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Practices of Clean Milk Production, Management and Decent Work

in Faisalabad, Punjab, Pakistan

The International Center for Development and Decent Work

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This working paper is based on a M.Sc. Thesis completed in July 2018 at the University of Agriculture, Faisalabad, Pakistan.

Contents

Abstract

This study aimed at determining the factors influencing clean milk production in Faisalabad, the third-largest city of Pakistan with more than three million inhabitants. A semi-structured pre-tested questionnaire was used to collect data following a snowball sampling approach. Interviews with each 60 semi-commercial small-scale (SCSS), commercial small-scale (CSS) and commercial large-scale (CLS) peri-urban milk producing households (HH) keeping mixed herds of cattle and buffalo were carried out during February and March, 2018.

Interviewed households had a dairying experience of 10±7.1 years. The number of female adult-buffaloes and adult-cattle heads averaged 7.7±6.81 and 7.4±8.01 in SCSS, 10.4±7.13 and 10.4±6.77 in CSS and 17.5±9.81 and 13.6±6.76 in CLS. Average monthly earnings from milk sales from SCSS, CSS and CLS were 70,000, 92,000 and 334,916 Pakistani Rupees (PKR), respectively. There was a significant ($P<0.001$) difference between SCSS, CSS and CLS not only in the earnings from milk sales but also in the farm expenses. Two-thirds ($n=136$) of the farms used traditional cowsheds and only 25% had modern barns, with significant ($P<0.01$) differences between SCSS, CSS and CLS farms with regard to barn design, drainage system and cleaning frequency. Flies were present in >90% of all farms. Management practices like hair-clipping, hoof-trimming, udder-washing and teat-dipping were significantly ($P<0.01$) different between CLS and the other two farm types and were more regularly practiced at CLS than SCSS, CSS farms. About 70% of the workers did not wash hands before milking, most of them (89%) did not trim nails, cover their heads (97%) while milking and carried on milking even when unwell (86%). The milk cane was hardly disinfected (79.4%) and milk was mostly (64%) stored in plastic containers without pre-filtration, whereby a significant difference existed in the container material between the three farm types ($P=0.001$). Across the farm types, farmers had little or no knowledge of dairy husbandry practices for clean/hygienic milk production.

In conclusion, most of the peri-urban milk in Faisalabad is produced under unhygienic conditions. While some reasons for unhygienic milk production, such as housing conditions and drainage system, are not easy to improve without major investments, systematic use of hygienic dairy management practices such as cleaning of dairy animals, milking equipment and improved workers' hygiene could easily be adopted and would improve the safety of raw milk in Faisalabad as well as in the other cities of Pakistan. Similarly, improving working conditions plays an important role to enhance food safety. Stable, fair and safe working conditions for dairy farm workers can augment productivity and make work–life balance, as well as food safety better.

Keywords: Small-Scale Dairying, Hygienic Milk Production, food safety, Public Health, Peri-Urban

1 Overview

1.1 Status of clean milk production in Pakistan

The dairy sector in Pakistan plays a pivotal role in the national economy and its value is more than the combined value of the wheat and cotton sectors (FAO, 2011). Annual milk production during 2017/2018 was estimated at 57.9 million ton, giving Pakistan a place in the list of the world's top milk-producing countries (GOP, 2018). Small-scale dairy farmers in rural and peri-urban areas produce 95 % of the country's milk, with less than five milking cows (Social Sciences Institute NARC, 2003). Despite the fact that dairy farming is practised on a large scale in Pakistan, primarily by the private sector in rural and peri-urban areas (FAO, 2011), dairying is still a fragmented subsistence sector of Pakistan's economy.

The rising demand for milk among city dwellers has prompted the establishment of urban and peri-urban dairy farms in cities like Karachi, Lahore, Faisalabad and Islamabad (Moaeen-ud-Din and Babar, 2006; Habib et al., 2007; Jalil et al., 2009), whereby the number of such urban and peri-urban dairy farms in Pakistan has tripled from 1986 to 1996 (Habib et al., 2007). Rather than lack of access to product markets, the major constraints to urban and peri-urban dairy production in developing countries are of technical nature and policy-related (Smith and Olaloku, 1998). Over the last two decades, the changing human demands for dairy products and urbanisation have led to the conversion of conventional milk production system from subsistence to more commercially oriented large-scale dairy production system (FAO, 2011). Moreover, policy interventions planned at the government level in 2007 (Pakistan's first-ever Livestock Policy) specifically brought in focus the development of dairy sector in Pakistan. As a result, a number of private stakeholders have expressed interest in investing in dairy farming sector, dairy processing and dairy procurement. In most studies on dairy production systems in Pakistan, dairy have been categorised based on their area, number of dairy animals kept, extent of commercialisation and resource allocation (FAO, 2011). Although the government has identified the dairy sector as one of the key development priority sectors in agriculture, the dairy farmers remain the main players in the industry with inherent constraints.

Milk of ruminant dairy animals is highly nutritious and it is the first food for their offspring before they can digest other types of feed and fodder (Bankole et al., 2011). Cow milk constituents include approximately 87.2 % water,3.7 % fat, 3.5 % protein, 4.9 % lactose, and 0.7 % ash, with a pH value of 6.8 (Olatunji et al., 2012). Due to its high supply of essential nutritional components, milk from dairy animals is universally considered as a complete diet for humans and recognised as the prime food for all ages (Benta and Abtamu, 2011).

At the same time, from its composition, milk is also a very suitable growing medium for microbes that may enter the substrate from the udder's and teats' surface, exterior surfaces of the animal body, during milk collection, storage equipment used and miscellaneous other sources including the animals' shed, the workers and the overall working environment (Worku, et al., 2012). At ambient temperatures, milk nutrients normally facilitate and completely support the multiplication of bacteria at a high rate, which can cause spoilage. Unhygienic dairy management practices, improper milk handling and storage, as well as fraudulent practices such as addition of water or unauthorised preserving substances to the milk can introduce microorganisms that lead to milk spoilage (Paul et al., 2004).

