people.

Goats are an important source of human nutrition by providing animal origin protein (Hokmollahi & Ehsani, 2020). Goat milk is being consumed more than that of other species (Getaneh et al., 2016). It is characterized by therapeutic value, higher digestibility and buffer capacity (Lad et al., 2017). It is an alternative source for the allergen people from cow milk or any other food sources (Ceballos, 2009). Its' remedial effects were observed against mal-absorption syndromes, hyperlipoproteinemia, coronary bypass, chyluria, childhood epilepsy, allergy, gastric ulcer and gallstones (Roy, 2006). Novel angiotensin-converting enzyme (ACE) inhibitory proteins released by gastric pepsin of goat milk caseins and whey proteins have been proved as a potent candidate against hypertension and associated

diseases (Ibrahim et al., 2017). It is a second best option after mothers' milk for infants because of unique composition. Goat milk contain many fold higher calcium and phosphorus than human milk. Moreover, the size of fat globules of goat milk is much smaller than bovine milk (Getaneh et al., 2016). Infants after consuming goat milk were observed very satisfied and had a good sleep (Park, 2006a). The present review article highlighted the milk production and compositional characteristics of goat milk as well as its' therapeutic importance to gather the focus of researchers to dig more research on goats and goat milk.

GOAT POPULATION

In last five decades, goat population have increased about 240% as compared to other livestock that have no or little increase in their numbers. Currently there are about one billion goats on the globe and among these about 90% are found in Africa and Asia (Capote, 2014). In 1994, global goat population was around 600 million heads which reached to over 1 billion in 2014, a 67% upsurge in just twenty years (Figure 1; FAO, 2017).

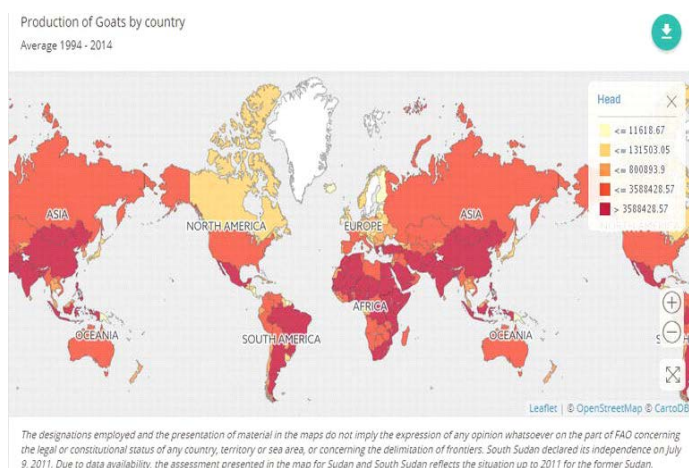


Figure 1: Global population of goats by country (number of heads) (FAO, 2017).

In Pakistan, the total population of goats is 78.2 million (Pakistan Economy survey, 2019-20). Goats are good source of income for 6 million people especially for landless people. There are various breeds of goat scattered through the four states of Pakistan, Punjab 37% Sindh 23.7%, Baluchistan 22.7% and Khyber Pakhtunkhwa 16% as shown in Figure 2. Breeds are categorized on the basis of some similarities of goats such as colour, horns, milk and meat production, etc. There are 36 breeds of goat in Pakistan in addition to 2 wild breeds, Markhor and Ibex (Khan, 2008; Muayad et al., 2019). All breeds are used for dual purpose, milk and meat; however, five breeds are well recognized for the milk production i.e., Beetal, Kamori, Dera Din Panah, Damani and Nachi (Muner et al., 2018). Population of Kamori breed is 5.29 million heads that is highest among all local dairy breeds (Table 1).

