Chapter

Current Standing and Future Challenges of Dairying in Pakistan: A Status Update

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Abstract

Pakistan is considered among the leading raw milk producing countries. Unlike the production systems in the developed countries, milk production systems in Pakistan represent smallholding with subsistence- or market-oriented-level farming followed by peri-urban or commercial-level farming. Historically, dairy sector has been owned and managed by the private sector. During the past two decades, new initiatives have been taken because of the active involvement of corporate private sector. These efforts have resulted in improvements like enlargement of herds and import of high-quality milk germ plasm, the productivity per animal, milk collection, processing and marketing, the supply of dairy inputs (machinery, equipment, feeds, semen, and elite dairy animals), and farmers knowledge, and skills on modern management practices. Conclusively, the dairy sector is performing at some sustainable level to meet the food requirements of the growing population and helping save a handful of foreign exchange. Yet, challenges like local replacements of high genetic potential dairy animals, health hazards of β-casein proteins, antibiotics and aflatoxins, and uneconomical operational costs facing the dairy industry in the near future need to be addressed. The main objective of this chapter is to identify the current trends in dairy industry of Pakistan and describe those factors, which can influence the sustainability and profitability of dairying in the near future.

Keywords: collection and processing, dairy inputs, food legislation, large peri-urban dairy farming, profitability, sustainability

1. Introduction

Pakistan is considered among the leading raw milk producing countries. Unlike the production systems in the developed countries like United States of America and most of Europe, milk production systems in Pakistan have similar characteristics to the most developing countries of subcontinent. Characteristically, smallholding with subsistence- or market-oriented-level farming keeps the major share (about 90%) followed by peri-urban or commercial-level farming [1].

Current dairying in Pakistan is a combination of both traditional and commercial methods of raising dairy animals, and producing milk and milk products. During last two decades, commercial farming with imported dairy inputs has increased and reached roughly about 1% of the total raw milk production. With the

changing human needs and urbanization, the traditional system are on the edge of converting from subsistence level to more commercial and large-scale production systems during the said period [2]. In addition, policy made at government level in 2007 (Pakistan's first-ever Livestock Policy) placed considerable focus on dairy sector development. This has invited several private stake holders to invest in the farming, procurement, and processing of dairy and dairy products.

Despite the fact that the government has identified the dairy sector as one of the key priority sectors for development, the farmers being the main stakeholders are still facing constraints of inherent nature. They find limited opportunities to access consumers or industry directly and, therefore, have little control on the price or quality of milk owning to small-sized enterprises and limited resource inputs.

This chapter reviews last 10 years data and reports those significant changes that have been brought about in dairying in the country. The main objective of this chapter is to identify the current trends in dairy industry of Pakistan and describe those factors, which can influence the sustainability and profitability of dairying in the near future.

2. Milk production systems: general characteristics

Unlike the production systems in the developed countries like United States of America, milk production systems in Pakistan have similar characteristics to the most developing countries of subcontinent; smallholders with subsistence- or market-oriented-level farming keeping the major share followed by peri-urban or commercial-level farming [1]. Dairy farming in Pakistan is practiced mainly by the private sector on various scales, in both urban and rural settings. However, the sector is generally characterized as fragmented and subsistence. With the exception of some peri-urban units, most dairy farming is practiced in mixed crop-livestock systems.

Classically, dairy production systems in Pakistan fall into five main systems of milk production based on location, herd size, and level of management. These are smallholder subsistence, smallholder market-oriented, rural commercial, peri-urban, and large peri-urban. **Figure 1** shows percentage contribution of different milk production systems in total annual milk production. These systems are explained in the following subsections.

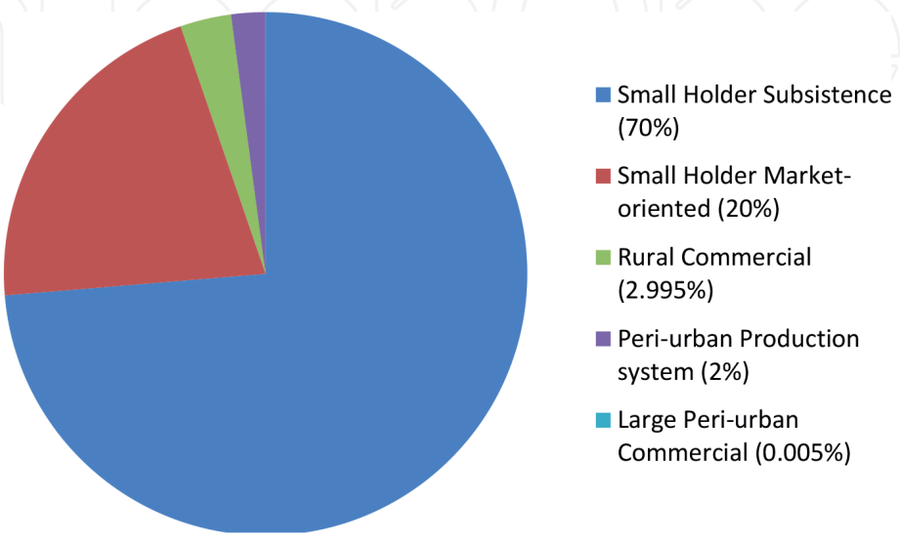

Figure 1.
Annual milk production from various milk production systems in Pakistan in 2016, based on Livestock Censes [4] and annual growth trends [5].

2.1 Smallholder subsistence production system

Smallholders produce milk to meet family requirements at minimal cost and have limited access to substantial milk market. The average subsistence unit consists of about three buffaloes, with at least two in milking. Average milk yields per animal are 3 L/day. The main inputs into these households' dairy production are often noncash resources, such as family-owned land and labor. Some 70% of smallholder milk producers fall into this category [3]. Most of the milk produced is utilized as fluid for fulfilling the family needs, and the rest is converted into butter and ghee. This system implies the use of household labor and therefore high labor-intensive occupation. Almost 50–60% of the feed requirements of these animals are fulfilled from grazing along with wheat straw and some green fodder. No purchased concentrates are offered. The proportional contribution of this system is declining and is replaced by smallholder market-oriented production system.

2.2 Smallholder market-oriented production system

As presented earlier, rural subsistence production system is changing into rural market-oriented smallholder production system with passage of years. This system is identified by its typical number of animal holdings and surplus milk production than the family requirements. There are usually 5–7 animals per household, both cows and buffaloes. Of these, there are usually 3–4 adult lactating animals along with one or two heifers and one or two male calves. Breeding bulls are normally absent. Feeding requirements of lactating animals are fulfilled from fodder along with wheat straw and seed cake. More than 70% of milk produced is sold either directly to retail shops or through intermediaries. This system is practiced by those smallholders who have access to nearby livestock markets, and they are encouraged to produce in excess of family requirements [3, 4].

2.3 Rural commercial production system

In 2006, dairy sector in Pakistan moved toward commercial side and this encouraged some progressive farmers to invest in milk production. A typical rural commercial dairy farm running on commercial basis consists of about 30 animals of which 70% are females, including some cows. Approximately 40% of these adult females are in milk during most of the year. Fodder crops provided 50% and straws about 35% of the feed requirements and concentrates made the rest of it. More than 90% of the milk produced at the farm is sold. Average milk yields per animal are 10 L/day. Potential channels for the marketing of milk in this system have changed from traditional system to selling to the commercial milk collection companies. This system presents the second largest source of milk collection by commercial dairy companies after large peri-urban commercial farming.

