

Research Article

Goat Production in El Salvador: A Focus on Animal Health, Milking Hygiene, and Raw Milk Quality

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Often referred to as “the poor man’s cow,” goats are important livestock in developing countries and in El Salvador goat management and milk are growing in popularity. This study focuses on the general health of Salvadoran goats and national husbandry systems as well as goat products and milking hygiene. The survey was submitted in western and central parts of the country: 191 goat owners were interviewed on animal management and production, 434 goats underwent a basic clinical exam, and raw milk samples were taken from 60 lactating does. Milk samples were examined for total plate count, *Staphylococcus aureus*, *Salmonella* spp., *Escherichia coli*, and *Listeria monocytogenes*. The majority of goats were managed under a traditional husbandry system naming milk production as their main purpose. Based on the physical exam, the overall goat health was acceptable but in need of improvement. The results of the raw milk samples did not indicate a mayor microbial contamination. Development programs and education of Salvadoran goat owners are recommended to improve goats’ health and productivity in El Salvador. Further studies on the microbial quality on raw goat’s milk are necessary to determine the health risk when consumed. The information obtained in this investigation will serve as a base for future projects.

1. Introduction

Goats were among the first animals to be domesticated 8,000 BC and, to this day, it is the species with the largest growth in population around the world [1]. In addition, more than 90% of goats are found in developing countries, where they play an important role in the sustenance of rural households [2, 3]. They are usually kept in smallholder production systems under basic husbandry circumstances providing poor families with meat, milk, and fiber. Aside from their beneficial products that assure a supply of high valuable protein to people living on the poverty line, goats also present an insurance against crop failures and function as investments for emergencies and social events [4, 5].

These small ruminants are highly adaptable to harsh environments surviving on little feed and water [6]. Goats efficiently convert nutrients from poor quality forage to

relatively high milk yields and, in comparison to livestock, demand less feed, care, and economic input [2, 7]. Goat milk production has increased significantly in the past decades and goats have become important for milk production in humid tropics as it represents an economic substitute to milk from cattle [8–10]. The composition of goat milk has nutritional advantages to people with health problems and its consumption is often recommended by healthcare professionals [11, 12]. Aid projects with goats have led to improvement of subsistence for many families in developing countries. However, little scientific information is available on small ruminants in less developed countries and enhancement programs can only become successful, if the current situation on goat husbandry is known [12–14].

For El Salvador, the circumstances are no exception; there is no official data available on the existing goat population,

herd sizes, herd distribution, feeding, animal health and control, management systems, and so forth (personal communication with the Salvadoran Ministry of Agriculture and Salvadoran Faculties of Veterinary Science). In addition, the consumption of goat milk has grown in popularity since it is considered to have medical benefits. Animals are many times milked in local markets for fresh consumption of the milk, although authorities do not execute controls of caprine dairy products (personal communication with Salvadoran Ministry of Agriculture and locals). This study attempts to provide elementary information on the present condition and health of Salvadoran goats, the most common husbandry systems practiced, and the principal products gained and their process hygiene. Furthermore, this survey will function as a base for future investigations and aid projects.

2. Materials and Methods

2.1. Study Area and Design. Known as the Land of Volcanoes, El Salvador is the smallest Central American country bordering the Pacific Ocean, Guatemala, and Honduras. The climate is tropical with an annual rain season from May to October and a dry season from November to April. The maximum altitude is 2,730 m above sea level [15]. The Human Development Index for El Salvador is 0.666 (rank 116, 2014) and the Gross National Income per capita is 3,920 US\$ (2014) [16, 17]. For administrative purposes of the public and agricultural sector, the country is divided into four regions [18]. A two-stage cluster sampling technique was conducted in regions I–III (region IV was excluded due to logistical reasons) to determine the farms to be included. As a result of nonexistent data on the goat population and its distribution, cantons were selected by clusters and the number of cantons to be included in the study was calculated in conformity with the formula by Cannon [19]. 43 cantons with an existing goat population were randomly selected using Excel 2010 (Microsoft Inc., USA). 178 farmers from selected cantons entered the survey that was carried out between May 2013 and May 2014. Since those 178 farmers only kept a few animals per establishment, 13 large herd animal owners that sell milk for a commercial purpose entered the study additionally (additional group (AG)). The results of this group were evaluated separately.