Table 1: Common dairy goat breeds of Pakistan [Million Numbers] (Livestock Census, 2006)

Provinces	Breeds				
	Beetal	Kamori	Damani	Dera din panah	Nachi
Punjab	3.11	0.04	0.05	0.075	0.03
Khyber Pakhtunkhwa (KPK)	0.65	0.05	0.9	0.045	0.018
Sindh	0.24	3.9	0.03	0.015	0.026
Balochistan	0.21	1.30	0.33	0.006	0.035
Total	4.21	5.29	1.31	0.14	0.11

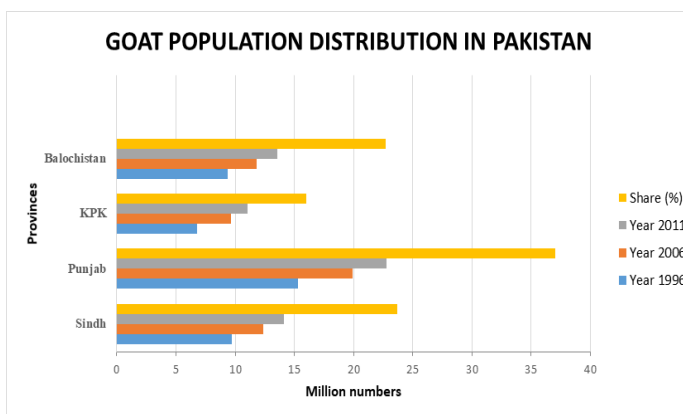


Figure 2: Distribution of goat breeds in different provinces of Pakistan (Economic Survey 2010-2011) Note: KPK= Khyber Pakhtunkhwa

GOAT MILK YIELD

Globally, the dairy goat population is about 218 million and the average milk production is about 18.7 million tonnes (MT) in the year 2017 (FAO, 2019). Milk yield of goats is varied area to area and country to country as shown in Figure 3. Goat production shares 2.3% in the total milk production, worldwide. Most of the goat milk is utilized for self-consumption; however, a small portion also used for the value-added products i.e., cheese and candies. In the United Kingdom, goat milk (15-20 million liters) is processed every year (Joon et al., 2017). The consumption of goat milk is increasing day by day due to the increase in the human population, therefore, goat is considered as the cow of the poor man (Park and Haenlein, 2007; Lad et al., 2017). Secondly, it is widely used for different products in the developing countries (Mowlem, 2005). Lastly, goat milk is well known for therapeutical purpose as people who have allergy from the cow milk. Ribeiro, (2008) reported that goat milk is used for pet consumption and pet care products as well.

In Pakistan, goat milk production is also increasing day by day as shown in Figure 4. The average lactation yield of some local dairy goat breeds is reported as: Beetal (195 lit

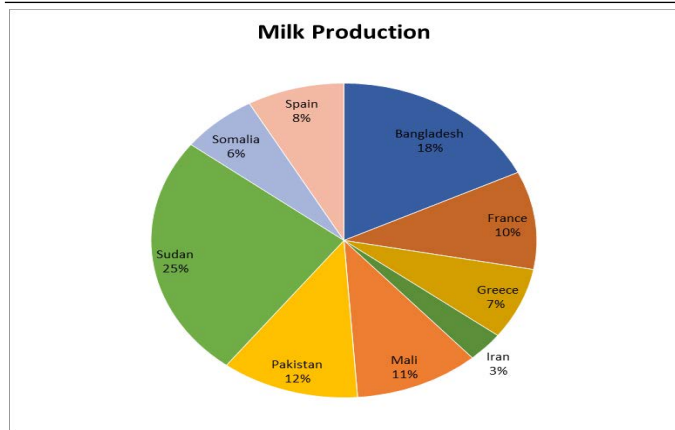


Figure 3: Goat milk production in different countries (FAO, 2020; Pakistan Economy Survey 2019-20).

ers/224days), Damani (110liters/110days), Dera Din Panah (245 litters/135 days), Naachi (110 litters/100days) and Kamori (210 litters/115days) (Iqbal et al., 2008; Kumsa, 2019).

