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Awareness and Practices among Dairy Producers and Consumers in Sri Lanka

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Notices

Contents

Tables

Figures

Abstract

Provision of food safety requires not only regulation but also a demand pull where value chain participants demand food safety or are able to play their role in providing safe food. In both cases, producer, and consumer awareness about requirements for food safety is a precondition for delivery of food safety. In this paper, focusing on dairy in Sri Lanka, we assess the awareness and choice of practices by producers and consumers towards food safety. Sri Lanka has unique features in the dairy sector, with very high import penetration and form of consumption, i.e., powdered milk, that actuates formalization.

Looking at different segments of the population, including rural, urban and estate, and different management systems, the evidence suggests only a moderate level of food safety awareness in dairy in middle-income consumers in Sri Lanka. Considering the differences across systems, the degree of adoption of food safety is lowest among farmers in the extensive system, while it is highest among farmers in the intensive system. However, in terms of choice between powdered and fresh milk, food safety consciousness is one of the most significant determinants where fresh milk is considered comparatively unsafe.

Even when food safety issues arose in powdered milk, only small adjustments occurred in consumption, both because the health effects were limited, and the choice sets were circumscribed by the number of brands across which some consumers switched following the food safety scare. In the push toward promotion of fresh milk consumption, ensuring food safety and convincing consumers about merits of fresh milk would be required in Sri Lanka beyond the preference change from well-established powdered milk consumption.

Keywords: Food safety, Sri Lanka, Dairy, consumer practices, intensive, semi-intensive, extensive system, melamine

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Acronyms

AHP	Analytical Hierarchy Process
AI	Artificial Insemination
DAPH	Department of Animal Production and Health, Sri Lanka
DCD	Dicyandiamide
FMS	Farmer Managed Societies
FSI:	Food Safety Index
HACCP	Hazard Analysis Critical Control Point
HIES	Household Income and Expenditure Survey
ISO	International Organization for Standardization
ITI	Industrial Technology Institute
MADM	Multi-Attribute Decision Making
NLDB	National Livestock Development Board
SLSI	Sri Lanka Standards Institution
WHO	World Health Organisation

I. Introduction

Food safety, or the absence of foodborne hazards at the point of consumption, is technically defined as the probability of not suffering hazards from consuming the food in question (Henson and Traill 1993). Food safety hazards are not only a public health issue, they also affect the growth and functions of domestic food markets and income and employment opportunities (Grace, and McDermott, 2014; Jaffee *et al*, 2018). Besides the social and economic importance of food safety and the regulations to ensure it, one in ten people still fall ill every year due to foodborne diseases, and 420,000 died in 2010 (WHO, 2015).

Animal source foods were estimated to account for a considerably high share of the burden of foodborne diseases in many countries (Jaffee *et al*, 2018). Being nutrient-dense, dairy products are subjected to different potential safety threats, such as microbial contamination, chemical adulteration, physical contaminations, and zoonotic diseases. Due to their very nature, milk products are extremely susceptible to microbial contaminations. Raw milk and other dairy products can be contaminated with microbes through improper handling, storing, or transporting.

However, it is not only through handling, storing, or transporting that these products can be contaminated, but also by bacterial infections of animals; raw milk obtained from animals also can be contaminated with harmful bacteria which can pose health risks to humans (Angulo, *et al*, 2009). Some of these microbes are Brucella, Campylobacter, Cryptosporidium, E. coli, Listeria, and Salmonella. Some of these microbes can spread zoonotic diseases to humans thereby posing a health risk to humans. Examples include Brucellosis, Salmonellosis and Tuberculosis.

Chemical contaminants of milk include pesticide residue, which comes along with feeding materials, and antibiotic residues (Girma, *et al* 2014). Since crop residues treated with agrochemicals are fed to animals in addition to fodder, there is a possibility that these chemicals enter animals and remain in milk. Similarly, as revealed by some recent food scandals, milk is often subject to some deliberate chemical contamination, as well. One example is the melamine scandal in China where melamine was added to increase the nitrogen content in milk (to appear as protein-rich) to secure a higher price (Grace, and McDermott, 2014).