2.4 Peri-urban production system

Peri-urban production occurs in commercial-scale units located on the peripheries of major urban centers. With growing demand for milk in urban areas, rural commercial dairy farming moved toward peri-urban areas. These maintain herd sizes ranging from 20 to 200 (small) and from 200 to 2000 (large) head, and averaging 50 animals; 90% buffaloes and 10 % cows with nearly 90% of adult females in production [6]. These units employ family and hired labor, the latter being paid at local urban rates. Milk is delivered to the market twice a day. Major overheads in this system include hired labor costs, animal shelter, veterinary care, feed, water

and electricity bills, and milk transport. Milk is usually sold through direct sale to retail shops in the city after decreaming with the target to sell almost total produced milk. Male calves are disposed off within first 2 weeks of birth. These animals are fed chopped green fodder and wheat straw and concentrate mixture with target to sell almost total milk produced. The current number of dairy farms falling into this category accounts for 200 units situated across the country.

2.5 Large peri-urban commercial dairy farming (key farms, mega farms, corporate farms, etc.)

A rapid increase in urbanization during the last two to three decades has encouraged shifting of peri-urban dairy farming to large peri-urban commercial dairy farming (corporate farming). The owners of these farms aim at getting maximum milk production with economical and quality feeding and good management. These farms are categorized as high inputs-high outputs production systems with no limits on provision of feeding (good quality green fodder or silage along with concentrate mixture) as well as other inputs (medicine, machinery, mechanization, etc.). Dairy animals maintained at these farms are considered elite animals from pure Holstein Friesian and crosses of Holstein Friesian and Jersey breeds; and their yields per day are considerably higher (25 L/day) than those maintained under other production systems. These farms are usually coupled with small-level milk processing (chilling, pasteurization, and packaging), and finished product is disposed of through outlets or departmental stores or supplied to dairy companies (chilled, unprocessed). These modern dairy farms represent less than 1% of total dairy animals and milk production in the country; however, peri-urban (Sections 2.4) and large peri-urban collectively make about 1% of the total. These farms are mostly located in the cultivated areas of the country especially central Punjab province (14) and Sindh (1) (data provided by the sector). The average number of exotic animals kept at these farms is between 2000 and 5000, and the farms with more than 5000 animals also exist. The farms produce large quantities of fluid milk ranging from 0.02 to 0.1 million L/day.

2.6 Trends in production systems

During the last 10 years, significant changes have occurred in dairy sector of Pakistan, and due to these changes, this sector is on the way to become an industry. A large number of modern dairy farms have been established in different areas. Such farms have adopted most modern management and feeding practices and well-trained man power. Milk produced on these farms is either sold out in processed/fresh form through outlets/departmental stores, etc. or supplied to dairy companies (data provided by the sector).

2.7 Trends in annual milk production and consumption

Approximately, 91% of milk is produced in rural areas, with peri-urban areas accounting for 19% now compared to previous corresponding figures of 80% (rural areas), 15% (peri-urban), and 5% (urban areas) [2] as presented in **Figure 2**. Annual milk production from 2006 to 2016 is presented in **Figure 3**, which shows that it increased by an average of 3.21% per year, or by an average of 1520 million L/year. Annual milk consumption increased at the same rate to that of milk production or by an average of 1216 million L/year. The extra volumes are a result of increased herd size, and cannot be attributed to enhanced animal productivity, which has remained constant.

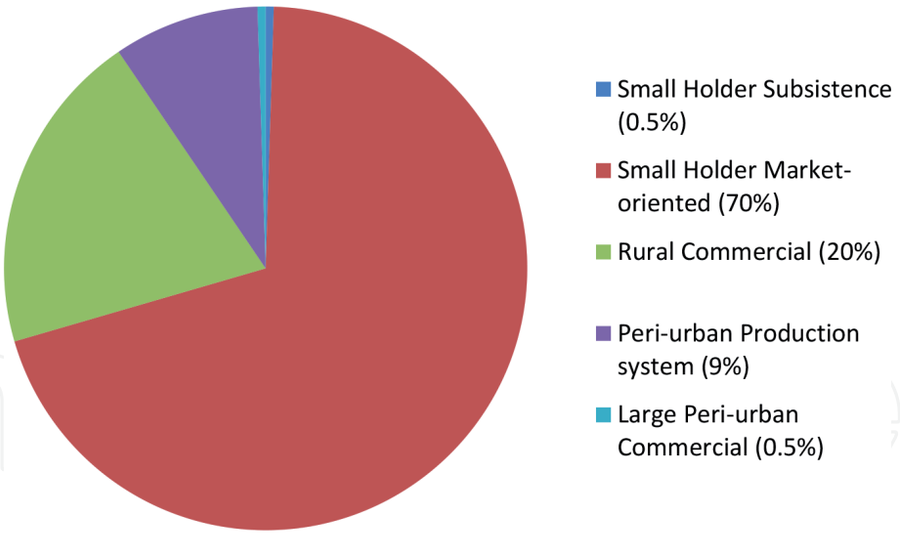

Figure 2.
Annual saleable milk production from various milk production systems in Pakistan in 2016, based on [6, 7] and the data provided by the sector.

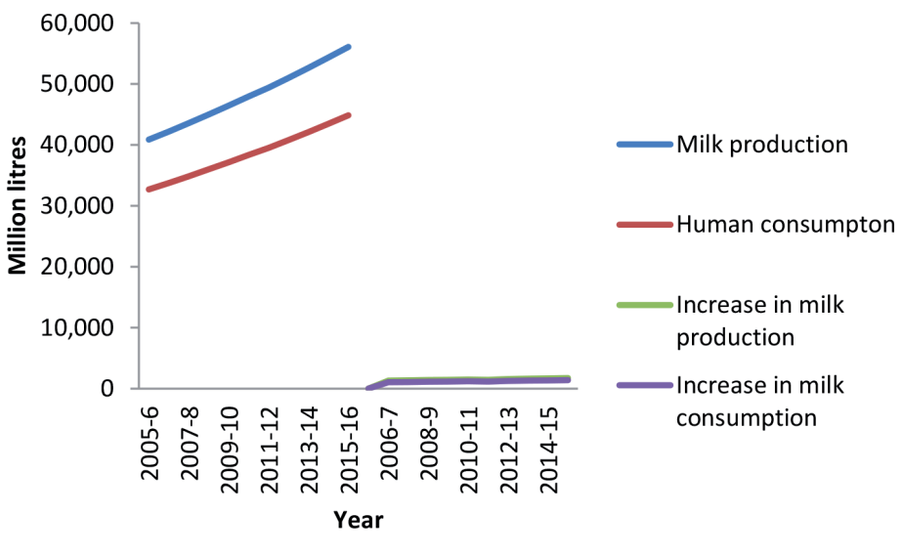

Figure 3.
Total milk production in the country and consumption by humans from 2006 to 2016. Source: Economic survey of Pakistan (2016–2017).