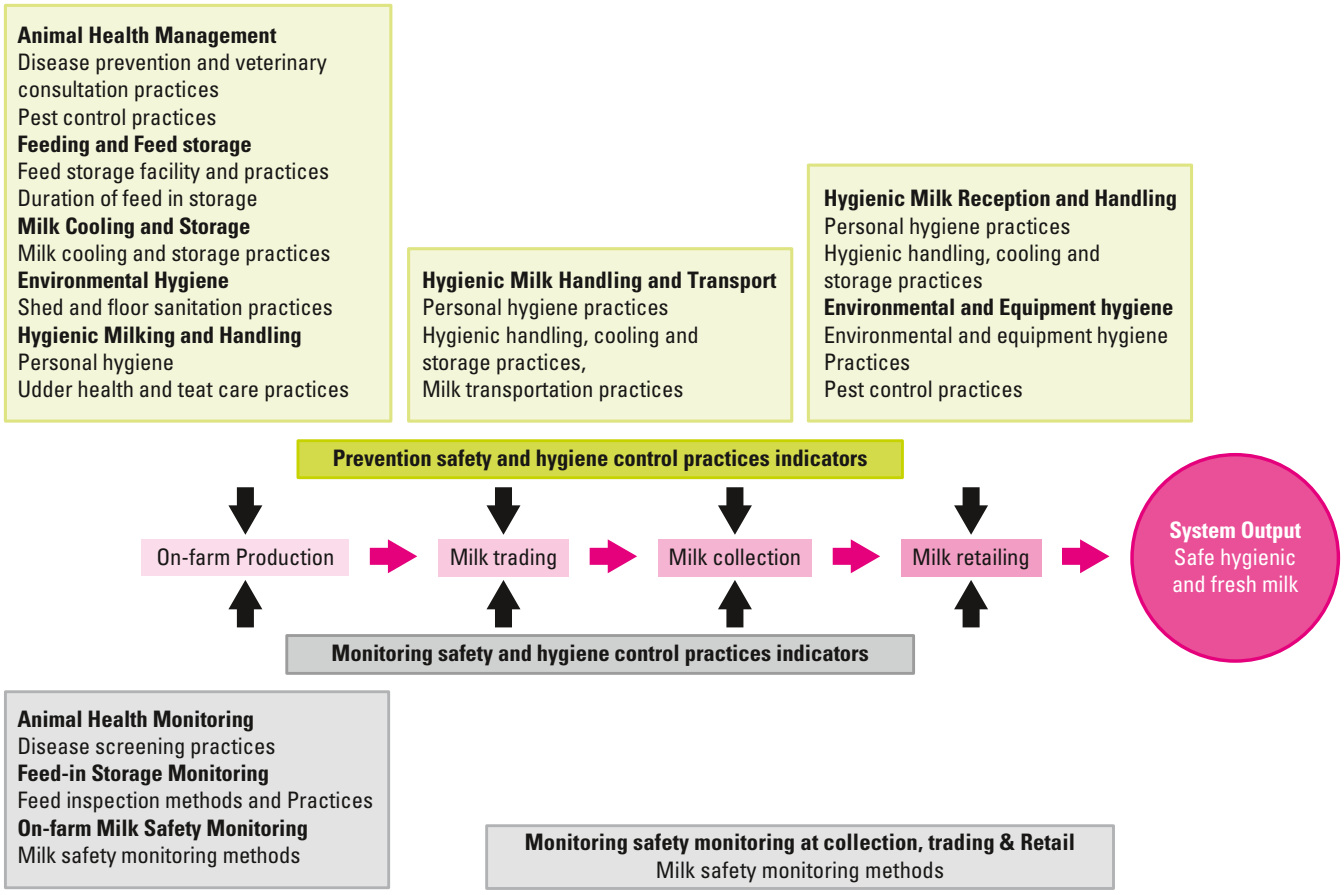

Figure 1: Conceptual framework showing the synthesis of crucial practices contributing to clean and hygienic milk production along the dairy chain (adopted from Ledo et al., 2020)

The common predisposing factors of milk contamination by microorganisms are milking environment, cows, milking personnel, milking equipment, milk transportation and water (Mbabazi, 2005). The key sources of contamination are: faeces; soiled animals, especially teats, udders and tails; bacteria, poor milking practices; soiled hands: inadequately cleaned and disinfected equipment (including bulk milk tanks), and failure to clean and disinfect teats prior to milking; failure to detect abnormal milk (mastitis pathogens, blood and clots); foreign bodies, especially from perished components in milking machines and bulk tanks, dust, bedding materials, dung, insects and animal hair; chemicals, metals, organics, etc., from veterinary product residues; cleaning chemicals and use of non-food grade equipment (FSA, 2013). Once these undesirable microorganisms enter milk, they can rapidly multiply and cause undesirable changes leading to deterioration of its quality. At the same time, low quality milk and other dairy products can cause health hazards to humans and may be a potential source of human pathogens which may increase the chances of food-borne diseases in humans (Barros et al., 2011). Because of its specific dairy production conditions, to avoid contamination of milk with micro-organisms is close to impossible, however, maintaining good dairy health measures at farm, strict adherence to good dairy production practices and maintenance of ruminant good shed and personnel environment hygiene play important role in reducing the microbial load in fresh milk produced at farm (FSA, 2006). Beyond the farm gate, the safety of fresh dairy produce is also affected by management and safety measures along the entire dairy value and supply chain. The crucial practices contributing to clean and hygienic milk production along the dairy chain have been elaborated as conceptual frame work in "Figure 1" (adopted from Ledo et al., 2020).

On the other hand in Pakistan, the dairy industry is a labour-intensive business with many hygienic considerations in milk production (Jalil et al., 2009). A poor hygiene level of personnel involved in the milking of dairy animals and handling of milk is a great source and could potentially contribute pathogens and other microorganisms that may transmit from their bodies, hairs, sneeze and cough in general, and there is a great chance of pathogen transmission increased in case of sickness (Ashenafi, 1994; Mbabazi, 2005). As socio-economic aspects and existing working conditions are relevant for the analysis of the situation of clean milk production in and the status of dairy workers working in peri-urban dairy production., it is also important to know that 75 % of the district's population have a low income and are defined as poor (City District Government of Faisalabad, 2006). It was observed by Erbach (2012) that the overload of working hours for the dairy labour in peri-urban dairy production units leads to a decline of productivity, because of declining mental concentration, health problems due to distress, and that additionally leads to an imbalance between personnel care and quality farm work in dairying.

Ultimately, clean and hygienic milk production under decent working conditions is important from the view point of consumer's safety. In Pakistan, there is no standard hygienic milk production at any level. The level of hygiene in milk production practices vary according to the system of milk production, level of awareness of the dairy farm workers about milk hygiene, and resources allocation and availability in dairying (Zelalem, 2003).

1.2 Study objectives

This study aims at developing an understanding of the status quo concerning clean milk production in Faisalabad, third largest city of Pakistan, by analysing pre- and post-milk production practices in view of (International) standards of clean milk production. The working paper should, therefore, serve as a statutory document for future projects aiming at an improvement of the situation and the introduction of good dairy practices, eventually enhancing the awareness for a wholesome and hygienic milk product at the level of smallholder dairy farmers, labourers associated with the dairy value chain and their primary milk traders, the "dodhees", to support their successful marketing of quality milk in the national market, which, in turn, will ultimately support their livelihoods, protect consumer health and may in the future allow the country to enter the international dairy market. At the same, it is very important to consider that milk production is a labour-intensive activity, as the technical status of the typical peri-urban dairy production systems is low. Hence, it is even important to explore if the dairy labour standards are decent and allow obtaining a sustainable clean milk production.

1.3 Study hypotheses

Based on the above objectives, the following hypotheses are tested:

1. Inadequate knowledge of the working conditions and their decency in the dairy production leads to unhygienic, low-quality milk.
2. Improving the situation of clean milk production through better working conditions in dairy operations including hygienic trading operations will help in reducing spoilage, production of high quality milk with longer shelf life and ensuring better health of consumers and farming families and bringing overall prosperity to dairy farmers.

2 Materials and methods

2.1 Study site

The city of Faisalabad, second largest in Punjab province and third largest in Pakistan, had a population of more than 2.5 million in 2005 with an average annual growth rate of 2.2 % (GOP, 2005). The District of Faisalabad is located between 31°20′ –31°33′ N and 73°13′–72°55′ E at an altitude of 184 m a.s.l. (Cheema et al., 2006). Four seasons can be distinguished, namely winter (December–March) with cool weather and moderate rainfall, dry summer (April–June), which is extremely hot and dry, humid summer (July–September) with high temperatures and scattered rainfall, and autumn (October–November) with cool and dry weather (Mustafa and Khan, 2005). The climate is semi-arid subtropical with average annual temperature and rainfall during the period 1975–2004 being 24.5°C and 408 mm, respectively. The highest temperature in summer may hit 50 °C, and the lowest in winter may fall below the freezing point (Cheema et al., 2006).

2.2 Data collection

A semi-structured pretested questionnaire was used to collect data following a snow-ball sampling approach. Interviews with each time 60 semi-commercial small-scale (SCSS), commercial small-scale (CSS) and commercial large-scale (CLS) milk-producing households (HH) were carried out during February and March 2018 (this classification of dairy farms was adopted from Tariq et al., 2018). These three dairy farm types (SCSS, CSS and CLS) were classified on the basis of resource allocation for dairy operation, the number of dairy animals kept, the level of milk production, daily milk sale and commercialisation (see Fig. 2 showing on-farm milk selling and transportation). These households were keeping mixed herds of cattle and buffalo and were all located in the urban and peri-urban zone of Faisalabad within a radius of about 4 to 9.4 km from the city centre (Hagmann, 2012). The questionnaire covered socio-economic and demographic aspects (HH size, herd size, hired labour, production assets owned, total HH income and off-farm occupation) as well as factors affecting clean milk production (related to the shed, the animals, feed, equipment, workers and other related factors affecting overall cleaning and sanitation). These facts have generally been reported in published data that animal housing and

feeding, animal health, management practices of milk harvesting, storage, transportation and retailing predisposed milk to microbial contamination (EACs, 2007; Shija, 2013). To measure the knowledge level of dairy producers of clean milk production practices and to assess the cleanliness of udder and dairy animal bodies a five-point Likert Scale was used by setting «one» as «very good» and «five» as «very poor» (Malhotra, 2010) along with other open and close-ended questions on different aspects of clean milk production practices. Moreover, response of dairy farmers about problems and future prospects with regard to clean and hygiene milk delivery were also recorded. The duration of an interview ranged from 17 to75 minutes (mean: 36 minutes). A pre-test of the questionnaire was conducted with 20 farmers not included in the final sample, and the questionnaire was modified where necessary.