Milk can also be contaminated with foreign materials, such as faecal material due to unhygienic milking, inappropriate storage, or an inability to maintain a hygienic environment, i.e., free from dust, bedding materials, dung, and insects. However, physical contaminants are less likely to cause damage to many individuals (Valeeva *et al*, 2005) and hence may be of a lower concern to policymakers.

Even though milk is prone to many contaminants and adulterants, most problems in milk can be prevented, controlled, and managed through proper production, handling, storing distribution, and preparation (Ruegg, 2003; Unusan, 2007, Jaffee et al, 2018). Hygienic milking practices, use of clean utensils, caring for animal health, maintaining a hygienic environment, and following recommended practices for storage and transport can reduce the probability of contaminations along the supply chain.

Proper storage, handling, and processing (e.g., pasteurization) can mitigate contamination at the processer level. Consumers can also reduce the risk of food hazards by employing practices such as boiling raw milk before consuming it and refrigerating dairy products (Agarwal, et al, 2012). In a nutshell, the safety of food can be attained by coordinated actions of the value chain actors. However, the extent to which this shared responsibility has been understood and people have been accountable for their actions is in question. Regulation *per se* may not guarantee adoption of safer practices by actors along the supply chain.

To create an effective system, regulations should be combined with voluntary actions of value chain actors, including consumers. The main hindrance to self-regulation leading to voluntary action to deliver on food safety is often lack of information and awareness, lack of resource endowment to implement mitigation strategies and lack of incentives. More specifically, adequate information and resources incentivize value chain actors to comply voluntarily with food safety practices (Bruhn and Schutz, 1999; Unusan, 2007).

From the consumer's perspective, attitudes, and awareness of food safety not only incentivizes them to adopt safe consumption patterns, but also helps in creating a demand-pull for safer food in the market. Hence, public policies need to be complemented with other non-policy efforts to alter the behavior of food chain actors toward ensuring food safety in milk by bridging the gap in knowledge and awareness of food chain actors to develop safe milk production systems. Only by bridging this gap will a comparatively more favorable attitude among the value chain actors be created, leading to greater demand and supply for safer food (Nesbitt, *et al*, 2014; WHO, 2015).

Demand for safe and quality dairy products in Sri Lanka has been driven primarily by historically high incidences of foodborne diseases. This was accentuated by the 2013 controversy involving imported powdered milk contaminated with Dicyandiamide (DCD) i.e., the melamine constitution in milk. Moreover, there have been recent allegations related to the presence of adulterants such as lard and palm oil in milk powder, and the presence of agrochemicals and crop residues in animal feed.

With this landscape of food safety in dairy in Sri Lanka, it is pertinent to gauge the awareness of dairy value chain actors in Sri Lanka if adequate demand-pull for the provision of food safety were present. In this study, we look at the two end nodes of the dairy value chain, i.e., the dairy producers and consumers, in terms of their knowledge, awareness and attitude regarding food safety and their behavioral responses in terms of risk mitigation practices. The study also assesses the level of compliance with food safety practices by producers in Sri Lanka and the determinants of the level of farmer compliance with food safety practices.

To the best of our knowledge, this is the first systematic study conducted in Sri Lanka to understand the knowledge and attitudes of consumers and producers about food safety in the dairy sector, and the degree of adoption of practices among farmers and consumers leading to the adoption of risk-minimizing dairy production and handling behaviors.

The paper is organized as follows. Section 2 provides an overview of the dairy sector in Sri Lanka, including the production and consumption of milk products and legislation to assure food safety. Following this, Section 3 and Section 4 provide details on the sampling strategy, details about the primary survey, the survey instruments used for data collection, and the method of analysis of the study. The results of the primary surveys carried out are reported and discussed in Sections 5 and 6 while the report concludes with Section 7, which carries the recommendation from the study.