3. Population of major milk producing species of the animals

Pakistan has 44.4 million cattle and 37.7 million buffaloes, producing 20 and 34 billion L of milk, respectively [5]. The indigenous breeds of buffalo and cows are considered as poor producers with lactation yields of 1800 and 1195 L [8] that remained constant across years. The population of major milk producing animals is increasing at a constant rate of 3.3% per annum (**Figure 4**).

3.1 Buffaloes

Buffaloes are the major milk producing animals in Pakistan, representing about 46% of the total dairy herd and providing 62% of total milk production [5]. The three principal breeds are Nili, Ravi and Kundi. The Nili and Ravi breeds have originated from within a large tract evolved in between the great rivers of Ravi, Sutluj, and Chenab, indicating deltas of Nili- and Sandal-bars. Most famous cities of this tract are Faisalabad, Jhang, Lahore, Sahiwal, Okara, and Sheikupura. The Kundi

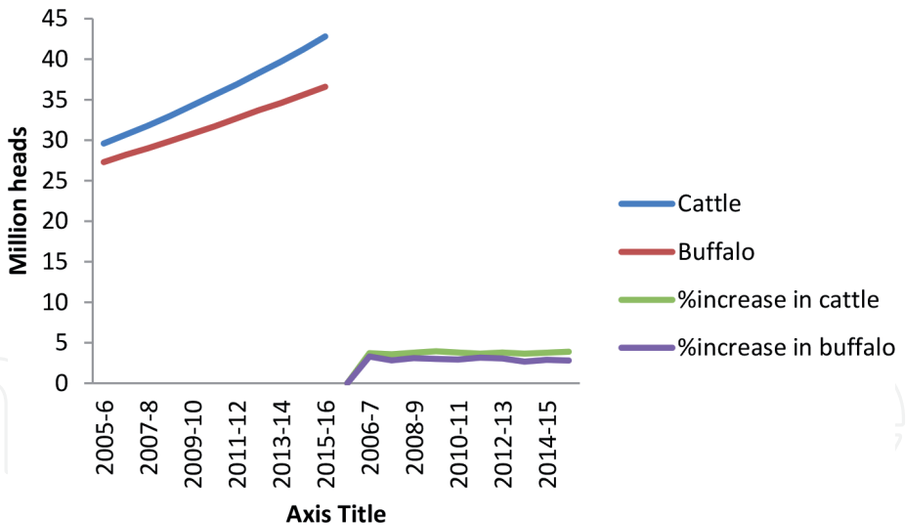

Figure 4.
Population dynamics of major milk producing species of large ruminants with percentage increase per year from 2006 to 2016. Source: Economic survey of Pakistan (2016–2017).

breed has been found all over Sindh province especially on the both side river Indus from Kashmore in the north to Shah Bandar in the south [9]. The Nili Ravi breed has evolved as a result of crossbreeding between the breeds: Nili and Ravi. The animals are massive and comparable to large imported breeds regarding feeding requirements. Their milk contains high contents of fat (**Table 1**; [10, 11]), which makes it possible to compare energy outputs in milk between buffalo and imported large dairy breeds of cows. There are currently breeding and performance evaluation programs established at various livestock research centers under the funding and supervision of the government, but farmers are largely excluded from the results of this research, thereby limiting its benefits. Buffalo farming at commercial levels is not common in the country because of less feed efficiency and other reproductive as well as managemental issues associated with the buffaloes. Therefore, the few set ups which were established in the past, e.g., Landhi Cattle Colony, Karachi and Fazal Dairy Farms, Muzaffargarh, are gradually shifting from buffalo to imported cattle.

3.2 Cattle

3.2.1 Indigenous dairy cattle

The cattle population is slightly larger than that of buffaloes, but cows produce on average only about 58% of the yield of buffaloes. All Pakistan's indigenous cattle

Parameters	Buffalo	Indigenous cow	Exotic cow (Holstein Friesian)
Total solids	15.6	12.1	12.2
Solids not fat	10.2	8.3	8.7
Fat	5.40	3.88	3.5
Crude protein	4.16	3.73	3.1
Lactose	5.30	3.84	4.9
Total ash	0.75	0.69	0.70

[1]*Jensen et al. [10] and Tahir et al. [11].*

Table 1.
Proximate parametric composition of raw milk from bubaline and bovine species.[1]

are Zebu (humped type, *Bos indicus*). There are 15 recognized breeds in the country, of which Red Sindhi and Sahiwal are well known internationally as tropical dairy cattle breeds. The home tract of Sahiwal cattle includes, Faisalabad, Jhang, Okara, and Sahiwal districts of central Punjab and Multan district of southern Punjab whereas that of Red Sindhi includes Dadu, Hyderabad, Karachi, and Thatta districts of province Sindh and Lasbela district of Baluchistan [9]. Cattle have traditionally been bred to produce bullocks for plowing and on-farm operations. Pure breeds account for 43% and nondescript for 44% [12].

3.2.2 Crossbred dairy cattle

A sizable population of cattle crossbreeds has recently emerged, and now represent 13% of Pakistan's total cattle population. Breeding policy allows the crossbreeding of nondescript cattle with Holstein, Friesian, and Jersey breeds, with the desired level of exotic inheritance being between 50 and 75%.

The productivity of dairy cattle crossbreeds is far higher than that of local nondescript or pure breeds, with longer lactation periods, higher milk production per lactation, and shorter calving intervals. These advantages make crossbred cattle highly preferred for intensive and semi-intensive dairy farming systems. Semen for crossbreeding programs is imported from countries such as the United States of America, the Netherlands, Germany, and Australia by private sector firms.

3.2.3 Imported dairy cattle

More recently, because of the involvement of private sector and policies made by the Government of Pakistan, Australian, Dutch, German and American Holstein Friesian and Holstein Friesian and Jersey crossbred cows have been imported and kept under specific management conditions by the commercial farmers. A sizeable (about 0.058 million heads to date) population of these elite cows is present in the country at large peri-urban dairy farms. These animals cost very high and require highly specific, most modern management and feeding practices and well-trained man power. These cattle represent less than 1% of total dairy animals and milk production (235 million L per annum to date) in the country (**Figure 5a** and **b**).

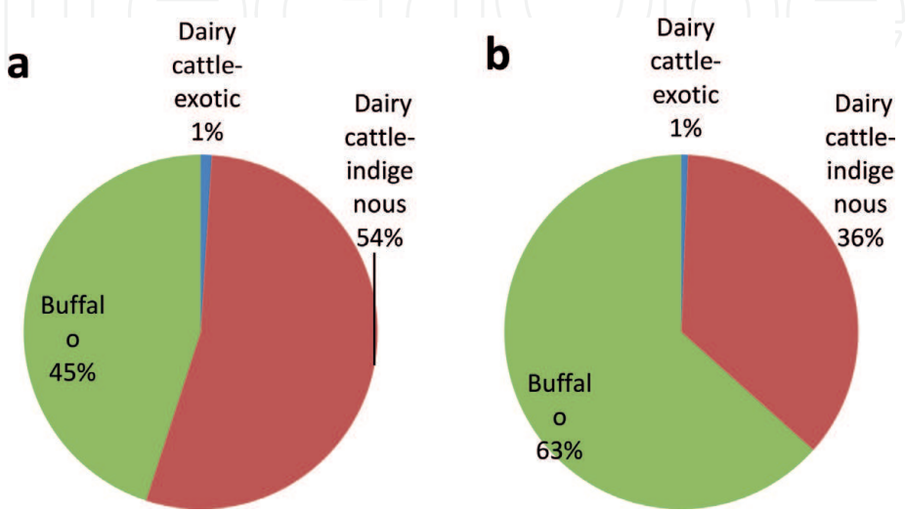

Figure 5.
Percentage contribution of imported dairy cattle in total population of large milk producing animals (a) and milk production (b), based on the data provided by the sector.