2.3 Statistical analysis

Recorded variables were coded into numbers, whereby scaled variables were kept in their original state and two-class nominal variables (e.g., yes/no) were coded into binaries. Each qualitative trait with more than two expressions was coded into a nominal categorical scheme where one numeric value represented one trait expression. All data was tabulated and compared through descriptive analysis using chi-square test. Association between different continuous variables was determined through Pearson's correlation coefficient. All statistical analyses were performed with SPSS 17.0 (SPSS Inc., Chicago, Illinois).

3 Results and discussion

3.1 Milk production and sale

Interviewed households had a dairying experience of 10±7.1 years and in terms of adult female buffaloes and cattle they kept 7.7±6.81 and 7.4±8.01 animals in SCSS, 10.4±7.13 and 10.4±6.77 in CSS and 17.5±9.81 and 13.6±6.76 in CLS respectively. The monthly earnings from milk sale averaged 70,000, 92,000, and 334,916 Pakistani Rupees (PKR) for SCSS, CSS and CLS ($P<0.001$) farms, respectively. Average monthly expenses were 34953, 51883, 251968 PKR on SCSS, CSS and CSL ($P<0.001$) farms, respectively. It was also observed that farm type was significantly correlated with milk sale, dairy farm expanses, adult dairy buffalo and cattle number and livestock strength at each studied farm with correlation coefficients (r) of 0.541 (milk sale), 0.27 (dairy farm expanses), 0.44 (adult buffalo), 0.34 (adult cattle) and 0.45 (total livestock); the relationship (see Table 2 & Table 3) between the individual independent variables were significant ($P<0.01$) in all cases on different farm types (see Table 1). The economy of scale for dairy operation plays a pivotal role for the adoption of good dairy practices that may be achieved by more resource allocation in the form of capital, labour and managerial costs across more units of milk produced (Wolf, 2003). It is also evident from the recent trends in commercial dairy production systems that a decreasing number of farms, although farm size has increased, especially the share of milk production from very large herds, allows more resource allocation and focused dairy management practices to produce quality milk (Evink and Endres, 2017).

Image 1: On-farm milk selling and transportation at peri-urban dairy farms in Faisalabad

Table 1: Comparison of different farm types with respect to milk sale, farm expanses and, dairy animals and livestock strength. Means with different letters differ significantly in the respective variable between the groups (Mann-Whitney-U-Test, a=0.05). SD = standard deviation

FARM TYPE	SCSS		CSS		CLS		TOTAL		
	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	N	MEAN±SD	P≤
Milk sale Income	60	70300.0^{a} ±64040.85	60	90383.3^{b} ±57440.34	60	334916.7^{bc} ±264910.56	180	165200.0±200300.79	0.001
Dairy Farm Expanses	60	34953.3^{a} ±29391.83	60	51883.3^{b} ±115746.52	60	251968.2^{bc} ±541232.94	180	112934.9±333198.31	0.001
Female Adult Buffalo	60	7.4^{a} ±8.00	60	10.4^{b} ±7.14	60	17.5^{bc} ±9.80	180	11.8±9.35	0.001
Female Adult Cattle	57	7.7^{a} ±6.81	58	10.4^{b} ±6.77	58	13.6^{bc} ±6.76	173	10.6±7.16	0.001
Total Dairy Animals	60	14.8^{a} ±13.40	60	20.4^{b} ±12.37	60	30.6^{bc} ±15.67	180	21.9±15.29	0.001
Total Livestock	60	21.7^{a} ±30.37	60	31.5^{b} ±19.37	60	64.9^{bc} ±47.60	180	39.4±38.98	0.001

a, b, c : Within rows, means with different superscripts differ at P<0.05

Table 2: Overall correlation coefficients (r) between farm type, milk sale, farm expanses and, dairy animals and livestock strength

	FARM TYPE	INCOME MILK SALE	DAIRY FARM EXPANSES	FEMALE ADULT BUFFALO	FEMALE ADULT CATTLE	TOTAL DAIRY ANIMALS	TOTAL LIVESTOCK
Farm Type	1	.541**	.267**	.440**	.335**	.424**	.454**
Milk sale Income	.541**	1	.435**	.621**	.573**	.656**	.489**
Dairy Farm Expanses	.267**	.435**	1	0.056	0.073	0.068	0.060
Female Adult Buffalo	.440**	.621**	0.056	1	.679**	.936**	.823**
Female Adult Cattle	.335**	.573**	0.073	.679**	1	.890**	.656**
Total Dairy Animals	.424**	.656**	0.068	.936**	.890**	1	.800**
Total Livestock	.454**	.489**	0.060	.823**	.656**	.800**	1

**. Correlation is significant at the 0.01 level (2-tailed)

Table 3: Correlation coefficients (r) between milk sale, farm expanses and, dairy animals and livestock strength of different farm types

FARM TYPE		MILK SALE INCOME	DAIRY FARM EXPANSES	FEMALE ADULT BUFFALO	FEMALE ADULT CATTLE	TOTAL DAIRY ANIMALS	TOTAL LIVESTOCK
SCSS	Milk sale Income	1	.517**	.865**	.865**	.960**	.844**
	Dairy Farm Expanses	.517**	1	.510**	.492**	.549**	.637**
	Female Adult Buffalo	.865**	.510**	1	.631**	.917**	.910**
	Female Adult Cattle	.865**	.492**	.631**	1	.884**	.661**
	Total Dairy Animals	.960**	.549**	.917**	.884**	1	.881**
	Total Livestock	.844**	.637**	.910**	.661**	.881**	1
CSS	Milk sale Income	1	-0.069	.524**	.828**	.766**	.441**
	Dairy Farm Expanses	-0.069	1	-0.067	-0.126	-0.105	0.055
	Female Adult Buffalo	.524**	-0.067	1	.554**	.884**	.882**
	Female Adult Cattle	.828**	-0.126	.554**	1	.873**	.449**
	Total Dairy Animals	.766**	-0.105	.884**	.873**	1	.766**
	Total Livestock	.441**	0.055	.882**	.449**	.766**	1
CLS	Milk sale Income	1	.359**	.525**	.549**	.584**	0.217
	Dairy Farm Expanses	.359**	1	-0.146	-0.033	-0.106	-0.149
	Female Adult Buffalo	.525**	-0.146	1	.700**	.949**	.706**
	Female Adult Cattle	.549**	-0.033	.700**	1	.890**	.706**
	Total Dairy Animals	.584**	-0.106	.949**	.890**	1	.722**
	Total Livestock	0.217	-0.149	.706**	.706**	.722**	1

**. Correlation is significant at the 0.01 level (2-tailed)

3.2 Housing management and clean milk production

Two-thirds (n=136) of the farms used traditional cowsheds (locally built conventional dairy sheds) and only 25% had modern barns (following scientific lines at least in basic dairy farm structure), with significant ($P<0.01$) differences in farm design, drainage system and cleaning frequency between SCSS and two other farm types CSS and CLS farms. Management practices related to cleaning and sanitation for dairy production and subsequent resource allocation for clean and hygienic milk production was more evident on CSS and CLS than on SCSS. In terms of proper shed construction ($P<0.001$), drainage system ($P<0.001$), disinfection and sanitation practices ($P<0.05$), cleaning of udder prior to milking ($P<0.01$), there was significant differences between SCSS and other two types CSS and CLS. If we compare CSS with CLS, CLS farms were ahead of

CSS in taking better steps in production of clean milk. Among the former, 46% had a brick floor, mostly (70%) had cracks and crevices, offering sufficient hiding places for ticks and other insects. During milking operation microbial quality of milk changes due to many reasons including udder infection, unsanitary milking utensils, personnel and sanitary status of the shed and environmental condition surrounding milking operation (El-Leboudy et al., 2014) (see Fig.3).