II. Production and consumption of dairy products in Sri Lanka

2.1. Milk production in Sri Lanka

Cattle rearing has historically played a significant role in rural subsistence agriculture in Sri Lanka. However, the purpose and method of rearing has changed over the years. In earlier times, cattle were reared to get draft power for agricultural activities and to fulfil milk and meat requirements, but with the arrival of Europeans, cattle milk became popular, and cattle rearing was organized into an industry where the primary purpose became the production of milk and meat (Abeygunawardena, *et al*, 1997).

In 2019, the industry produced 356 million litres of milk with a cattle population of 1,527,649 (DAPH, 2020). However, this satisfies only about 42 percent of the domestic requirement, the rest being supplied by imports. To reduce this demand-supply gap through local milk production, successive governments have implemented many programs and projects. These initiatives were targeted at increasing milk productivity by upgrading native herds, providing financial and technical assistance, promoting liquid milk consumption, introducing a guaranteed price for fresh milk, and improving the infrastructure of the milk supply chain. The Artificial Insemination (AI) heifer calf rearing scheme was started in 1993 to reduce calf mortality (Nettisinghe, et al, 2004).

A dairy village development project, a liquid milk promotion program (Bandara, 2000), and a program that promoted private breeding farms were some of the other projects implemented in Sri Lanka. One such recent initiative promotes medium- and large-scale dairy farms by distributing imported dairy animals at a subsidized price and provides a credit subsidy to meet start-up costs (National Livestock Development Board, 2000).

In terms of the regional variation in the distribution of the cattle population and milk production, the highest population of cattle was recorded in Northern Province, though their contribution to total milk production is less than the contribution from Central Province (*Table 1*). The difference can be attributed to the purpose of rearing cattle and the cattle rearing system. In Central Province, cattle are reared under semi-intensive or intensive systems to obtain milk. In the Northern Province, cattle rearing is mainly practiced under an extensive rearing system as way of finding draft power.

Table 1: Distribution of cattle population and milk production, milk collection and number of chilling centres in each district in Sri Lanka, 2017

Province	Milk cattle population	Total Production (million liters)	Milk collection (million liters)	Share of milk collection	Number of chilling centers
Western	24,640	28	12	43	19
Central	37,890	111	89	80	55
Southern	25,880	49	18	37	8
Northern	88,743	44	23	52	9
Eastern	86,621	62	23	37	40
North Western	53,689	83	54	65	32
North Central	46,688	54	48	89	19
Uva	25,781	42	16	38	29
Sabaragamuwa	8,676	9	2.4	27	4
Sri Lanka	398,608	483	285	59	284

Source: Department of Animal Production and Health, Sri Lanka (DAPH), 2017

In terms of the marketing of milk, 59 percent of the milk produced in Sri Lanka enters the formal market, which comprised large-scale public and private enterprises and small-scale private milk processors. The share of milk production which comes to formal markets also varies significantly across provinces (*Table 1*). While around 89 percent of production in North Central province comes to the formal market, only 37 percent of production comes to the formal market in Southern province (DAPH, 2017). In areas where the formal milk market is not well-developed, a large portion of milk is sold informally to hotels, restaurants, eateries, and neighbours (DAPH, 2013). Almost all the milk entering the formal market is processed into different products.