4. Safety of milk and dairy products

The demand for safe, high-quality foods with a long shelf-life is increasing day by day in the country. This reflects an improvement in the income as well as knowledge and awareness level of common masses. However, milk and milk products are biochemically unstable; i.e., they deteriorate very quickly and they accept foreign odors and materials very easily. Hence, maintaining the quality of milk poses a great challenge to the producers, collectors, and/or processors until it reached to the final destination. This is a fact that the dairy industry is highly unregulated in Pakistan, and the marketing chain is exclusively in the private sector. Generally, the milk is produced under compromised hygienic conditions that results in poor quality. Adulteration has been very common to increase milk volumes at farmer and intermediaries level in the past. The quality of milk is ensured by boiling at high temperatures during household consumption. Lack of hygiene, adulteration by various agents, and absence of a cold chain were identified as the primary contributors to low-quality milk in the past [2].

4.1 Measures being taken

Maintaining a high standard of hygiene is one of today's most important milk production objectives. The hygiene level directly influences the production's economical result, and dairies are enforcing this by steadily raising their quality requirements for raw milk. More importantly though, consumers are concerned about the safety of dairy products and the conditions under which these are produced. It is critically important to ensure the high quality at each step of this chain. It is, therefore, required that raw milk should be produced from healthy animals under good hygienic conditions and all control measures be applied from production to consumption to protect human health.

Several dairy development programs for the production, distribution, and processing of hygienic milk have been started during the last two decades at private sector. These programs seek to ensure the production of hygienic milk by providing farmer education, implementing strict quality tests, and establishing cold chain collection and supply systems.

4.1.1 Quality tests and hygienic measures

The corporate private sector has implemented various strategies to ensure milk quality and safety at collection. At the first place, various milk qualitative and quantitative tests at village (VMC) and regional milk collection centers (RMC) are performed. These include organoleptic, temperature, clot on boiling, fat%, solids not fat, total solids, and specific gravity. Tests for aflatoxins, antibiotics, and physiochemical characteristics are performed at RMC to ensure product processing quality and safety. A complete list of the tests performed at dairies is presented in **Table 2**.

At the second place during processing or intermediate steps, various systems for quality and safety management, e.g., ISO 9000, FSMS 22000, total quality management (TQM), hazard analysis and critical control point (HACCP), and many other ISO certificates are adopted [13].

4.1.2 Farmers' support

The large dairy organizations like Nestle and Engro have provided farmers with the dairy inputs that have facilitated enhance and good quality milk production. Nestlé Pakistan Ltd. through its Kisan Club (https://www.nestle.pk/asset-library/

Physical	Organoleptic	Chemical	Physiochemical	Ratios
Clot on boiling	Appearance	Acidity	Aflatoxin	Protein to SNF ratio
pH	Consistency	Ammonium sulfate	Antibiotics	Solids not fat
Specific gravity	Smell	Formalin	Alcohol precipitation test	
Temperature	Taste	Hydrogen	Butyro-refractometer value	
Total solids		Salt	Detergent	
		Sodium	Fat	
			Free sugars	
			Glucose	
			Methylene blue dye Reduction	
			Protein	
			Sorbitol	
			Starch	
			Total plate count	
			Urea	
			Whey protein	

[1]*Based on the data provided by the sector.*

Table 2.
List of physiochemical, chemical, and organoleptic tests performed at regional milk collection centers and processing plants in Pakistan.[1]

documents/financial_reports/csv_report_2016.pdf: accessed October 19, 2018) aimed for major improvements in dairy farm sustainability by helping farmers decrease farm input cost and increase productivity resulting in better economic returns. Kisan Club helps achieve that by providing access to subsidized farm supplies like chillers and farm machinery, financial support through milk advances, and bank loans and technical services about health, breeding, and management. The results of this project showed an increased hygienic milk production and ensured supply to the collectors.

4.1.3 Rewards and punishments

Many commercial milk collection organizations such as Engro Foods Ltd. and Nestle Pakistan Ltd. have adopted a reward and punishment system to ensure milk quality and wholesomeness. Engro Foods Ltd., for example, has adopted such a system, which is called as Incentive Systems, and they have introduced the following incentives:

1. Volume incentive will be paid to commercial dairy farmer (CDF; with 51–500 L/day milk production) and large farmers (LF; with more than 500 L/day) if either of these is supplying more than 51 L daily to the collection center. Different volume slabs per day above a minimum of 51 L/day corresponds to different incentives.

2. Loyalty incentive will be given @Rs. 1/L to either CDF or LF if he supplies milk to the company at least 28 days a month.

3. Total plate count (TPC) incentive will be given @Rs. 0.5/L to only CDF if his milk sample TPC falls under 200,000/mL of milk. The rate of this incentive is reduced to Rs. 0.2/L if TPC level falls between 200,000 and 300,000/mL of milk.

4.1.4 Establishment of cold chain

Under traditional system of milk collection and transportation, milk is transported over long distances, often in extreme weather conditions without cold storage facilities. Milk losses due to the lack of cold storage are estimated at about 15–20% of total milk production in some areas according to an Asian Development Bank report [14]. To minimize the effects of transportation on milk quality, the corporate private sector has maintained collection centers and established the cold chain.

4.2 Food safety legislation and regulation

Previously, food safety issues in Pakistan were dealt by the following laws [15]:

i. Pure Food Ordinance, 1960

ii. Pakistan Hotels and Restaurant Act, 1976

iii. Pakistan Standards and Quality Control Authority (PSQCA) Act, 1996.

These laws had the capacity to achieve at least a minimum level of food safety; however, they were very poorly enforced.

As presented earlier, use of growth promoters such as (Boostin®), milk let down facilitators (Oxytocin®), and addition of water to increase physical milk volumes have been very common among the suppliers other than supplying to the dairies.

However, these malpractices have been banned by law (Punjab Pure Food Act, 2011; accessed September 28, 2018) and declining by strict actions of Punjab Food Authority and quality control units of private sectors.

The Punjab Food Authority [16], formed under the Punjab Food Authority Act 2011 and the Pure Food Rules 2011, has been very active since its inception on July 2, 2012 in various districts of Punjab province. The authority aims to ensure food safety & quality in the entire food chain in collaboration with manufacturers, food business operators, consumers, government departments, autonomous bodies, and other stakeholders. The authority issues guideline for the stakeholders related to the food industry, regulates and monitors the food business and certifies food items to ensure compliance with the food standards [16]. The authority also arranges awareness programs and takes part in educating people related to food business. In recent years, remarkable improvements in the keeping quality of milk can be partially attributed to the role of PFA.