PHYSICAL AND CHEMICAL CHARACTERISTICS OF GOAT MILK

Goat milk has intense flavour due to short chain fatty acid and white colour due to conversion of carotene. Goats have

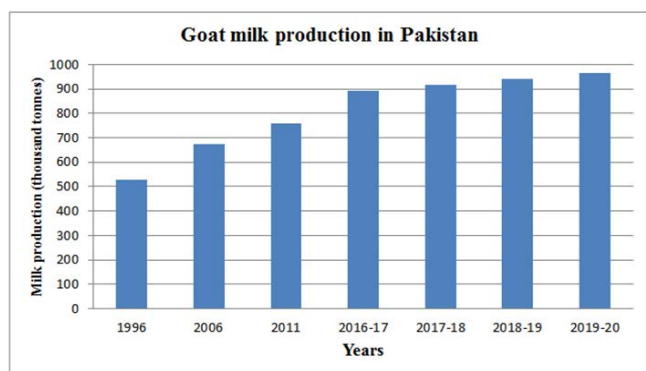


Figure 4: Changes in goat milk production (Economic Survey of Pakistan 2011-12 & 2019-20)

the capability to convert all beta carotene into vitamin A because of that the colour of goat milk is white (Yakan et al., 2019; Ranadheera et al., 2019). Goat milk is alkaline in nature, has lower lactose and a greater amount of chloride, fat, mineral and vitamins in comparison to cow milk (Park, 2005). The composition of goat milk reported by different workers has been presented in Table 2, and it has been observed that various factors such as breed, geographical location, milking stage, season, nutrition etc., may largely effect on goat milk composition (Nehru et al., 2018; Tyasi et al., 2020). Rafiq et al. (2016) reported that the goat milk is composed of total solid (12-13.5%), protein (3.5%), fat (3.8-4.5%), lactose (4.1%) and minerals (0.8%). Further, Park, (2005) stated that the goat milk contains a low

amount of casein protein and a high amount of non-protein nitrogen (NPN). Goat milk characterized by high digestibility due to the small size of fat globule and small soft and friable curd (during stomach acidification) than that of milk contain large size fat globules (Park, 2006a). Goat milk contains 12-18% total solid and 3-4.5% protein (Haenlein, 1993). Cerbulis et al. (1985) found that the goat milk contains 98% free lipids and 1-3% bounded to make phospholipids. Goat milk is well known for glutamate, proline and leucine amino acids (Rafiq et al., 2016). It resembles human milk on the basis of oligosaccharide. It contains essential minerals (calcium 134mg and phosphorus 141 mg per 100g) as reported by researchers (Park, 2006b; Yangilar, 2013). However, Posati and Orr, (1976) reported that the goat milk contains a lower amount of minerals than that of sheep milk (phosphorus 270mg, chloride 154mg, sodium 50mg, potassium 204mg and calcium 194mg per 100g). Alkaline phosphatase enzyme found at lower concentration in goat milk (Magariños et al., 2007).

VALUE ADDED GOAT MILK PRODUCTS

Worldwide, goats are reared for milk, meat, hair, bones, skin and horns (Kalyan et al., 2018; Amundson, 2019). In Pakistan, goats are mostly used for milk, meat and fibre production (Hasnain, 1985). Pandya and Ghodke, (2007) reported the different products of goat milk such as dry milk, condensed milk, whey protein, concentrated and evaporated milk, cheese, butter, paneer, ghee and ice cream as shown in Table 3. Pirisi et al. (2007) stated that people use goat milk as in fashion as different beauty products such as soaps and lotions are prepared and have great demand in the market by women for their beautification.