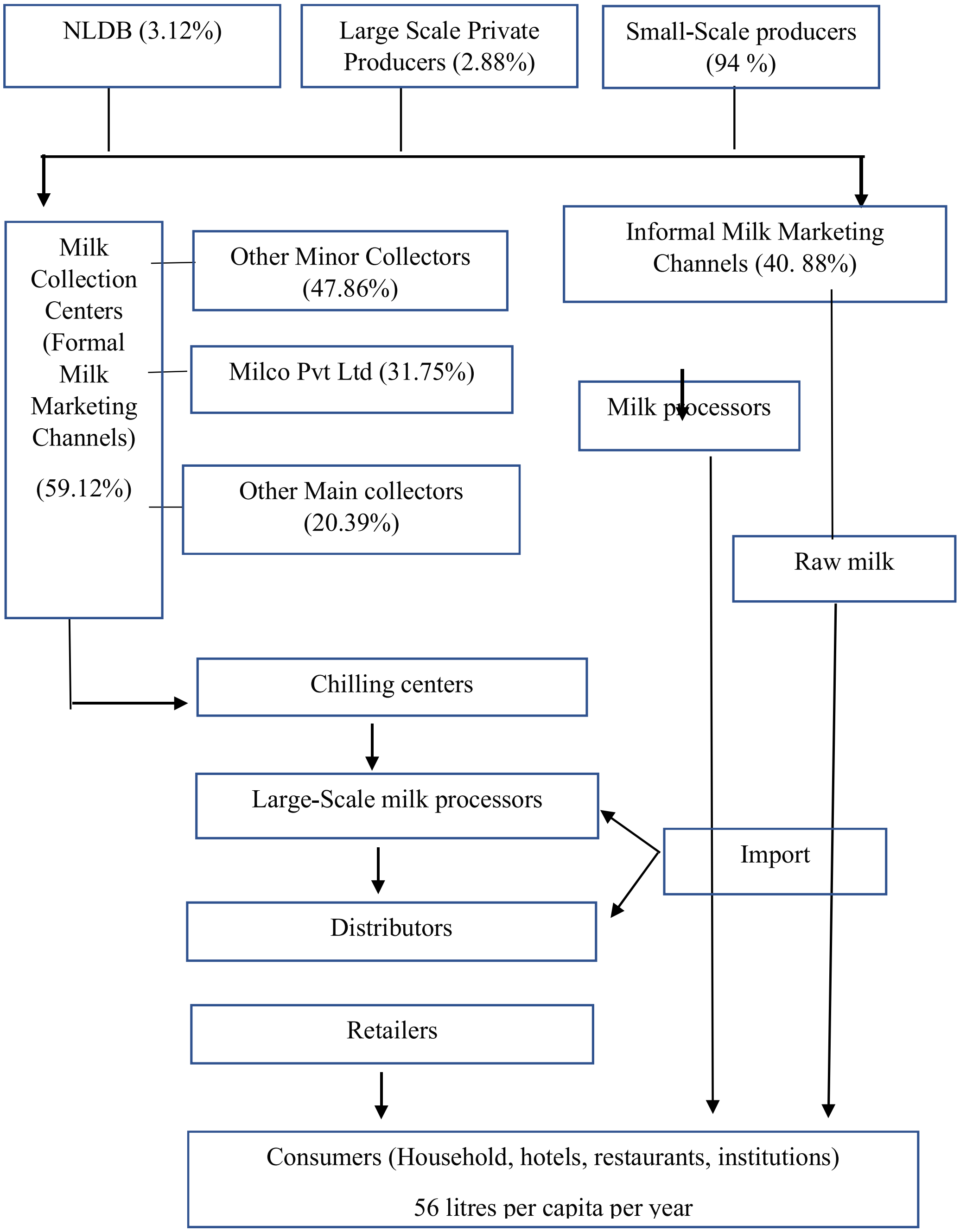
The formal marketing channel is comprised of three main players: farmers, private or public collectors/processors, and retailers. Among these public or private collectors, MILCO (a government-owned company) is the largest collector, accounting for 30 percent of the milk collected in Sri Lanka. Following MILCO, the largest private entity, Nestle Lanka Private Limited, collects around 23 percent of milk in the formal sector. Apart from these two companies, Pelwatta companies, Rich Life, Kothmale, Cargill, Fontera, Ambewella, and CIC engage in milk collection (Vernooij, *et al*, 2015).