A brief overview of PFA is given in Annexure 1. The new regulations [16] and Punjab Pure Food Rules (Punjab Pure Food Act, 2011; accessed September 28, 2018) have clearly stated definitions of various food items including all forms of milk, and explicitly prohibit or limit the use of harmful preservatives, including bacteria inhibitors such as penicillin and formalin, and other substances such as urea, sugar, and glucose. The use of oxytocin or any growth promoters is also prohibited by law. These laws also obligate rules and regulations for dairy processing corporations to provide hygienic milk through regulated quality testing, packaging, storage, distribution, and recalling.

5. Environmental consequences of dairying

Livestock activities play a significant role in the maintenance of surrounding environment, including, air land, soil, and water. These may have direct impact on subsoil water, rivers, and lakes by adding solid waste and pollutants, which emits nutrients, organic matter, pathogens, and drug residues or indirect, in the form of competition for natural resources. Animals and their waste contribute to climate change by emitting greenhouse gases or by changing land use resulting from increased demand for feed grains and grazing. **Figure 6** shows a most recent estimate of greenhouse gas emissions from the livestock activities within agriculture sector of Pakistan.

5.1 Sources of environmental pollution

The production systems and large dairy facilities have been identified as the two major sources of environmental degradation in Pakistan's dairy sector [2].

5.1.1 Production systems

The data on the production systems indicate that there has been rapid growth in peri-urban and large peri-urban commercial dairy farming with intensive management conditions. This means that large numbers of animals are kept in small compounds. Under traditional management practices, the solid and liquid waste is often disposed of in major water bodies. Furthermore, the water used in farming operations is drained into main water resources. This not only contaminates public drinking water, but also leads to unchecked methane emissions. The second aspect of animal farming with respect to environmental consequences is the overgrazing and competition for food between animals and humans. The ever increasing livestock population [5] with poor level productivity poses serious threats on sustainability of range resources and cultivable lands for feed production [17].

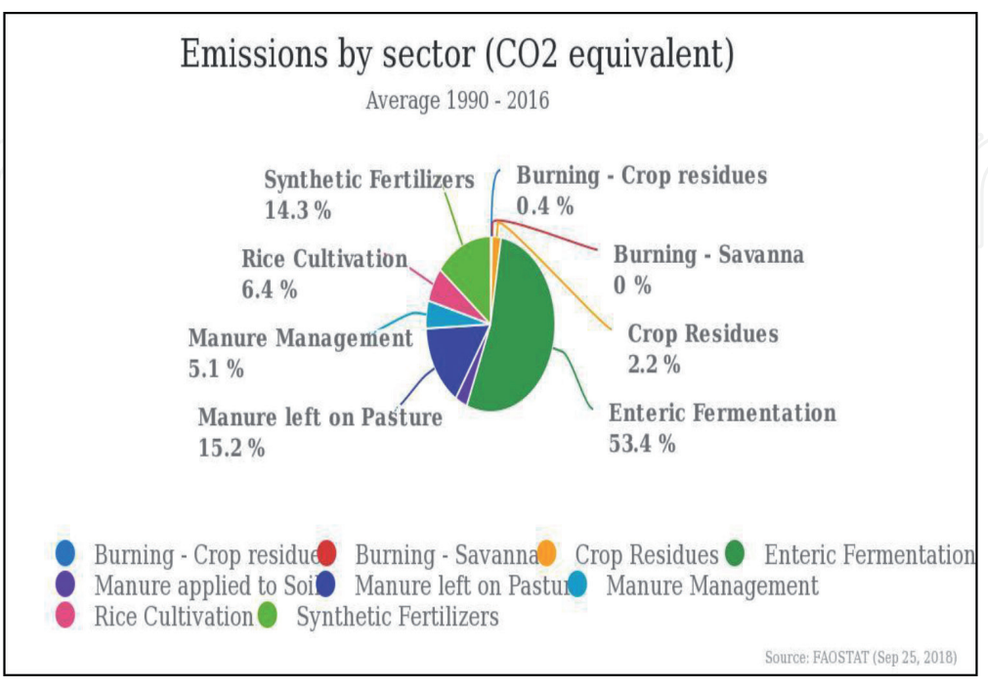

Figure 6.
Total greenhouse gas emissions from agriculture sector in Pakistan. Source: FAOSTAT 2018 (accessed: September 25, 2018).

5.1.2 Processing facilities

In the recent years, a sizeable number of milk processing plants is in operations. These plants pollute the surrounding environment and contribute to climate change by adding solid waste, liquid waste, soil pollution and noise, and air emissions. Of these, wastewater from washing and cleaning operations is the greatest pollutant, and is estimated to be between 5.5 and 30 cubic meter for every cubic meter of milk processed at a typical dairy unit [18, 19].

5.2 Awareness and understanding of environmental consequences

There is a lack of understanding for environmental consequences of livestock in developing countries and the situation in Pakistan is no different, as demonstrated by the Livestock Policy's (2007) failure to consider environment. Awareness and understanding of the environmental consequences of dairying are extremely limited in almost all sectors, especially the government sector and small-scale farming. The focus is on the more obvious contamination, such as flies and odor, rather than the serious threats of land degradation, water pollution, biodiversity erosion, and global climate change.

6. Improvements

Since last reviews in 2002 [1], 2011 [2], 2013 [20] and 2015 [21], various changes have been brought about in various subsectors of the dairy industry in Pakistan. Only significant improvements are being identified here and a summary is presented as Annexure 2.

Realizing the positive impact that development funding can have on raw milk production, the private sector has recently started to implement projects aiming at organizing farmers for milk collection and marketing, while providing them with information and access to market channels resulting in enhanced productivity. These projects, started under public-private partnership, reach large number of beneficiaries, and show relatively quick results. The rapidly increasing demand and high margins are additional driving forces behind private sector investments.

6.1 Enlargement of herds and import of high-quality milk germ plasm

To date, various companies are supplying elite class pedigreed dairy animals and high-quality semen imported from various countries including the United States of America, Australia, Germany, and the Netherlands. A total of about 0.058 million heads exotic dairy cattle have been imported during the last two decades and are being maintained at large peri-urban commercial dairy farms. These companies supply 3–7 months pregnant heifers with a farm gate price range of 2500–4700 US$ per imported animal (based on the data provided by the sector). The animals are usually ensured against any accidental injuries or death during the transportation and afterward. The semen doses from elite class pedigreed bulls are also available with a price range of 40–80 US$/dose.

6.2 Focus on improving the productivity per animal rather than improving their number

While looking at the statistical data for the last 10 years (2006–2016) or even before, it is clear that policy focus was mainly put on increasing the number of

animals per year rather than on increasing the productivity per animal (**Figure 4**). This indicates that any improvements in raw milk production are mainly caused by increase in number of animals every year. As presented previously, the indigenous dairy animals are characterized as poor producers with low daily milk yields (4.78 vs. 6.0 L), lactation yields (1195 vs. 1800 L), and less days in milk (250 vs. 300) [8, 11]. With the introduction of crossbreeding, daily milk, and lactation yields are far better now (12 and 3600 L, respectively) with compromised milk fat content (6 vs. 3.6% for buffaloes and crossbred cattle, respectively) under rural commercial and peri-urban dairy farming. This provides some evidence that there has been improved productivity per animal; however, crossbred cattle represent a small proportion of total population [7, 12].