2.2. Data Collection and Analysis. The survey was conducted by personal interviews with farmers using a set of structured questionnaires (available in Spanish upon request). During the interview, 44 questions, mostly in the form of open questions, were read out to the farmer. The answers given by the livestock owners were ticked against a prepared list in the questionnaire and if the answers did not exist, they were written down. The inquiry was designed to obtain information on general flock sizes, type of husbandry and establishments, feeding management, and animal health as well as veterinary services. Corresponding to the obtained information, herds were assigned to a management system as follows: *semi-intensive*: establishment with stable or corral with weather shield; registering estrus, mated animals,

and births; using improved pastures and concentrate feeds; *extensive*: establishment with corral, registering of estrus as well as mated animals and/or births; feeding of supplements; *traditional*: animals pasture free or tethered; records nonexistent; no feeding of supplements [4, 20]. Furthermore, the questionnaire was designed to gain information on the purpose of keeping goats, an estimation of milk yields and lactation length, milking hygiene, and the consumption of raw milk, and the commercialization of milk and meat. All herds within the selected canton entered the survey; however, a few exceptions were made due to refusal by the goat owner or as a consequence of unsafe neighborhoods. All female and male goats older than 6 months underwent a short general examination to evaluate their overall condition, mean age, and gender as well as most common breeds. A total of 335 animals were examined (further 99 goats from the AG). The nutritional condition of the goats was evaluated with the means of a body condition score (BCS). Scores were assigned by applying a scale from zero to five as follows: BCS 0: cachectic, BCS 1: very thin, BCS 2: thin, BCS 3: backbone is not prominent, BCS 4: backbone and ribs cannot be seen, BCS 5: excessive fat [21–23]. The length of the hooves was evaluated and registered either as physiological length or as overgrown. Samples were taken upon detection of external parasites, preserved in individual tubes with 70% ethyl alcohol, and classified at the end of the survey. The results are presented in three main subjects: animal condition and health, animal management, products, and their microbial quality.

2.3. Raw Milk Samples and Diagnosis. To determine the microbial quality of the milk, 60 lactating goats from herds distributing the milk for commercial purpose were sampled (herds from selected cantons and AG). The udder was cleaned and disinfected with 70% ethyl alcohol and several streams of milk were discarded prior to collection of aseptic milk samples (200 mL) from both udder halves. Samples were promptly refrigerated ($+8^{\circ}\text{C} \leq T \leq +10^{\circ}\text{C}$) and transported within five hours to the Central Laboratory of Veterinary Diagnostics, Ministry of Agriculture in San Salvador. Microbiological cultures were plated for aerobic mesophilic counts (total plate count (TPC)), *Staphylococcus* (*S.*) *aureus*, *Salmonella* spp., *Escherichia* (*E.*) *coli*, and *Listeria* (*L.*) *monocytogenes*. Samples were tested and interpreted by accredited assays according to AOAC (Association of Official Analytical Chemists) and BAM/FDA (Bacteriological Analytical Manual/Food and Drug Administration) [24, 25].

3. Results

3.1. Animal Condition and Health. Out of 335 (99 in the AG) examined goats, 265 (79%) were female and 62 (21%) were male (AG: 85 (86%) and 13 (14%), resp.). Seven (two percent) bucks were castrated (AG: one (seven percent)) and one animal was a hermaphrodite. All animals were crossbred (criollo) goats; however, a dominance of phenotype from exotic breeds was detected as follows: 67% Anglo-Nubian, 7% Saanen and Alpine, and 5% Toggenburg (AG: 76%, 6%, 4%,

and 3%, resp.). The majority of goats were four years or older (41%, AG: 58%) and had a BCS of one, two, or three (20%, 36%, and 42% (AG: 21%, 39%, and 37%) resp.). 61% of the animals (AG: 38%) had overgrown feet and 23% (AG: 25%) were infested with external parasites. All the parasites had the same morphology and were diagnosed as goat biting lice (*Bovicola (Damalinia) caprae*) by microscopic identification [26, 27]. During examination, pathologies such as dilation of teats, abnormal hoof structures, nonphysiologic vaginal discharge, and testicle asymmetry were detected sporadically in different animals. 33 farmers (AG: 5) reported animal losses due to disease and 44 (25%) (AG: 3 (25%)) informed on a number of visible clinical signs (abortion, mastitis, weak lambs, infertility, anorexia, dystocia, metritis, diarrhea, and sudden death). Only six farmers (AG: three) sought veterinary help.