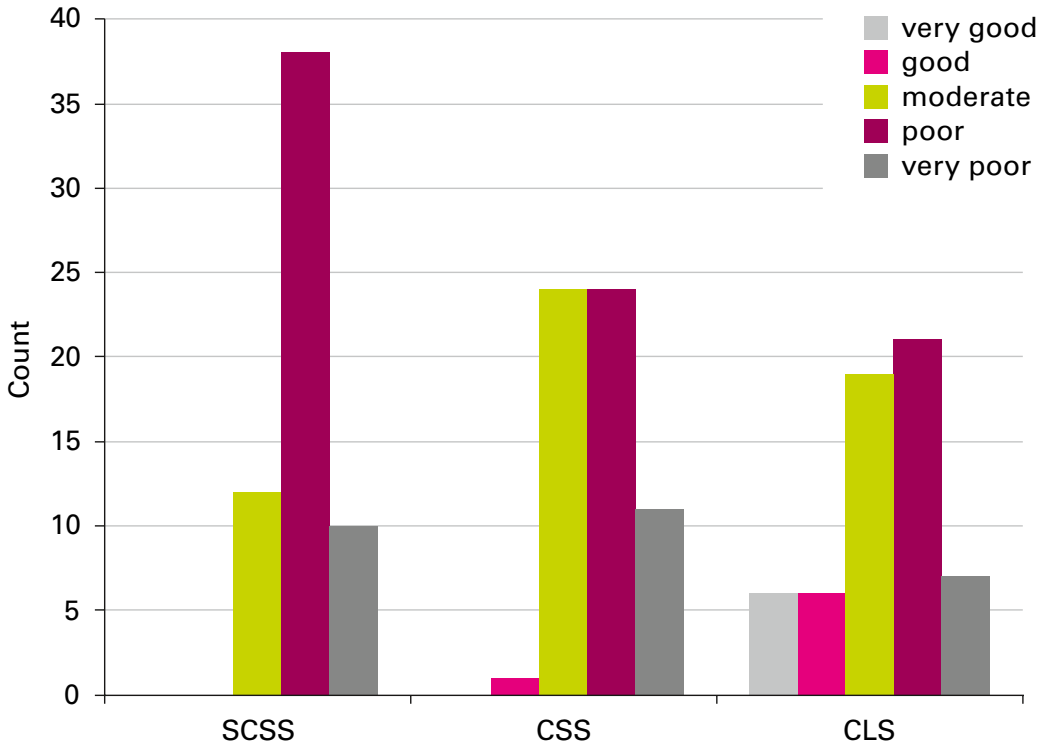

Figure 2: Level of shed cleanliness on three farm types (SCSS, CSS and CLS)

Flies were present in >90% of all farms and only 22% of the farms practiced fly control measures. There were no significant differences observed for insect control measures among all three farm types. The SCSS observed more formal system of dairy cleaning and sanitation, housing management and other dairy management practices than the CSS and CLS farms. A dirty environment with filthy and dirty premises provides a suitable breeding place for flies and other insects, which may fall into the milk during the milking process and thereby deteriorate milk quality (Mbabazi, 2005). On overall basis most of the floor area of these peri-urban dairy farms had pits (33%) and surfaces with pours and uneven flooring (62%) were observed. The floor surface at SCSS farms had more pits and was more uneven than the CSS and CLS ones, but this difference was non-significant (P=0.06) among three farm types. Such type of floor surface conditions

offered permanent standing places for urine, washing water and slurry. Air, bedding and surface sanitation are all important aspects of farm animal shed hygiene and quality milk production. Surface hygiene is linked to intensive farming systems, and is exacerbated by poor maintenance (Pasanen et al., 2000). Most of the farms (79%) had no proper drainage slope; amongst the three farms, SCSS had least developed drainage system ($P<0.001$). Urine and waste water accumulated at most of these dairy farms due to the absence of proper drainage system and drainage slope, thereby causing bad odour in 79% farms. The concrete floor is considered ideal for dairy shed so that urine, faeces, mud and feed residues can be quickly washed out. For hygienic and quality milk production before and after each milking, the floor should be hosed down with clean water and therefore, the slope of the shed floor should be properly constructed to allow for proper drainage. For ideal dairy conditions, there should be proper waste disposal facilities and the shed area can be cleaned easily. Proper arrangements should be made to avoid contamination of milk with dung, dust, dirt, soil, feed urine and flies (FAO, 1989). A comfortable environment, clean and dry flooring and good bedding conditions play pivotal roles in minimising the spread of harmful and disease-causing microorganisms (Gurmessa, 2015). An acceptable milk quality requires proper and clean dairy premises with frequent and routine cleaning and sanitation (Asaminew, 2007). In case of the stall-fed animals, the bedding material and the feed, particularly, are the major sources of milk contamination, along with faeces and urine that are accumulated in the bedding material (Alehegne et al., 2009).

Image 2: Shed conditions in which milk is being produced at peri-urban dairy farms in Faisalabad

Table 4: Comparison of factors (expressed in %) related to shed and animal affecting quality of milk production at three studied farm types

	FARM TYPE			
Variable	**SCSS** (n=60)	**CSS** (n=60)	**CLS** (n=60)	**P<****
Housing Type				
Proper shed	9	7	37	0.001
Temporary shed	23	37	11	
Under tree shade	20	9	10	
Use of bedding material				
Yes	13	9	32	0.001
No	47	51	28	
Flies				
Yes	56	58	53	n.s
No	4	2	7	
Frequency of cleaning dairy shed				
Daily	10	2	2	0.001
Weekly	14	5	18	
Fortnightly	28	31	29	
Monthly	8	22	11	
Proper slope of drainage				
Yes	12	8	28	0.001
No	48	52	32	
Cleanliness level of udder and hind quarter				
Very Good	1	1	3	0.001
Good	4	9	20	
Poor	30	30	30	
Very Poor	25	20	7	
Frequency of animal body washing				
Weekly	1	11	14	0.01
Fortnightly	27	20	13	
Monthly	13	11	9	
Others	19	18	24	
Washing of udder before milking				
Yes	7	28	39	0.001
No	53	32	21	
Milking of sick treated animals				
Yes	27	35	22	0.05
No	33	25	38	

**Chi-Square test for differences between production systems, significance at P<0.05; n.s. not significant.

3.3 Animal hygiene

Across the studied farms, 93 % animals had dirt and dung-coated bodies and 90 % had dirty hindquarters and udders, which indicated poor cleanliness and dirty shed conditions. If we compared three farm types, the cleaning level of the animal body was better on CSS and CLS than SCSS, but there was no significant differences ($P = 0.6$) observed among three farm types regarding farm cleanliness. There was significant difference ($P < 0.01$) in udder and hindquarter cleanliness level on CLS than SCSS and CSS. In most cases, hair trimming was missing (83 %), as was hoof trimming (74 %), washing of the udder before milking (59 %) and teat dipping (n = 152, 84 %) after milking. Body cleanliness, hair clipping, hoof trimming and washing of the animal's body was more frequently observed on CSC and CLS farms than on SCSS farms but differences were non-significant and there was significant difference ($P < 0.001$) in washing of the udder before milking in CSS and CLS than SCSS farms. Teat dipping was observed only in few farms (n = 26, 14 %,) and the situation was non-significant for three farm types. One of the most important practices to ensure high milk quality is cleaning of udder before milking (Zelalem et al., 2011), because the udder always is in direct contact with the floor surface and thus mud, faeces, urine and contaminated feed residues. Cleaning the udder surface, the teats and the area around the udder from dirt and contaminants is necessary to avoid the entrance of different types of microbes and pathogenic bacteria into the fresh milk (O'Connor, 1995). The dairy animal's body, flanks, udder area, udder skin and teat surface are directly exposed to the shed environment and can acquire undesirable microbes and bacteria (Nangamso, 2006) (see Fig. 4).