NUTRACEUTICAL EFFECTS OF GOAT MILK

Goat milk has been showing numerous medical properties as shown in Table 4. It is the most common alternative for people who have a cow milk allergy (Risko and Csapo, 2019). Furthermore, goat milk is used for different diseases such as acidity, stomach ulcer, asthma, insomnia, constipation, and neurotic indigestion (Clark and Garcia, 2017). Goat milk exhibits biological properties as it contains a higher amount of protein, phosphate, and non-protein nitrogen NPN that makes it highly digestible and has a good buffering capacity (Lad et al., 2017; Clark and Garcia, 2017; Nasir et al., 2018). Goat milk is also utilized for the young one of many species including human beings that's why it is known as the universal foster mother (Mowlem, 2005). Studies have reported that the rats affected by anaemia showed a greater growth rate on goat milk consumption in comparison to cow milk (Gaucheron, 2013). Goat milk performs various biological functions under enzymatic hydrolysis such as increased blood flow to the intestinal epithelium, probiotic activity, mineral binding capacity, and improved immunity and antimicrobial activity (Maestri et al., 2019). Bioactive components are released under

Table 2: Chemical characteristics of goat milk

Studies	Milk constituents							
	Fat %	Protein %	Lactose %	Mineral %	Casein %	Solid not fat %	Moisture %	Energy (Cal. Per 100ml)
Anifantakis <i>et al.</i> , 1980	3.8	3.4	4.1	0.8	2.4	8.9	87.9*	70
Haenlein & Caccese, 1984	3.8	3.5	4.1	0.8	-	8.4*	87.8*	-
Saini & Gill, 1991	3.8	2.9	4.0	0.8	2.4	10.3	88.5*	70
El-Alamy <i>et al.</i> , 1990	4.0	2.9	3.9	0.8	-	12.3	88.4*	-
Sawaya <i>et al.</i> , 1984	3.0	3.4	4.5	0.8	-	8.7*	88.3*	-
Szymanowska & Lipecka 1997	4.1	2.9	-	0.8	-	-	-	-
Park & Haenlein, 2007	3.8	3.5	4.1	0.8	-	12.2	87.8*	-
Banerjee, 2018	4.3	3.5	-	-	-	-	-	87

* shows the value made by difference formula

Table 3: Value added goat milk products

Milk products	Studies
Fluid milk	Loewenstein <i>et al.</i> , 1980; Ribeiro and Ribeiro, 2010
Evaporated and dried milk	Park, 2005; Pandya and Ghodke, 2007
Cheese	Park, 2001
Fermented milk (Kefir)	Morand-Fehr <i>et al.</i> , 2007; Farnworth, 2005
Desserts (Ice cream and Chakka)	Prajapati and Nair, 2003; Park, 2005; Correia <i>et al.</i> , 2008
Sweets	Park and Guo, 2006; Ribeiro and Ribeiro, 2010
Butter like products (Cream and Ghee)	Rodriguez <i>et al.</i> , 2003 Mowlem, 2005; Park, 2005;
Whey products	Pandya and Ghodke, 2007
Cosmetics	Ribeiro <i>et al.</i> , 2007

Table 4: Nutraceutical effects of goat milk and its constituents.

Nutraceutical Effects	Milk /milk Constituents	References
Anti-cow milk allergy	Goat milk	Risko and Csapo, 2019
Acidity, stomach ulcer, asthma, insomnia, constipation, and neurotic indigestion	Goat milk	Lad <i>et al.</i> , 2017; Clark and Garcia, 2017
Digestibility and buffering capacity	Goat milk protein, phosphate, and non-protein nitrogen	Lad <i>et al.</i> , 2017; Clark and Garcia, 2017; Nasir <i>et al.</i> , 2018
Anaemia	Goat milk	Gaucheron, 2013
Immunomodulation	Goat milk proteins	Lad <i>et al.</i> , 2017; Yaser <i>et al.</i> , 2018
Maintain blood pressure and prevent cardiovascular diseases	Goat milk potassium and nitrogen	Barrionuevo <i>et al.</i> , 2002
Bone mineralization	Goat milk phosphorus and calcium	Barrionuevo <i>et al.</i> , 2002
Arthritis	Goat milk bioorganic sodium	Getaneh <i>et al.</i> , 2016
Malabsorption syndromes	Goat milk medium-chain fatty acids like capric, caprylic and caproic	Sampelayo <i>et al.</i> , 2007
Intestinal inflammation, brain development, anti-diabetic, and anti-cancer	Goat milk	Claps <i>et al.</i> , 2014
Gut microbiome modulation	Goat milk	Ceapa <i>et al.</i> , 2013