3.2. Animal Management. The vast majority of farmers owned 1–5 animals (95%). Out of the additional group, 54% had small herds and 23% were keeping flocks of 20–40 individuals. 92% (AG: 69%) practiced a traditional husbandry system, 8% (AG: 15%) were identified as extensive management systems, and only one farm from the AG managed their animals in a semi-intensive system. 16% reported (AG: 38%) to hold a record on either breeding dates or births and 72% (AG: 62%) acquired a method to determine when animals are in heat. The majority had been practicing goat husbandry for the last one to five years (63%, AG: 54%) and most goats were kept under a mixed herding system together with other species (Figure 1).

89% of the farmers (AG: 69%) reported a complete lack of hoof trimming. Vaccination of animals was scarce; 6 (3%) animal holders vaccinated against anthrax (*Bacillus anthracis*) and/or *Pasteurella multocida*, *Mannheimia haemolytica*, *Clostridium (C.) chauvoei*, and *C. septicum*. For the additional group, three (23%) owners were vaccinating their animals. In 48% of the establishments (AG: 69%), goats were treated with anthelmintics, whereby the majority applied Ivermectins ((Ivermectin, Doramectin) 88%, AG: 78%), Benzimidazoles (Albendazole, Fenbendazole (12%, AG: 33%)), and Levamisole (1%, AG: 11%). Tethering (92%), followed by free ranging (40%), was the most common form of letting the goats graze in selected cantons. The herds from the AG were larger and 77% let their animals pasture freely and 69% also used to tether them. 34% of the establishment (AG: 62%) had some sort of corral or stable to lock up their livestock and the majority (95%, AG: 100%) held a weather shield. 10% (AG: 15%) kept their animals in the house at night or as a protection against rain. Only 17% of the goats from selected cantons had access to water ad libitum whereas the number from the AG was 54%. The forage derived from grass, shrubs, trees, and wild herbs. Only five farmers (AG: 0) additionally fed hay or silage; however, 164 (92%) goat owners (AG: 10 (77%)) fed supplements (concentrate feed, corn, and/or sorghum) throughout the year or during lactation. 150 (84%) also fed household residues (AG: 8 (62%)).

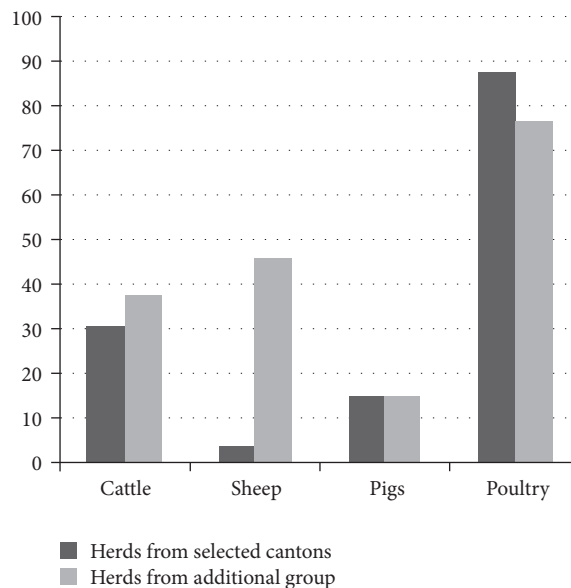


FIGURE 1: Herds stating mixed farming systems: divided by species and presented in percentage.

3.3. Products and Milking Hygiene. 53% of the animal owners (AG: 54%) put milk production to be the principal function of their animals, followed by dualpurpose animal keeping (30% AG: 31%). Only 3% (AG: 8%) had goats mainly for meat production, commerce, or adornment. It should be noted that farmers were asked to name the main reason for having goats; naturally, those interested in milk production also used animals for breeding and commerce. 74% (AG: 13%) held dairy goats for subsistence milk needs, whereas 25% (AG: 88%) also sold the milk, primarily (94%) directly from their homes. The majority of dairy goat owners from the AG (57%) distributed the milk on local markets, either in bottles or milking the goats directly in the street. The numbers are similar for meat production: 89% of farmers had goats for their personal needs and 50% from the AG slaughtered the animals for their own use or commerce. The goats were either sold alive or freshly slaughtered at the establishment.