Image 3: Animal hygiene and body condition of dairy animals at peri-urban dairy farms in Faisalabad

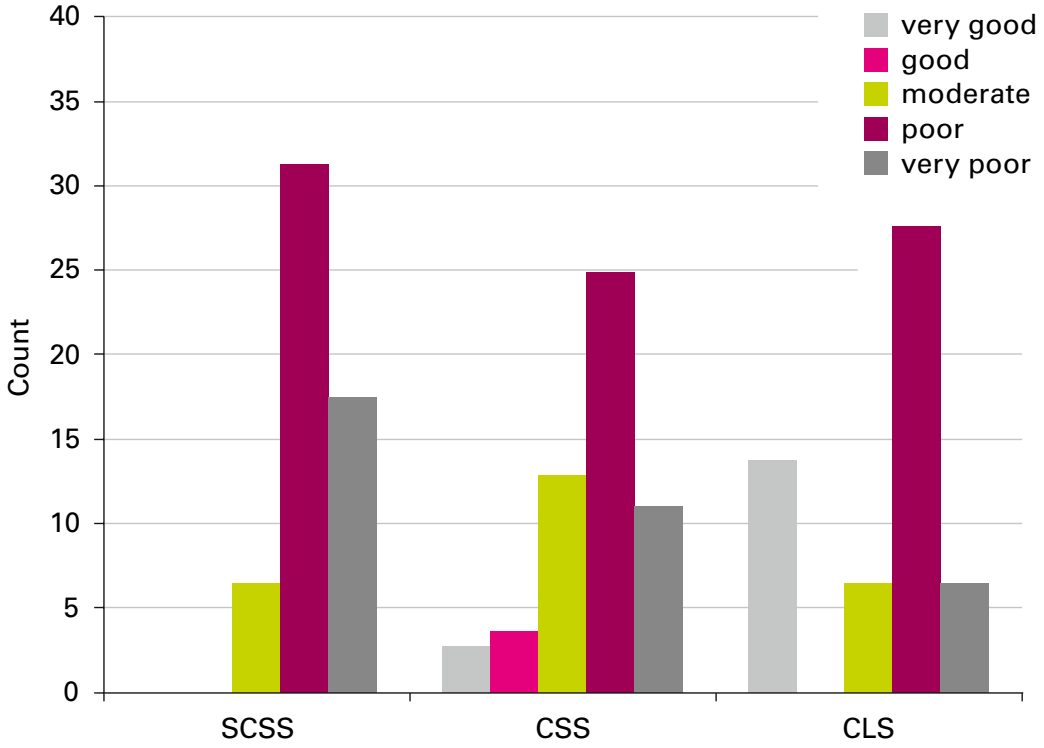

Figure 3. Level of udder cleanliness on three farm types (SCSS, CSS and CLS)

In another study it was reported that the udder pathogens reside mainly in the environment and can be transmitted from there to the udders between milkings, for example, via contaminated animal body, licking of the teats and udder by other animal, contacts of udder with the dirty tail or legs (Olofsson, 2013). Cleaning of the udder with water and subsequent drying with cleaning and drying cloths sustainably reduces milk contamination by microorganisms. Cleaning cloths and towels used for udder cleaning and drying should be properly managed and dealt with care (O'Connor, 1995). Not washing the udder before milking can impart contaminants and pathogens into the milk, whereas proper cleaning and sanitation for udder preparation before milking can reduce teat contamination by up to 90 % (Murphy, 1996; Murphy and Boor, 2000) (see Fig.5).

3.4 Feed and water quality

Many farms (n = 108, 60 %) used dried bread that was mostly infected with fungus for feeding their cows; this can be a source of aflatoxin in milk. Farmers in Punjab, along other feeds, including concentrate feed mix, maize and cotton seed cake, also offer bread pieces, which are waste material and high source of aflatoxin contamination to feed their dairy animals, (Akbar et al., 2020). Published data reported that those animals, who fed on bread pieces and concentrate mix, evolved higher amount of aflatoxin in milk (Asi et al., 2012). Furthermore, most farms used dusty feed (e.g., wheat straw and powdered concentrate) with poor conditions (50 %) and did not or were not quick enough to remove feed leftover and, in most cases, cleaned feeding area fortnightly (n = 66, 36.7 %) and 16.1 % on monthly basis and there was no significant difference in the cleaning of feeding area among three farm types. Such practices add to particles suspension in the air of the shed and finally milk contamination (Tariq et al., 2018). Furthermore, feed storage facility was lacking at 125 out of the 180 farms, and 39 % farms had poor availability of fresh water for cleaning and drinking purposes. However, feed storage and fresh water facilities were significantly ($P < 0.05$) better at CSS and CLS than at SCSS farms. The animals should be fed in clean places and they need to be fed and watered with products of suitable quality and safety as overall quality of both water and feed is an important factor for the overall health status of the cow and production of quality milk (FAO and IDF, 2011). In developing countries, the water supply to dairy

Image 4: Feeding and watering conditions at peri-urban dairy farms in Faisalabad

farms is generally of poor quality and the access to nutritious feed is usually inadequate, especially during the dry season. The cows should be fed in a clean and dry place and the drinking place should be washed and protected against contamination (Olofsson, 2013). It was observed on studied farms that water trough was mostly cleaned on fortnightly (29.4 %) or monthly basis (33.9 %) and only a few farmers (17.1 %) do it on daily basis. The animals' water troughs were not cleaned regularly; published data indicates that water served as the primary source of microbes that potentially contaminated milk (Mbabazi, 2005) (see Fig.6). The supply of clean drinking water, free of all types of contaminants especially of human origin, would make a great contribution to clean and healthy milk production.

3.5 Milking management and mastitis incidence

At most dairy farms milk let-down was stimulated with the help of oxytocin (n = 103, 57 %) or suckling of the calf (33 %), whereby only few farmers (10 %) used feeding for milk let-down. It was observed that the use of oxytocin was significantly ($P < 0.05$) higher on CLS and SCSS than on CSS farms. A previous study by the author (Tariq and Younas, 2013) revealed that the prolonged use of oxytocin for milk let-down stimulation makes milk unfit for human health and has also deleterious effects on the dairy animals as it inhibits the normal milk ejection reflex, causes fertility disorders and enhances the incidence of mastitis. Proper cleaning and washing of the udder after suckling of the calf is very important to avoid mastitis. On 52 % of the dairy farms there were more than 10 cases of subclinical mastitis reported during the two months preceding the interviews. The incidence of subclinical mastitis was little bit higher (60 %) on CLS than SCSS (48 %) and CSS (47 %), however, there was non-significant difference in mastitis incidence between the SCSS, CSS and CLS farms. High incidence of mastitis on these farms was most probably due to low quality feed, personnel hygiene, absence of timely screening tests and poor milking methods (see Fig. 6). Subclinical mastitis is a common disease among dairy cows, which changes the composition of the milk and gives a reduced milk production leading to severe economic losses (Olofsson, 2013). Overall health status of dairy animals was significantly ($P < 0.05$) better on CLS than on SCSS and CSS farms. Milking of sick and medically treated dairy animals (47 %) was also practised on all farms. Mastitis affects herds in all countries and is the most economically burdensome and important udder disease condition that is caused by a wide range of infectious agents, be it bacteria, viruses or fungi; it is the most common and economically important disease in dairy animals causing high economic losses in dairy farming (Cobirka et al., 2020; Nielsen, 2009). This multifactorial disease is mostly caused by inefficient dairy hygiene, hence, exposure to pathogenic microbes; recurrent (subclinical) mastitis reduces the efficiency of the dairy animal's humoral defence mechanisms (Oviedo-Boyso et al., 2007). Mastitis

increases the number of pathogenic microorganisms in milk, lowers milk quality and enhances the risk of milk-borne diseases. It is also reported that even in well-managed dairy herds, on average 15 % of the cattle are infected with mastitis (Cobirka et al., 2020). Up to 75 % of the cattle in poorly managed herds can be infected with mastitis (Younan, 2013). This infection is very painful for the cows. Mastitis-infected quarters produce between 15 % and 30 % less milk, as compared to healthy quarters (Carrillo-Casas and Miranda-Morales, 2012; Younan, 2013).Mastitis in dairy cattle cannot be fully prevented, but its frequency, severity and the economic losses caused by this disease can be reduced drastically (Younan, 2013). There has not been much observations on pre-stripping of milk before milking. As a standard of food safety, fore-stripping practice ensures that abnormal milk is diverted from the human food chain (Wagner and Ruegg, 2002). In order to detect subclinical mastitis in daily routine milking, a good practice is to use the California Mastitis Test (Kivaria et al., 2004).

Image 5: Milking management at peri-urban dairy farms in Faisalabad

3.6 Hygiene of utensils

Milk cans were hardly disinfected (79.4%) and milk was mostly (64%) stored in plastic containers without pre-filtration; however, CLS more frequently (50%) stored milk in steel containers than SCSS (25%) and CSS (20%), whereby a significant ($P<0.01$) difference existed in container manufacturing material among the three farm types (see Fig. 7). If we compare milk storage materials, stainless steel is expensive than plastic but by far the best option. Plastic equipment will become scratched on the surface after some time, be nearly impossible to clean and is therefore not advisable (Pandey and Voskuil, 2011). The milk utensils and equipment used for milking and storage should be non-corrosive and easy to clean and disinfect (FAO, 2011). Thus, materials that are non-absorbent and non-corrosive, have smooth surfaces, minimal joints and are free from dents may be recommended (FAO, 2011; Pandey and Voskuil, 2011). Improperly cleaned and disinfected milk cans, milk storage equipment and other milk handling utensils are also a potential source of contamination with many harmful microorganisms (Kurwijila, 1989). A trace of milk and milk drops left on the surface of these utensils after using them might serve as the medium for the growth of a great number of different types of bacteria (Banwart, 1989; Bramley, 1990; Pandey and Voskuil, 2011).