These companies have formed their own Farmer Managed Societies (FMS) and chilling centers. In addition to collecting milk, they perform various tasks in bringing milk from producer to consumer. The largest player among these companies took the lead in determining the farm-gate price of milk before 2010 (Daniel, 2008). However, since 2010, the government introduced a guaranteed price of Rs. 50 on fresh milk (Fat and Solid Non-Fat ratio at 4.2/8.3) to safeguard the interest of producers and increase local dairy production. This guaranteed price was increased to Rs. 70 in 2015. Many processors use imported milk powder in addition to the locally procured milk for their products. From collection centers, through their distribution channels products are distributed to retailers.

To showcase the critical points for biological, physical, and microbiological contaminations in the supply chain, the different marketing channels in which milk flows are presented in Figure 1. As the figure indicates, raw milk can be contaminated with foreign materials, chemicals, and microbes at any point in the supply chain. However, the possibility of contamination at certain points are higher than other points. A higher level of microbial and physical contaminations can occur at the producer, collector, processing, and consumer points. Chemical contamination can occur at the farmer level.

Apart from this, since imported milk enters the marketing channel at the processer, this is also a critical point for chemical contaminations.

Figure 1: Milk supply chain in Sri Lanka



Source: Adapted from Vidanarachchi et al, 2019

Even though microbial contaminations can pose a significant health risk to consumers, as milk is subjected to heat and cooling in processing in the formal milk marketing channel (i.e., pasteurization), the threat of microbial contamination is substantially reduced. However, these same processing techniques do not guarantee that milk is safe from chemical contaminants. Once milk is contaminated with chemicals, it is difficult to remove them (Valeeva, *et al*, 2005). Since the bulk of the milk produced locally or imported is consumed as processed milk, the risk of chemical contamination should be a major concern, along with microbial and physical contaminants, for Sri Lankans.

2.2. Milk consumption in Sri Lanka

According to the Household Income and Expenditure Survey (HIES) of 2016, per capita, monthly consumption of cow milk and powdered milk are 94.64 ml and 348.43 g, respectively (Department of Census and Statistics, Sri Lanka, 2018). Compared to the values in 1980 and the pre-liberalization era, i.e., before 1977, there is a clear reduction in fresh milk consumption in Sri Lanka (Table 2). Prior to liberalization, domestic milk production was nearly 63 percent of the domestic market (Daniel, 2008). However, after liberalization, the consumption pattern of milk changed from liquid to powdered milk, and since there is no developed powdered milk sector in Sri Lanka, the country started to import powdered milk in large quantities.

The contribution of local dairy products to the domestic market was only 42 percent in 2017. Apart from raw and powdered milk, processed products such as pasteurized milk, yogurt, ice cream, flavored pasteurized and cheeses are quite prevalent in Sri Lanka. These processed products may have lower probability to cause foodborne diseases.

Powdered milk is microbiologically stable and safe, as microbes are destroyed with processing (Kalyankar *et al*, 2016). Therefore, the linkage between farm production practices and the safety of processed milk has been weak (Ruegg, 2003).

Table 2: Household consumption and expenditure on milk and milk products

Household consumption	1980/81	1985/86	1990/91	1995/96	2002	2005	2006/07	2009/10	2012/13	2016
Milk (liters)	2.7	2.4	1.4	0.7	0.4	0.7	1.4	1.9	0.4	0.4
Household expenditure on milk and milk product as a percentage of total food and drink expenditure										
Milk and milk products	3.4	4.3	5.1	7.1	8.4	9.9	8.7	7.8	8.9	8.2

Source: Department of Census and Statistics, 2016

2.3 Rules and Regulations Pertaining to Food Safety of Milk and Milk Products

Regulations for safe milk production and consumption in Sri Lanka are specified under the Food Act, 26, 1980. It is the main legislation governing food control activities in the country. The Act, which applies to all food products, prohibits the manufacture, import, distribution, or sale of food items considered injurious to human health and unfit for human consumption. The Act specifically prohibits adulteration of food products, and food products which are contaminated with unclean animal or plant substances. Furthermore, the Act forbids import, manufacture, and sale of food under unsanitary conditions.