Probiotic like effect

Goat milk (Folate-binding protein, protease peptone, prolactin, transferring, lactoferrin and ferritin) Lima *et al.*, 2018

the hydrolysis of milk protein that has a positive impact on the different functions of the body (Korhonen and Pihlanto, 2003). Goat milk also contains lactoferrin, transferring and prolactin as well which are important for the different functions of the body such as immunity, milk production, etc. (Lad *et al.*, 2017; Yaser *et al.*, 2018). Goat milk is a rich source of potassium and nitrogen, which are the essential elements to maintain blood pressure and prevent cardiovascular diseases. It also improve bone mineralization by improving the digestive and metabolic use of phosphorus and calcium. Consumption of goat milk also enhance the utilization of copper and iron (Barrionuevo *et al.*, 2002). Moreover, goat milk also provide bioorganic sodium that is known to prevent arthritis (Getaneh *et al.*, 2016). Goat milk contain many medium-chain fatty acids like capric, caprylic and caproic, which have pharmacological effects against malabsorption syndromes (Sampelayo *et al.*, 2007). Oligosaccharides, a well known class of bioactive compounds which have several beneficial effects like protective action against intestinal inflammation, immunomodulation and brain development, relief in constipation, antidiabetic, improvement in mineral absorption, and reduced incidence of colonic cancer etc., are found 4-5 times higher in goat milk as compared to bovine milk (Claps *et al.*, 2014). Goat milk also contain a significant amount of probiotics (bacterial organisms providing beneficial effects on host health) that produce several types of physiologically active metabolites in the intestine that have nutraceutical properties (Lima *et al.*, 2018). It's also known to modulate gut microbiome and regulate it for inflammatory and immune processes (Ceapa *et al.*, 2013). In addition to casein which is 80% in goat milk, there are several other minor proteins in goat milk that have nutraceutical properties including folate-binding protein, protease peptone, prolactin, transferring, lactoferrin and ferritin (Lima *et al.*, 2018). ACE is a multifunctional enzyme that also known as a principal regulator of blood pressure. ACE inhibition, confine the formation of angiotensin II or block its receptors that results arteriolar vasodilation and a decrease in total peripheral resistance (Acharya *et al.*, 2003). Recent studies have proved that goat milk and milk products have significant effects on ACE inhibition (Ibrahim *et al.*, 2017).

CONCLUSION

The goat population showed an increasing trend year wise as the people show interest in goat rearing. They are easily adaptable and have little cost of invest in farming in comparison to large ruminants. In addition to that, they are fast growers than that of large ruminants. Goat milk plays

a vital role in milk demand especially in rural areas because the goat is the cow of poor people. Goat milk has been utilized for several value-added products as they have great demand in the market due to therapeutic properties, easily digestibility and buffer capacity in comparison to the milk of other animals. Goat milk is the best alternative of bovine milk and have no or little allergens. It considered most suitable for infants because it is easily digestible and shows a somewhat similar composition to human milk. Goat milk shows superior characteristics over the cow milk. It shows nutraceutical effects for various conditions including malnutrition, poor mineral absorption, constipation, colonic cancer, blood pressure and inflammation.

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CONFLICT OF INTEREST

There is no conflict of interest.

AUTHOR'S CONTRIBUTION

AL design and wrote the manuscript. MA searched the literature and reviewed the manuscript.

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