Most farmers estimated lactation length to be 150–180 days (35%, AG: 50%) and 90–120 days (33%, AG: 25%). Some households milked their goats up to a year (10%, AG: 25%). The majority (91%, AG: 100%) were milking their goats once a day, usually in the morning, leaving the rest of the milk for the lambs. Notice that kids are not weaned and the milk is shared for human purpose and offspring nutrition. Main milk yield was estimated between 750–1500 mL and less than 750 mL (74% and 16%, resp.). The majority of goats from the AG had a somewhat higher production rate: 50% produced 750–1500 mL and 38% yielded up to 1500–2250 mL.

Almost all goat holders (99%, AG: 100%) indicated to wash their hands prior to milking; however, 18% (AG: 0%) did not clean the udder. 16% (AG: 38%) never filtered the milk before consumption, especially those milking directly in cups for sale on the market. Neither milk (84%) nor meat (66%) was accustomed to be cooled, thus consumed directly

TABLE 1: Results of 60 raw milk specimens. The range of cell counts from all samples is presented in colony forming units per milliliter (CFU/mL).

	TPC ^a CFU/mL	<i>S. aureus</i> CFU/mL	<i>Salmonella</i> spp. in 25 mL	<i>E. coli</i> CFU/mL	<i>L. mono-</i> <i>cytogenes</i> in 25 mL
CFU (range)	<10–4.8 × 10 ³	<10–3.9 × 10 ³	Absence	<10	Absence

^aTotal plate count (aerobic mesophilic bacteria).

or dried. On the contrary, 75% from the AG indicated to refrigerate the milk and 50% cooled or froze the meat after slaughter. For the most part, people were only interested in the milk production; when asked upon other dairy products, 8% (AG: 38%) indicated to manufacture cheese from leftover milk. One farmer alone had also made butter. 88% (AG: 75%) consume raw milk and 46% (AG: 50%) boil the milk; amongst those were people that usually consume the milk raw but occasionally drank boiled milk. Microbiological results from the raw milk samples are summarized in Table 1.

4. Discussion

This is the first study on caprine health, management, and production in El Salvador and the purpose was to provide a better understanding of the goat husbandry systems practiced. In Latin America, the main purpose of keeping goats is for their meat and estimations by the FAO on goat products for El Salvador only include meat production since information on milk production is lacking [23, 28]. However, the results of this survey reveal that the major use for goats is milk production and to a smaller extent dual-purpose. The animal holders' preference of keeping does instead of bucks leads back to the main purpose of owning goats. In accordance to the findings of this study, the crossing of criollo goats with exotic dairy breeds has been described in El Salvador, Guatemala, and Costa Rica [29, 30].

Over 55% of the animals in this study had a fairly acceptable to poor body condition (BCS: one to two) and, according to literature, the mean BCS under intensive dairy goat conditions should be three for good milk yields. An inadequate nutritional state leads to reduced production and fertility performance [23, 31]. Most goats were four years or older and a fourth were infested with lice; a similar situation was found in an Argentinean study where goat herds were made up by older animals with poor body conditions and infested with biting lice [32]. The most widespread ectoparasites of goats are lice and, in general, animals of poor body condition are infested. Furthermore, biting lice cause irritation to their hosts which may lead to reduced feed intake and poor performance [23, 27, 33]. While there was no difference in BCS and lice infestation of the two groups, more than half of the goats of the AG had a physiological hoof length in comparison to goats from selected cantons (39%). In general, a fourth of the animals from both groups had overgrown hooves, which is led back to the complete lack of hoof trimming among goat owners. Trimming should be

realized according to the amount of exercise the goat gets, but at least once a year. Overgrown feet lead to diminished feed intake which leads to weak kids with low birth weight, decreased milk yield, and lower weight gain [34]. Only a handful of goat keepers reported to seek veterinary assistance; however, comparing the two groups, animal owners in the AG were more disposed to do so than the ones from selected cantons. Although the Official Veterinary services offered by the Salvadoran Ministry of Agriculture are free, goat owners were unaware of this service or did not know that the veterinarians also attended goats. In less developed countries, it is common that Veterinary Assistance is focused on large livestock which is seen as economically more important, leaving small scale farmers marginalized from these vital services [6, 12, 35, 36].