Apart from these general rules which are applied to all food products, Amendment 1994 makes illegal the use of preservatives in milk except under special circumstances. The Act was again amended in 2010 to regulate the melamine content in dairy products. The Act specifies the maximum allowable melamine content in import milk as 1.0 mg/kg (Part Per Million.). Other than the Food Act, Animal Feed Act No 15 of 1986 regulates, supervises, and controls the manufacture, sale, and distribution of animal feed in the country.

One of the objectives of the Food Act is to prevent public health hazards that could be created by pharmaceuticals. Under the Act, several pharmaceutical products have been banned in Sri Lanka to avoid the presence of these drug residues in livestock products. In addition to this, Sri Lanka has introduced a hazard analysis critical control point (HACCP) system for fresh and processed food products through the application of ISO 22000 (SLSI, 2005; Munasinghe, *et al*, 2015).

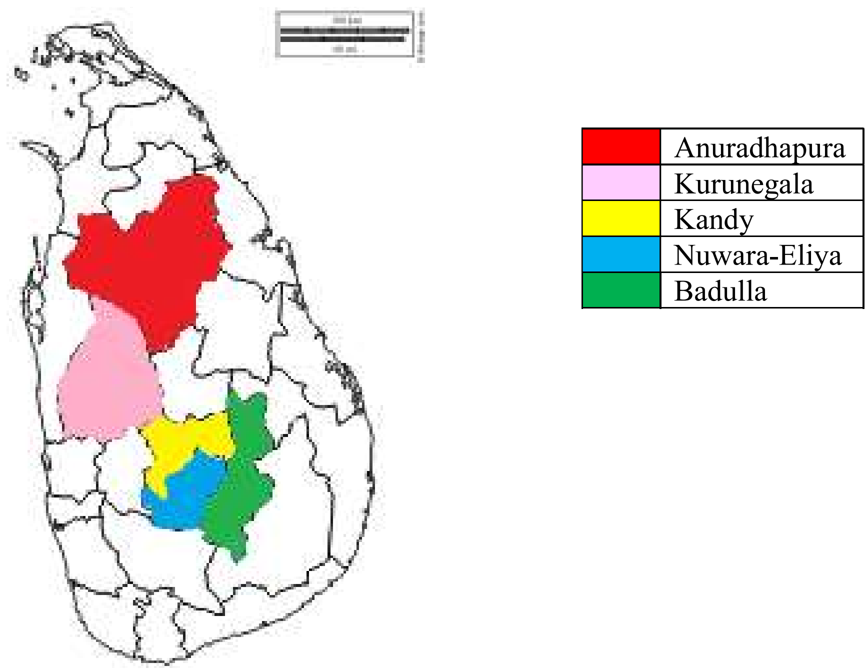
III Data and Survey Design

To explore the food safety awareness, attitude, and practices adopted by farmers as well as by consumers, two separate field surveys were carried out in 2016 and 2017: one for producers and one for consumers. To capture the variation in management practices adopted in rearing cattle, which could create a difference in food safety management practices adopted by farmers, the study selected five major milk producing areas in Sri Lanka for the producer survey: Anuradhapura, Kurunegala, Kandy, Nuwaraeliya, and Badulla (Figure 2). Apart from the diversity that these districts represent in terms of the cattle rearing system used, the abundance of dairy farmers who sell their milk to a formal milk collection system also formed a basis for selecting the districts.