6.3 Improvements in milk collection, processing, and marketing

In the past 10 years (2006–2016), the private sector dairy organizations namely Engro Foods Ltd./Frieslandcampina & Nestle Pakistan Ltd. played a vital role in milk collection and marketing. They mainly aimed at getting high-quality, safe, and secure milk. To ensure this, they have installed milk chillers at village level so that milk can be preserved safely on immediate basis after collection from individual farmers and maintained a cold supply chain, thus, providing with means for securing quality and wholesomeness of the product and successful marketing at the doorsteps of the farmers. According to a recent update, Nestle Pakistan Ltd. has installed about 2100, Engro Foods Ltd. installed 1250, whereas Nurpur installed 300 chillers with about 500 chillers installed by other dairy companies. **Figure 7** shows trends in milk collection by private dairy sector (both traditional and commercial) in two base years of 2006 and 2016.

Similarly, there has been a significant increase in the processing capacity of various dairies during this period of 10 years (2006–2016). **Figure 8** shows that the total processing capacity for pasteurized and ultrahigh-treated fluid milk and milk products from all dairy processing was estimated to be 32 million L/year in 2006 [2], which reached to a corresponding value of 2326 million L/year in 2016. Some recent figures indicate that a total of about 15 dairy processing plants are functional in the

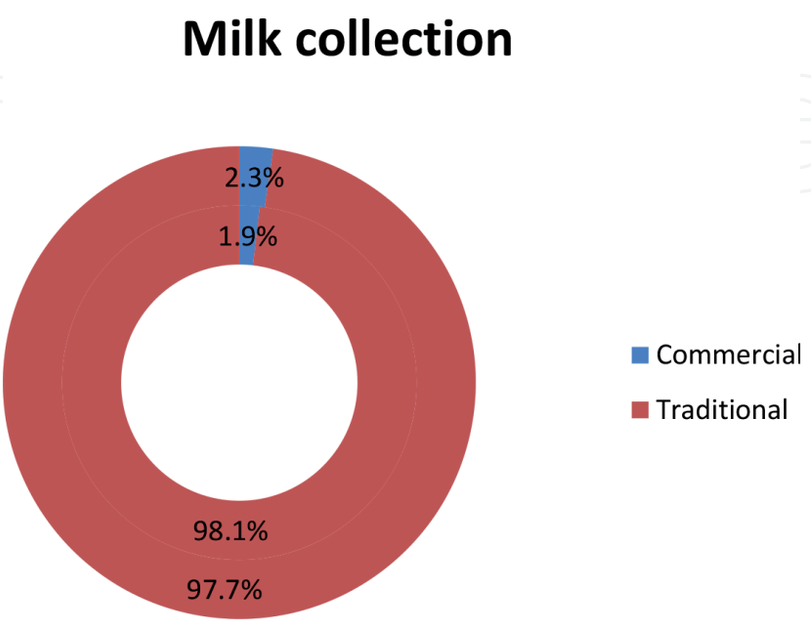

Figure 7.
Milk collection by traditional and commercial methods in two base years (2006 inner circle and 2016 outer circle). Based on data provided by the sector.

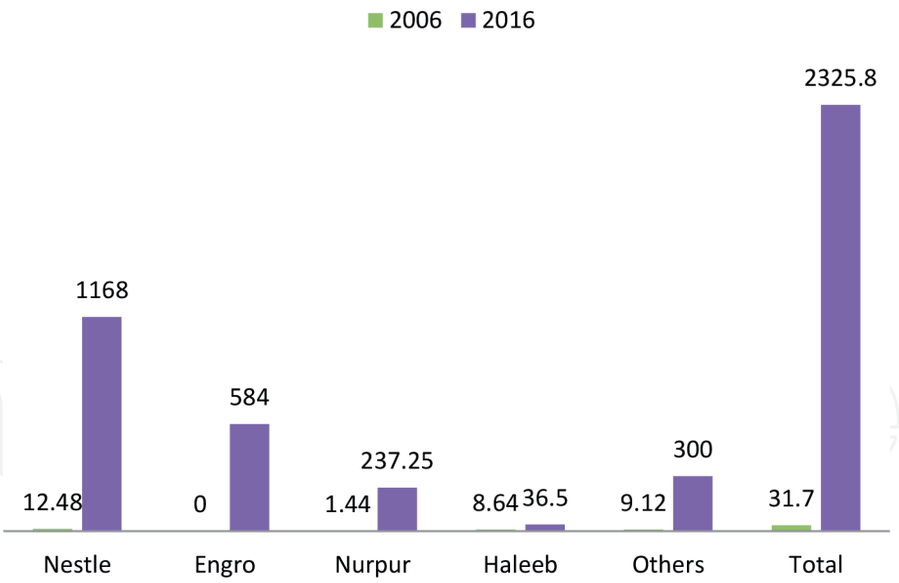

Figure 8.
Milk processing (fluid milk and dairy products) by large dairies in two base years (2006 and 2016), based on [2] and the data provided by the sector.

country with varying capacity for product volume and assortment. Three big dairy companies, e.g., Nestle Pakistan Ltd., Engro Foods Ltd., and Nurpur Ltd. occupying the first, second, and third position, are processing about 1168, 584, and 237 million L/year, respectively. In addition to the fluid milk collected from inside the country, a large amount of dry milk is also imported. The large differences between collection and processing of fluid milk by dairies are explained through the import of dry milk, which had an estimated amount of 284 million L/year during 2016–2017. The dry milk is used after reconstitution for various purposes, during flush and lean periods.

6.4 Improvements in the supply of dairy inputs

As the trend from traditional to commercial dairy farming is gaining fame and acceptance among the farmers and corporate stake holders, the demand for dairy inputs is on an increase on daily or monthly basis. These inputs range from seed stock dairy animals, modern dairy housing fixtures and equipment, commercial feeds including concentrate, silage and hay to medicine, vaccines, and semen. A significant number of multinational and local companies to supply dairy inputs has emerged in the recent past and continues to grow in the future. These firms are mostly located in Lahore or Karachi, and the surrounding of these cities are known as the hubs for peri-urban and large peri-urban dairy farming.

6.4.1 Establishment of commercial feed units and silage making

Little is known about the actual number of commercial feed units supplying concentrate, hay, or silage in 2006, as there number was so small to be included in the counting. Importantly, Ghazi Brothers and ICI, Pakistan are considered as two main companies who started their sale operations of animals inputs of medicine and supplements as early as 2000s. Then, the era came when more players started their business for supplying complete range of animal farming inputs. These companies were either sister companies of some most famous brands or were off-shoots of some international groups (Bovitech®). The animal inputs of feeding (commercial concentrate, bailed hay and silage, vitamin and mineral premixes, and growth promoters), treatment (de-wormers, vaccines, and medicines), and reproductive management are examples of year-round supplies by these companies (based on data provided by the sector).