The goats were managed under a traditional or extensive management system, a husbandry practice common in the tropics. These systems are of advantage since they require little economical input such as family labor, small flocks, basic establishments, and small feed investments and are of little risk. However, the level of productivity is low because of circumstances such as underfeeding and diseases as well as poor husbandry and these negative characteristics were all determined in this study [4, 7, 20, 37]. Goats were tethered or grazing freely, which gives them the opportunity to seek diversity in their ingesta containing necessary nutrients at no additional cost. Nevertheless, studies show that the energy supply in plants of the tropics is often reduced [35, 38]. Farmers would give supplements rich in starch but this can only compensate low energy forage in limited amounts, since goats are very sensitive to feeds poor in fiber and rich in concentrates [31]. As mentioned before, underfeeding is common in the tropics and often not controlled; furthermore, the poor body condition of the goats in this survey is probably due to inadequate nutrition [9, 35]. In Central America, supplements normally consist of corn, sorghum, and to a low extent concentrate feeds for dairy cattle (because of the economic input). A cheap alternative to increase the goats' energy intake could be the feeding of bananas [29, 39]. Most goats in this study did not have access to water ad libitum although a sufficient water intake takes priority over the animals nutritional needs and, under tropical conditions, the water necessity is higher than the requirement for energy. When goats consume fiber rich diets low in energy, their water intake rises even more and ignored water demand leads to lower feed consumption [31].

About half of the goat keepers administer anthelmintics; the other half did not think of deworming as necessary or had no knowledge of its practice. However, the majority of substances applied were Avermectins, which have a milk withdrawal time up to 60 days or are not authorized to be applied in dairy goats because of the potential toxicity of residues [40, 41]. In El Salvador and Latin America in general, there are no restrictions on the purchase and use of most medicines, leading to pesticide input with no veterinary supervision. Furthermore, Ivermectin is sold under a number of different brands, many at a low and very accessible price, which is the main reason for a wide input, resulting in growing resistances among parasites and high residues

in products that, if controlled, would be inappropriate for human consumption [42–44].

Managing goats was something recently initiated by half of the animal owners. The majority in both groups could determine estrus in animals but a minority kept a record of mating and births; however, goat owners in the AG were more likely to keep a register. These facts together with the lack of hoof trimming, almost to none vaccination regimes, and the absence or inadequate use of anthelmintics testify insufficient education on the basic management of goats, a common situation in developing countries [1, 32]. To improve the situation, farmers should be trained on basic husbandry such as adequate feeding, animal health, breeding, and production. One efficient way of distributing education is helping smallholders to form associations that have access to education on goat management and veterinary service. Improving the welfare for animals will also improve the welfare of their owners [7, 12, 36]. While cattle owners are members of different local associations, such a group is still absent for goat owners in El Salvador (personal communication MAG).

The animal owners charted from the selected cantons kept one to two goats mainly for their own personal needs of milk and meat, which explains the small flock sizes. Herds from the additional group consisted of 20–40 animals and goat keepers emphasized the commercial purpose of the products. A similar situation on the purpose of goat products has been reported in Honduras and Guatemala [29]. The mean lactation length reported in this study is comparable to data from Honduras, Guatemala, Ethiopia, and the tropical Asian region but much lower than in Costa Rica and Chile. In selected cantons, milk yield was about 750 mL/goat/day; similar amounts have been described in other tropical countries. Goats from the AG had an estimated milk production of 1500 mL/day; in spite of a shorter lactation length, these yields are comparable to animals in more intense production systems in Mexico, Chile, and Costa Rica [9, 29, 45–47]. In general, lower milk yields and shorter lactation lengths are common in the tropics and a result of limited water supplies and inadequate nutrition, such as low energy intake and mineral deficiencies [9, 46].