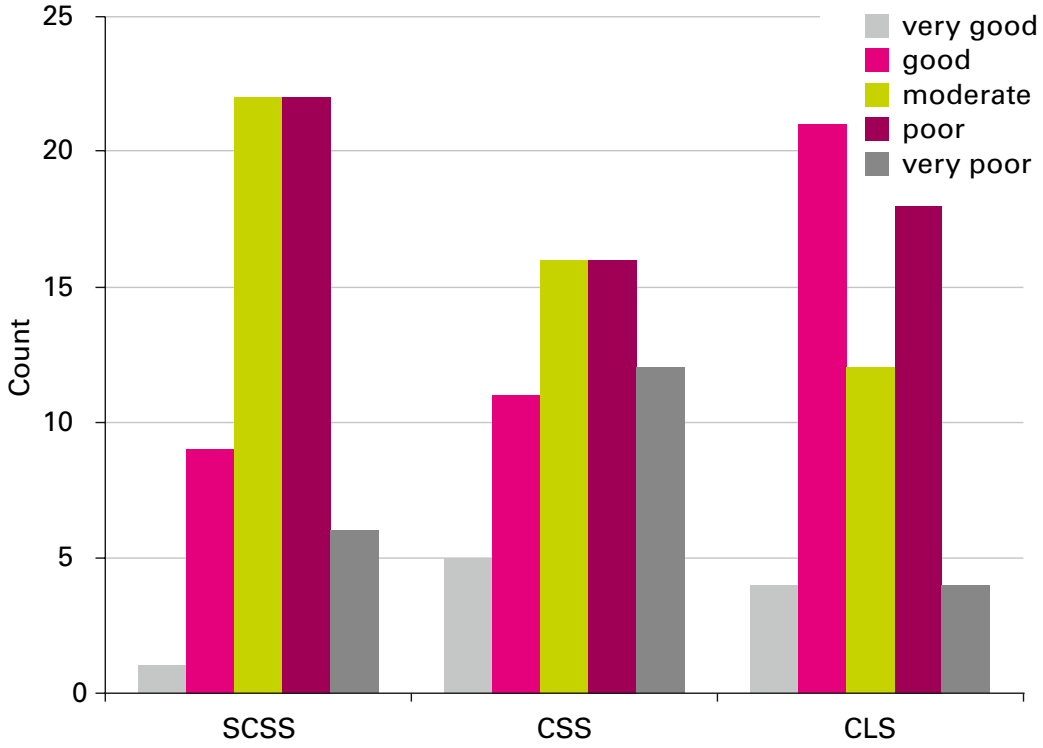

Figure 4. Level of cleanliness of utensils on three farm types (SCSS, CSS and CLS)

Similarly, cracks in milk containers may accumulate traces of milk and develop bio-films and layers of hazardous material over time. Good dairy equipment must be manufactured from material that is food safe and easy to clean, such as aluminium and stainless steel (Zelalem et al., 2011). A clean brush with good bristles, hot water and a detergent should be used during washing. The equipment should be rinsed with clean water and dried immediately, preferably kept upside down and in the sun. It was also observed that in most cases (n = 144 farms) milk was stored at the farm for two to four hours before transportation to the market without prior cooling. Such careless handling increase bacterial loads if the transportation equipment is not properly cleaned and sanitised; thus, chances of milk spoilage increases during the transportation process (Grimaud et al., 2007) (see Fig. 8).

Image 6: Variety and condition of milk containers used for milking and milk storage at peri-urban dairy farms in Faisalabad

3.7 Workers' hygiene and decency of work

On overall basis about 70 % of the dairy farm workers did not wash their hands before milking and there was 100 % hand milking on all three types of farms (see Table 5). It was also observed in the previous study by Hagmann in 2012 that dairy animals in peri-urban Faisalabad were milked twice daily, exclusively by hand. Literature shows that hand milking is the oldest technique to remove milk from dairy animals and in many parts of the world, where farmers do not have access to electricity or technology for machine milking (Millogo et al., 2009). But there is higher risk of contamination in the case of hand milking as compared to machine milking (Pandey and Voskuil, 2011). Most of them (89 %) did not trim nails nor cover their heads (174, 97 %) during milking and in some farms, workers even carried on milking with personal sickness (24 %). Sometimes, the labour is bound by the owner to carry on dairy management practices even if they are sick or find it hard to continue work. In most cases, they got very low wages that hardly fulfilled their family needs; however, they kept on working most probably because they had no other means of earning livelihood and had borrowed money from the owner of the farm. In another study on peri-urban dairy production (Erbach, 2012), it was observed that there was no direct use of force, but bonded labour definitely existed. Bonded families had to work on farms until they returned a credit, though the payment they received was hardly enough to cover their daily expenses. Even at times, family members of the next generation were bound to work for the farm owner. Such a relationship between employee and employer was characteristic of forced labour (Erbach, 2012).

Most of the farm workers wore dirty clothes (89 %), 76 % had hands with wounds and injuries; if they washed hands before milking they only used tap water and only a few applied soap (29 %) to clean hands before milking. If we compared three farm types for personnel hygiene level, the working conditions were very poor and even worst for dairy farm workers on all these dairy farms. There was a great possibility of transferring pathogens and other microbes to other dairy animals in the herd while the dairy worker/milker moved from one dairy animal to another (Olofsson, 2013). Therefore, it is advisable that dairy workers wash their hands properly with soap and water and dry them with a clean towel before milking and handling the milking utensils, and during the milking process between different dairy animals (Pandey and Voskuil, 2011). Inadequate working conditions make it very hard for dairy farm workers to work with full zeal and zest on these dairy farms. Hence, they did not enjoy their working routines. It was also observed that they had to work during religious holiday as well in most of the cases. Poor working conditions, low personnel hygiene levels of farm workers and continuous working with daily tough routines were probably one of the leading causes in low quality milk production. Decency of work should include a measurement of the daily work time. To determine the duration of work one has to make a clear definition and separation between work and leisure time (Erbach, 2012). It was also observed in this study that long working hours in peri-urban dairy production units led to declining productivity because of declining mental concentration, health problems caused by distress and imbalance between personnel care and quality farm work in dairying. It was also observed by another author that poor hygiene level of dairy farm workers involved in milking of dairy animals and handling of milk may potentially contribute pathogens and other microorganisms especially when they fall sick but are forced to work (Ashenafi, 1994). Subsequently, microorganisms maight get transmitted from their bodies, hairs, sneeze and cough in general, and pathogen transmission increased in case of sickness (Kurwijila, 1989; Mbabazi, 2005).

After careful analysis of the core problems faced by these dairy farm workers, one can find ways to improve the working conditions for the dairy labour force. When these dairy farm workers would be satisfied with their working conditions, they would be very useful in the production of quality milk. Thus, it is desirable to start from the beginning, with a bottom-up strategy, where the target people would take part in the evaluation of their situation at work, as also described by (Erbach, 2012).

Table 5: Comparison of factors (expressed in %) related to farm workers and utensils affecting quality of milk production at three studied farm types

	FARM TYPE*			
Variable	**SCSS** (n=60)	**CSS** (n=60)	**CLS** (n=60)	**P<****
Health status of workers				
Healthy	41	44	41	n.s.
Sick	19	16	19	
Knowledge level of worker about hygiene and clean milk				
Uneducated	53	51	33	0.001
Trained	7	9	27	
Sick workers are allowed to work				
Yes	8	11	6	n.s.
No	52	49	54	
Clothing of farm workers				
Very clean	2	2	4	n.s.
clean	2	6	4	
dirty	36	29	35	
very dirty	20	23	17	
Trimming of nails by farm workers				
Yes	8	4	8	n.s.
No	52	56	52	
Are the workers' hands free from wounds or any injury				
Yes	15	10	19	n.s.
No	45	50	41	
Filtration of milk				
Yes	16	16	20	n.s.
No	47	45	38	
Disinfection of milking pan				
Yes	11	7	19	0.05
No	49	53	41	
Type of material used for storage of milk				
Metallic	20	18	19	0.001
Steel	15	12	30	
Plastic	25	30	11	
If storage is in a large drum, is it covered properly?				
Yes	15	22	6	0.01
No	45	38	54	

**Chi-Square test for differences between production systems, significance at P<0.05; n.s. not significant.

3.8 Knowledge of farmers about clean milk production

About 137 farmers (76%) had no knowledge of farm hygiene, 62% had little or no knowledge of clean milk production and 46% had no knowledge about improved dairy farming practices. There was no significant (P=0.081) difference observed among all three farm types SCSS, CSS and CLS regarding knowledge of farm workers about improved dairy farm practices (Fig 9). There was highly significant difference observed regarding knowledge of clean milk production (P<0.01), cleaning of animals, shed (P<0.001), utensils (P<0.05), water trough (P<0.001) and mangers (P<0.01) among SCSS and other two types of farms CSS and CLS. The knowledge level about these attributes was better on CLS and CSS than on SCSS. This resulted in an overall poor cleanliness level at most farms (n=169, 93%), ultimately leading to poor quality and unhygienic milk production. The labour working in the milk shed should include healthy persons who are aware of the importance of personnel hygiene. They should wear clean clothes, wash their hands prior to milking and trim their nails (Mbabazi, 2015).