6.4.2 Ensured supply of dairy farm machinery

The most updated dairy farm machinery and equipment are available in the country now. Many commercial companies are either preparing the required equipment at local market level or import from abroad. These companies not only provide inputs but also services and consultancy. The important farm machinery and farm structures may include, but not limited to, dairy sheds and layouts, milking machines, lines and parlors, milk chillers and utensils, forage harvesters, choppers and inoculants mixtures, and hay and silage bailers (based on the data provided by the sector).

6.5 Farmers' education on modern management practices

As mentioned earlier, several farmers education programs related to dairy farming are in place now. In the recent past, Engro Foods Ltd. started and completed a large farmers and extension worker training program titled "Big Push," in which they trained a total of 12,000 Basic Livestock Workers for basic dairy farming, keeping in hygienic, and clean milk production (http://www.engrofoods.com/bigpush.html: accessed October 15, 2018). Among those trained, 750 persons got special training as livestock extension workers (LEW), artificial insemination technicians, and farm supervisors and village milk collectors. This program was completed in collaboration with Punjab Skills Development Foundation during a period of one and half year (February, 2017–June, 2018).

Similarly, Nestle Pakistan Ltd. has taken several initiatives to rural development by taking several steps to increase the knowledge and skill level of farmers for enhanced and good quality milk production and quality of life (https://www.nestle.pk/asset-library/documents/financial_reports/csv_report_2016.pdf: accessed October 19, 2018). The company's initiatives positively impacted the lives of small dairy farmers by imparting training to around 77,000 farmers through farmer help camps. Nestle, through its famous Dairy and Rural Development Foundation (DRDF) trained 48,600 dairy farmers and 500 commercial farmers and farm managers on best dairy farm management practices, trained and established 2450 AITs, trained and established 7000 Women LEWs as entrepreneurs serving farmers in 10,000 villages in South Punjab. They started a street theater and mass awareness campaign, which reached approximately 3 million dairy households to increase knowledge of best dairy farm practices. They upgraded 118 local farms to model farms to meet rural communities' requirements and now serving as service and supply hubs for small farmers.

7. Future challenges

Conclusively, the dairy sector is performing at some sustainable level to meet the food requirements of the growing population and helping save a handful of foreign exchange to be expended on the import of milk and milk products, yet some challenges facing the industry in the near future need to be addressed.

7.1 Replacements considerations of high genetic potential dairy animals

Dairy heifer replacement raises significant attention among the stakeholders, and this issue should be taken as challenge if we want to keep the pace of commercial dairy farming. To the present day, in the absence of specific breeding plans adopted, the corporate and mega farms established in various parts of the country are importing their seed stock from various technological advanced countries. The first seed

stock has completed their productive life or near to completion at many of these farms. To maintain the commercial activity and profitability, the older and spent seed stock needs to be replaced with the younger ones of same genetic potential for milk.

Import of dairy animals every time from the exporting countries requires high input costs and extensive paper work. It is also an indicator of poor sustainability of farm economics. Furthermore, many political situations around the globe may delay or cut off the supplies of these important dairy inputs. It is, therefore, required that the replacement stock should be raised locally. However, the production of high genetic potential heifers at low costs is challenging and requires huge resources to be spared for research and propagation of research outcomes.

7.2 Considerations for β-casein proteins

Among the milk protein, the casein constitute 80% and the whey proteins constitute the rest. There are several types of casein in milk, and β-casein is the second most common. β-casein exists in at least 13 different forms [22]. Two major forms of β-casein protein exist in the form of A1 and A2. A2 is the original β-casein protein in all dairy animals. Breeds like the Holstein, Friesian, Ayrshire, and British Shorthorn that originated in northern Europe produce milk that is generally high in A1 β-casein. Other breeds that originated in the Channel Islands and Southern France, and the rest of the world (*Bos indicus*) produce milk that is high in A2 β-casein. This includes breeds like the Guernsey, Jersey, Charolais, and Limousin in Europe and Sahiwal, Red-Sindhi, etc. in subcontinent [23].

Several health hazards are associated with β-casein A1 type protein. During processing and digestion of milk, several peptides are released due to enzymatic cleavage and have various beneficial effects on the body. These peptides are called bioactive peptides. Bioactive peptides vary due to the genetic polymorphism for β-casein protein. β-Casomorphin7 (BCM7), having opioid like properties, can be released easily from A1 type β-casein [24, 25]. BCM7 has potential negative effect on the opioid receptors of nervous system, endocrine system, and immune system of the human body. BCM7 is associated with diabetes type 1, coronary heart disease, Autism, schizophrenia, and sudden infant death syndrome [26–29]. However, Truswell [23] in his review on the A1 and A2 hypothesis, negated any association between the A1 type β-casein protein in milk and mentioned health issues.

A1 and A2 debate is still an open challenge to the dairy industry and for human health. Several techniques are available to quantify the A1 and A2 in individual milk, bulk milk, dairy products, and different breed milk. More precise and accurate research on the association of the A1 with different diseases and syndromes, and their tolerance levels adjustments is needed. The research should expand to include the milk from other species of the animals too. If the scientific studies rule out hazardous effects of A1 β-casein on the human health, a great shift in the current dairy farming practices is expected in the country and the world afterward.

7.3 Presence of antibiotics and aflatoxins

7.3.1 Antibiotics

Presence of antibiotics in milk is a worldwide issue. In countries like Pakistan with poor hygienic conditions, prevalence of various diseases is common. Antibiotic residues are regarded as the unacceptable antibiotic levels or their active metabolites in tissues or products from the treated animals. Over the last few decades, antibiotics residues and antibiotic resistance are posing the biggest challenge to the public health. The potential hazards of antibiotic residues can be classified as: those who

directly affect human health by consuming animal products (cause allergic reaction to the sensitive persons, ototoxicity, carcinogenicity, reproductive effects, and teratogenicity), those which are excreted in animal feces and urine and pollute water and other land resources, and those which hinder the process of culturing during the production of dairy products.

In order to minimize the residues of the antibiotics in the milk, multiple international agencies like FAO, WHO, CAC, and EEC are working and they have set the standard maximum residual levels (MRLS) for animals and their products. Products containing residues more than these levels are considered illegal. Several awareness programs should be addressed at the public level to minimize antibiotic residue. These may include: improved hygienic management practices at farm, minimum use of antibiotics after the laboratory procedures and sufficient withdrawal period, grading of milk according to the presence of antibiotic residues, and rejection of milk with unacceptable antibiotics levels.

7.3.2 Mycotoxins

Mycotoxins have a great range of the diversity, but aflatoxin (AF) is the abundant toxic compound found in various food and feeds. Aflatoxins are the dangerous toxic chemical compound produced by the *Aspergillus spp*. of fungi predominantly *A. flavus* and *A. parasiticus*. The aflatoxin problem is worldwide even in the temperate zones where the temperature, humidity, and harvesting conditions favor the growth of this fungus. More than 20 different AF derivatives like B1, B2, G1, G2, M1, etc. are identified as the dominating derivatives. AF after ingestion or after entry through skin disseminate within the body and have serious health hazards like carcinogenicity, mutagenicity, retarded growth, impaired liver functions, and allergic reactions [30]. The public health problems depend upon the severity of exposure, duration of exposure and type of AF exposure, and on the basis of this, aflatoxicosis is considered as acute and chronic.