A basic milking hygiene (i.e., washing of hands and udder, filtration of milk) was practiced by most goat keepers; comparing the two groups, owners in the AG were more prone to clean udders before milking but less likely to filtrate the milk than those in selected cantons. Whether or not meat and milk were cooled was of little significance, since milking or slaughtering was executed contemporary to consumption or preparation. The great majority of people in this survey were consuming raw goat milk, although some stated an occasional boiling of the milk before drinking. The health hazards associated with raw milk consumption is the ingestion of infectious pathogens and this risk outweighs any nutritional benefits that may come from drinking unpasteurized milk [48–50]. Many people were unaware of these perils, once again stating the necessity of education among goat keepers. In addition to ignorance, a great number of people drink raw milk because of costume or convenience and the milk sold directly in the streets is under no regulations. It is highly

recommended that unpasteurized goat milk commercialized to the public should be subjected to official controls [51].

The raw milk samples from 60 goats did not indicate a major microbial contamination and there were no significant differences between milk samples from selected cantons and AG. The low number of microorganisms in the milk samples of this study could be related to the fact that the goats sampled came from rather small herds that were all milked by hand. Further, it could be based on good premilking standards, no influence of inadequate clean milking equipment (in this study, no farms used milking equipment), and a low threat of infection due to small herds which has also been described by other authors [52, 53]. The results for TPC in this study correspond to the quality of a grade A milk according to the Salvadoran code for raw cow's milk (classification of raw cow's milk; Grade A: $\leq 300\,000$ CFU/mL, Grade B: $>300\,000 \leq 600\,000$ CFU/mL, and Grade C: $>600\,000 < 900\,000$ CFU/mL) (no Salvadoran standard for raw goat milk is available) [54]. Taufik et al. [55] reported similar results for TPC (5.4×10^3 CFU/mL) in raw goats' milk from udder half milk samples in Indonesia. In comparison to an investigation from South Africa (TPC of 4.8×10^4 CFU/mL in caprine udder half milk samples), the results for TPC assessed in this survey were lower [56]. The isolations of *E. coli* were insignificant (<10 CFU/mL) and the absence of *Salmonella* spp. and *L. monocytogenes* has been described by other authors [57–59]. The maximum limits for *S. aureus* are not contemplated by the Salvadoran norm for raw cow's milk and the amount necessary for this germ to produce sufficient toxins that would cause a food-borne intoxication is 10^5 CFU/mL. With the amounts presented in this investigation (<10 – 3.9×10^3 CFU/mL), there is no risk of illness if the milk is consumed instantly. Nevertheless, farmers claimed that milk usually was not cooled and, when stored under room temperature, growth of bacteria could exceed this limit [60, 61].

5. Conclusions

The results from this study reveal the requirement for development programs in Salvadoran goat husbandry. Education of goat owners and improved accessibility of veterinary services would not only promote animal health and wellbeing but also enhance goats' productivity. Furthermore, a better management system also implies an advanced subsistence of rural households that own goats. In addition, the implementation of official microbiological controls of goat milk is highly recommended, since consumption and commerce of raw milk are executed at a large scale. The samples in this survey did not exceed health code regulations; however, additional investigations emphasizing the microbial quality on Salvadoran goat milk are necessary for a reliable statement that excludes a public health risk associated with drinking raw goat milk in El Salvador.

Competing Interests

The authors declare that they have no conflict of interests.

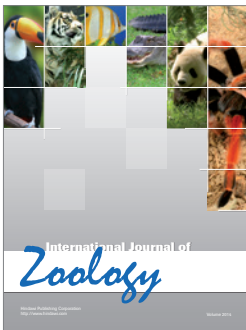
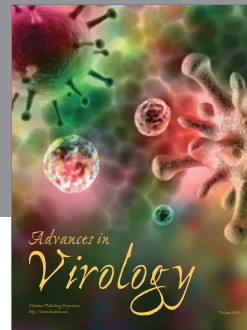
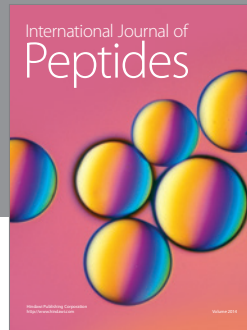
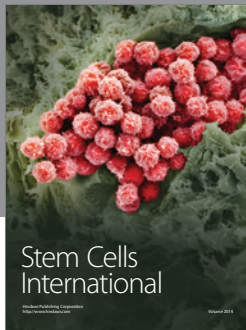
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