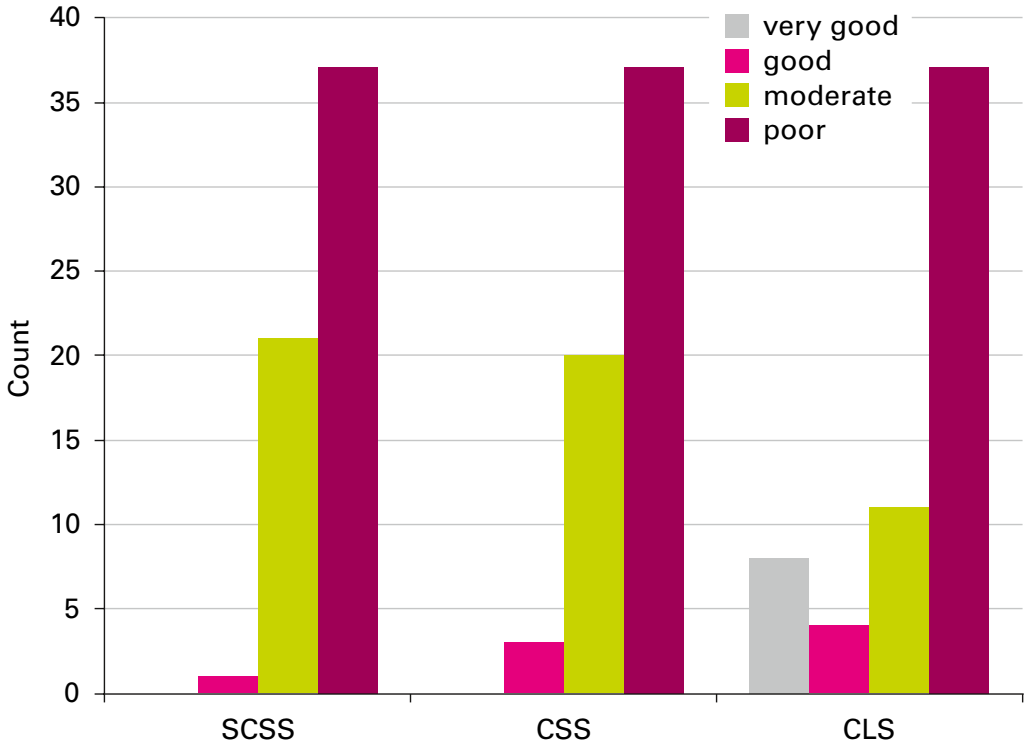

Figure 5: Knowledge level of farmer about clean milk production at three farm types (SCSS, CSS and CLS)

To enable small-scale farmers practice good milking routines, it is of great importance that they receive proper advice and assistance (Pandey and Voskuil, 2011). The labour involved in dairy operations at all levels of the peri-urban dairy farms in Faisalabad was mostly hired and they were poor. They were mostly illiterate and completely ignorant of improved farming practices for clean and hygienic milk production (see Fig. 10). Owners of dairy farms should provide regular health checkups of hired labour. Proper facilities should be provided by the farm owners to their dairy farm workers in order to improve their health and personnel hygiene, and make the working conditions conducive and comfortable. They should take interest in capacity building and training of farm workers about good dairy management practices and clean milk production. This would ultimately improve the situation of clean and hygienic milk production in the country, which can further be augmented by implementing good management practices, quality management techniques, as well as promoting and building the capacity of smallholder dairy farmers, in order to reduce the risks associated with milk production by dairy farmers in general and farm workers in particular (Lemma et al., 2018).

Image 7: Condition of workers working at peri-urban dairy farms in Faisalabad

3.9 Problems and solutions associated with clean milk production

When farmers and farm workers were asked about their problems and suggested solutions they ranked lack of resources (38%) as their main constraint following high construction costs on modern and scientific lines and daily expanses (18%) to produce clean and hygienic milk (Fig. 11). According to Ali and Saifullah (2006), milk production is a labour-intensive activity, and there are a number of biological, technical and socioeconomic constraints including high input costs and lack of resources. They also explained the low number of animals (15%) as their problem and they correlated it with inadequate means. Other limitations include absence of government support (13%) with regard to dairy as an enterprise to provide basic facilities regarding low interest loans, subsidies, animal health facilities, free vaccination, etc. Another study (Jalil et al., 2009) on peri-urban dairy farmers in Lahore concluded that the growth of peri-urban dairy production requires effective decision-making in the dairy industry from the planning department, key stakeholders, and policymakers. About 10% farmers considered traditional farming as a constraint as they could not avail modern innovation because of insufficient resources and government aid. A few farmers (6%) also pointed out deficient knowledge and training about clean milk production practices in peri-urban dairying as hindrances. Jalil et al. (2009) observed that the lack of training and dairy-related education hinders opportunity for quality milk production and value addition.

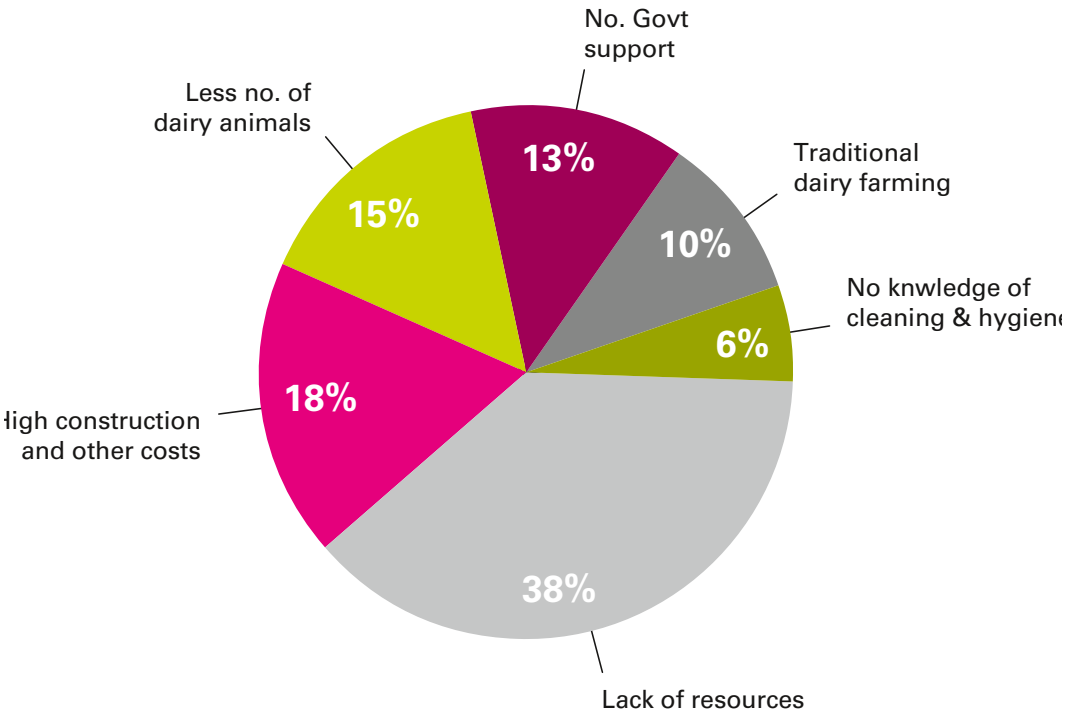

Figure 6: Ranking of problems faced by dairy farmers in view of clean milk production.