Large number of fatalities occurs due to acute aflatoxicosis, but due to chronic exposure, most of the animals and humans got infected. Annually, 4.5 billion of human population is presented to the chronic exposure of AF [30] causing immune suppression, decreased food intake, susceptibility to the other infections like plasmodium and HIV, and reduced production.

Aflatoxin M1 (AFM1) is the major (about 95%) excreted AF metabolite in the milk and is related to severe health issues. Trace amounts of AFM2, AFL, AFM4, and AFQ1 are also detected in milk but have less public health importance [31]. Long-term feeding of AFB1-contaminated feed results in the appearance of AFM1 in the milk [32]. Studies suggest that the highly producing animals secrete more AFM1 in milk due to the more consumption of highly concentrated feed. Rate of carryover of AFM1 in the milk from the dairy cows ranges from 0.3 to 6.5% [33].

There is no standard procedure to control carryover of AFB1 from feed to the AFM1 in the milk. However, numerous strategies have been described [34–37] and they are listed as follows:

- Pasteurization decreases 7.62% of AFM1 from the milk
- Milk concentration can reduce AFM1 by a factor of 60–70%
- Development of proper standards and rules for AFS
- Interaction with the international organizations like FAO and WHO for the adoption of standardization

- Setting a standardized upper limit of the AF in food chain
- Development of precise, specific, and economical innovative technologies for the detection of multiple AF in the feed, milk, and milk products
- Development of resistant plants to the fungus growth.
- Development of the breeds that have the genetic resistance to that biotransformation from AFB1 to AFM1 in the milk
- Research on gene regulation of mycotoxin producing organisms.

7.4 Considerations for competitive operational costs

The current day dairy operations like starting the enterprise, feeding the animals, maintaining a high level of hygiene and cleanliness at farm, and disposal of milk are performed at relatively high costs because of high costs of various dairy input (elite dairy animals, feed ingredients, preventive medication, electricity bills, etc.). These high costs directly control the product price and reduce the profit margins, and are variable among different systems of milk production. As per estimates of collected data from farmers maintaining herds in different production systems, the farm-gate price for 1 kg milk production of cows ranges from 42 (rural subsistence and rural market oriented) to 52 PKR (all other cow milk production systems; the prices are usually discounted for dairy organizations as a reward of the dairy inputs provided by them to the farmers) and that of buffaloes ranges from 55 to 65 PKR. These prices are relatively higher than those incurred in the more developed countries of the world. This situation prevents the investors to invest in the dairy business and causes the import of milk and milk products to fulfill country's requirements of milk. It is, therefore, suggested that farmers should be encouraged to produce milk at relatively low prices to make dairy sector of Pakistan to be more competitive with rest of the world. It is further suggested that a system for price determination of per kg milk production based on differences arising from species and system of milk production to propagate buffalo dairy farming and reduce malpractices in milk marketing may be introduced.

7.5 Research

7.5.1 To save environment and water resources

Pakistan has been included among the countries to face severe shortage of clean and hygiene water in the near future. The underground water table is getting deeper, and the available surface water is facing a merciless run-off. As discussed earlier, milk production and processing activities require large quantities of clean and hygienic water. No resources are committed to research on and discussion of the environmental effects of the dairy sector either by private or public sector, although there has been some recent interest in the development of treatment plants of wastewater and biogas by the private dairy organizations [19]. Therefore, sincere efforts are required with focused strategies to: (1) accurately estimate the current emissions of greenhouse gases and waste water from the agricultural sector, especially livestock and (2) mitigate these emissions through available resources.

8. Conclusions

The dairy industry in Pakistan represents smallholding with subsistence- or market-oriented farming followed by peri-urban or commercial-level farming. Historically, dairy sector has been owned and managed by the private sector. The population of dairy animals as well as milk production from these animals is increasing at a constant steady rate every year. The per animal productivity of the local dairy cows and buffaloes remained the same over the years; however, crossbreeding and import of elite dairy cows tended to increase in pursuance of increased productivity per animal. During the past two decades, various changes have been brought about in various subsectors as a result of new initiatives taken by the corporate private sector. These efforts have resulted in enlargement in the size of dairy units, improvements in milk collection, processing and marketing, increased supply of dairy inputs (machinery, equipment, feeds, semen, and elite dairy animals), and enhanced farmers knowledge and skills on modern management practices.

Conclusively, the dairy sector is performing at some sustainable level to meet the food requirements of the growing population. Yet, challenges like local replacements of high genetic potential dairy animals, health hazards of β-casein proteins, antibiotics and aflatoxins, and uneconomical operational costs facing the dairy industry in the near future need to be addressed.

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Conflict of interest

No conflict of interest is declared.

1	Punjab Food Authority regulates and monitors the food business in order to ensure compliance by farmers, manufacturers, distributors, importers, and other stake holders in order to provide safe food
2	Formulate standards, procedures, processes, and guidelines in relation to any aspect of food including food business, food labeling, food additive, and specify appropriate enforcement systems
3	Enforcement of food safety and quality standards
4	Specify procedures and guidelines for setting up and up-gradation of food laboratories
5	Specify licensing, prohibition orders, recall procedures, improvement notices, and prosecution in the court of law
6	Provides scientific advice and technical support to the government in matters relating to food safety
7	Establishment of food laboratories
8	Organize training program in food safety and standards
9	Promote general awareness regarding food safety and standards

10	Certify food products/items for export
11	Forward and backward traceability of food items
12	Surveillance including collection, integration, analysis, interpretation, and dissemination of data related to food and nutrient intakes

[1]*Punjab Pure Food Rules (2011).*

Annexure 1.
Responsibilities of Punjab Food Authority, 2011.[1]

1	Milk procurement markets in remote areas with heavy investments
2	Clear milk purchasing norms (introduced 13 total solids system, previously people were purchasing milk at fat/gross system only)
3	Quality norms, 28 tests have been introduced to market
4	Cold chain in the milk value chain
5	Efficient mode of payment (milk automation networking, weekly payment system through banks to make the payment structure safe)
6	Introduced exotic breeds—proved to be a turning point in dairy farm developments and in farm mechanization
7	Encouraged, motivated farmers and investors to invest in dairy farming
8	Made demonstration farms
9	Provide free veterinary & agricultural services
10	Offered premium incentives for farm development and milk quality
11	Encourage financial institutions to extend loans for dairy farming
12	Brought global expertise and resources of dairy farming in Pakistan
13	Attract Foreign aid and developed entrepreneurships among small livestock holder through trainings & workshops
14	Developed institutes like DRDF to develop AIT/livestock extension workers to help the dairy farmers
15	Offered incentives to commercial dairy farmers to produce aflatoxin, antibiotic-free healthy milk
16	Offered low-interest loans to newly developed farmers by involving different banks like Alfalah, JS Bank
17	Aflatoxin-free feed has been introduced by involving the investors
18	Low cost feed pattern has been introduced like beet pulp feeding and sugarcane mud in the areas where animals were facing feed deficiency due to less resources of dairy farmers
19	Provision of hybrid fodder seed to farmers at relatively low price to tackle the feed shortage during lean months

[1]*Based on data provided by the sector.*

Annexure 2.
A summary of dairy initiatives taken by private dairy sector in collaboration with public sector partners.[1]

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