When these farmers were asked about suggested solution for the said problems 58% of the farmers suggested that the situation about decent working conditions in dairy farming and clean milk production could effectively be improved with the help of government policies and support. These farmers (25%) also emphasized on proper training and capacity building of farm workers about principles of good dairy management and clean and hygienic milk production through improved knowledge of dairy and personnel hygiene. Further proposed solutions included subsidizing dairy production inputs including feed, farm structure and other equipment of decent dairy production operations for clean and hygienic dairy products (Fig. 12).

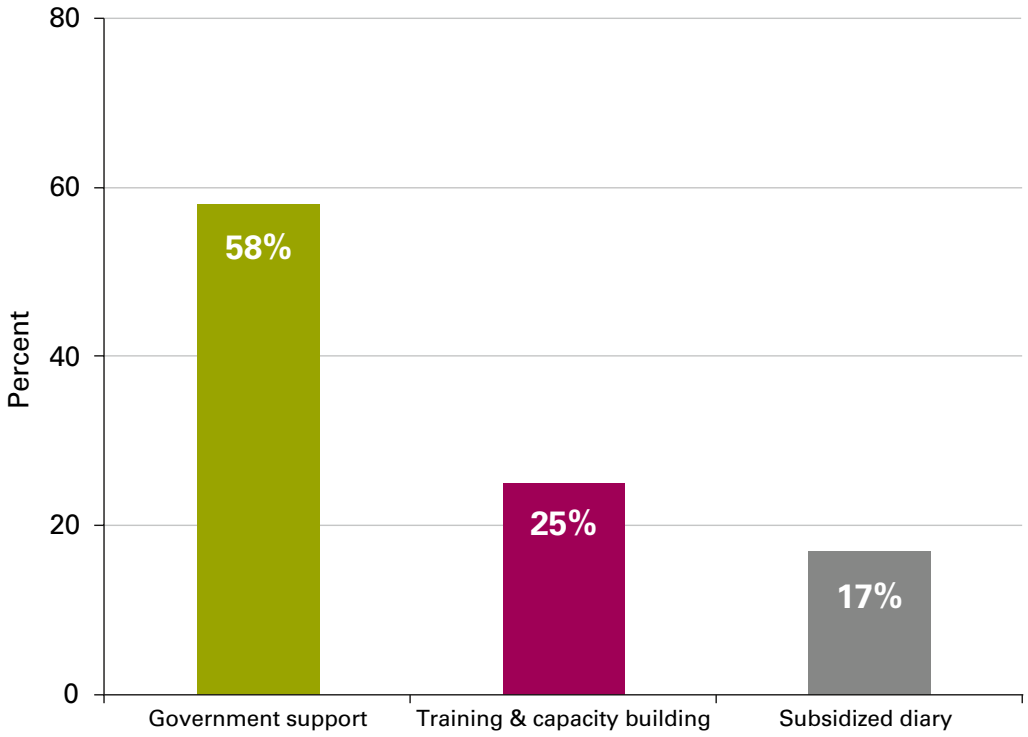

Figure 7: Ranking of solutions suggested by dairy farmers in view of clean milk production

4 Conclusions

Based on findings, the present study could be concluded that hygienic and milking practices in peri-urban dairy farms in Faisalabad, the third largest city of Pakistan, were poor, resulting in the production of poor-quality milk, as well as working conditions for labour were also not decent. This may be due to lack of compliance of strict hygienic practices during milk production and subsequent handling and also lack of resources and subsequent resource allocation. Moreover, there were other associated challenges facing dairy farmers including proper construction of shed on modern scientific lines, feed and fodder free from all types of contaminants, adoption of good sanitary practices and manure disposal, herd health, use of hygienic equipment and utensils for milk, training of labour and maintenance of good personnel hygiene and decent working conditions for dairy farm workers. As we step forward to meet increasing food demands through intensive dairy farming, food safety remains a matter of high priority for small-scale, urban and peri-urban, dairy producers in particular. Dairy operation Intensification without careful management, lack of infrastructure, poor support services by the government, and absence of appropriate regulations can lead to an increase in food safety concerns and public health risks within the dairy industry, which must be addressed to enhance sustainable dairy food systems. Improvement of milk safety in various dairy production systems in Pakistan can be achieved through good dairy management practices, efforts of various stakeholders, improving working conditions and following appropriately successful experiences from elsewhere. In this regard, building the capacity of farmers is essential in most developing countries. Last, but not the least, dairy farm-level efforts in production of good quality milk is more vital for controlling most hazards. Thus, improving food safety requires the improvement of working conditions. Flexible provisions to dairy farm workers can enhance productivity and improve work–life balanceas well as food safety.

The following measures could lead us toward the production of clean and hygienic milk. While some reasons for unhygienic milk production, such as housing and drainage system, need major investment to improve, systematic cleaning of dairy animals, milking equipment and improved workers' hygiene can easily enhance milk safety in Pakistan's cities.

5 Recommendations

Overall, the following issues would need to be addressed:

5.1 Efficient dairy extension

Well-organized dairy extension services are needed to help dairy farmers and farm workers with dairy operations (such as milking, barn cleaning, and manure management) that influence the production of high-quality milk.

5.2 Adequate dairy farming practices

Dairy farmers must follow adequate dairy farming practices, including proper construction of shed on modern scientific lines, feed and fodder free from all types of contaminants, adoption of good sanitary practices, maintenance of good personnel hygiene, right milking procedures, involving the use of suitable equipment and utensils, their cleaning, disinfection and post-rinsing.

5.3 Role of multi-stakeholders and government

Ensuring milk safety will necessitate a holistic approach involving many stakeholders (particularly, veterinary service, dairy farmers, feed administration and control authority, human health extension) and strategies together with a coordinating government body in place.

5.4 Improvement of working conditions of dairy farm workers

After a thorough examination of the key issues confronting dairy farm workers in these peri-urban dairy farms, it is possible to identify ways to improve the working conditions in dairy production. For this reason, it is preferable to begin with a bottom-up approach, in which the target people are involved in the assessment of their job situation. One of the purposes of this study was to better understand and clarify the variety of personal and environmental factors that contribute to dairy workers' practices of clean milk production regarding health and hygiene. It has long been believed that by enhancing the safety, skills, and working conditions of dairy farm workers, productivity and profitability can also be increased, creating a win-win situation that benefits both the workers and the dairy business owner. Flexible working conditions can boost output, enhance work-life balance, and boost employee trust, motivation, and personal trustworthiness. They can also help employers retain their best workers. Similarly, improved working conditions play an important role to augment food safety measures, pertaining to the production of clean and hygienic milk through an ecological orientation that takes into account factors at various levels, including dairy farm workers' social and economic conditions.

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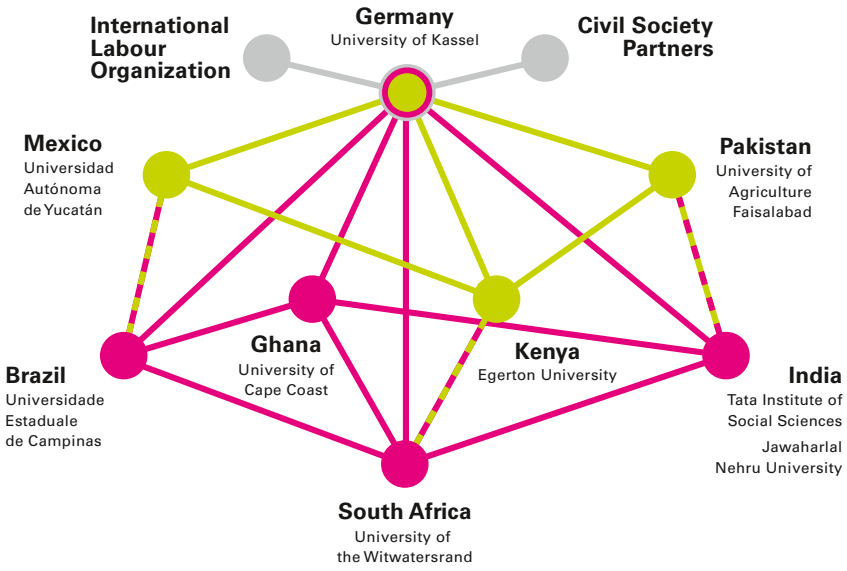

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