Due to the large size of the population, which was dispersed across a large geographical area, the study adopted a cluster sampling to obtain a sample of dairy farmers. Cluster sampling is a process in which the sample is selected by randomly choosing smaller and smaller subgroups from the main population. As done for this study, this approach may be used in cases in which a list of the all the subjects in the population is not available or it would be too difficult to randomly select from the total population. Instead of randomly selecting subjects, smaller subgroups of subjects are selected. The advantage of this method is that it not only preserves random selection at each step but is more representative of the overall population. (Thompson & Panacek, 2006) In selecting the clusters in each district for the producer survey, veterinary officers assisted, to assure that the survey could cover a large number of producers. With the help from veterinary officers and milk collectors, the study first located milk collection centers in each district. Once the collection centers were selected, farmers who bring milk to these collection centers were randomly selected for the sample. Through this method, the study collected information from 500 producers.

In selecting the respondents for the consumer survey, consumers in the same districts considered for the producer survey were interviewed. Out of the 998 respondents from the sample, closer to fifty percent were dairy producers and the rest were dairy non-producers. The selection was done to capture the demographic variables of the population of interest.

Figure 2: Surveyed districts



Source: Authors

IV Methodology

4.1 Development of a food safety index

Farmers were surveyed to explore the extent of their adoption of food safety practices. For better comparisons, using this information, a food safety index was developed. A Food Safety Index (FSI) is a composite index to reflect the level of adoption of food safety practices at the farm level. It captures three dimensions: farmer compliance with practices that ensure the biological, chemical, and physical safety of the milk.

Since the food hazard associated with each dimension is different from the others, different weights were assigned to different dimensions. Apart from this difference across dimensions, to accommodate the difference in importance of each dimension across the farming system, different sets of weights for each dimension were obtained for the different farming systems (Equation 1).

Equation 1

$$FSI = \sum_{i=1}^{3} W_i S_i$$

Where:

FSI: Food Safety Index

W: Weight assigned for i^{th} component of the Index

S_1: farmer's compliance with practices that ensure the milk's biological safety

S_2: farmer's compliance with practices that ensure the milk's chemical safety

S_3: farmer's compliance with practices that ensure the milk's physical safety

Subject to $\sum_{i=1}^{3} W_i = 1$

Theoretically, the FSI ranges between 0 and 1. If the farmer practices all the food safety practices, then the FSI value will equal 1; if the farmer does not practice any, the FSI value will be zero.

Equation 2 is the weighted summation of the proportion of practices that are adopted by farmers out of the total available practices under each subcategory of practices needed to ensure the n^{th} safety dimension of the milk.

Equation 2

$$S_i = \sum_{j=1}^{n} W_{ij} X_{ij}$$

Where:

W_{ij} = Weights assigned for j^{th} sub-component in the i^{th} component

X_{ij} =Proportion of food safety practices adopted in the j^{th} sub-component in the i^{th} category

To obtain weights for computing the FSI, a group of elements under each dimension is evaluated against one another and for that, one of the Multi-Attribute Decision Making (MADM) tools, "Analytical Hierarchy Process" (AHP) is used. In this method, pair-wise comparison of each attribute is done by an expert or group of experts. Usually, the comparison is done using a seven- or nine-point Likert scale. For this study, four experts were interviewed. Their fields of expertise are microbiology, veterinary science, and animal science. Once their responses to the pair-wise comparison were obtained, a comparison matrix was developed.

Determinants of compliance with food safety practices by farmers

Econometric model

In this section, we assess the factors associated with food safety perceptions and practices. The outcome variable in the analysis is the FSI. The independent variables are (i) farmer as a recipient of a subsidy program (the subsidy is given to improve the animal shed) (SUB), (ii) participation of the farmer in a training program on dairy production (TRN), (iii) home consumption of fresh milk as a percentage of total production (CON), and (iv) cattle-rearing management system, either intensive (INT) or semi-intensive (SINT). Apart from this, demographic characteristics of the farmer, education level (EDU) and age (AGE), are included in the model as explanatory variables (Equation 3).

Equation 3

$$FSI = \beta_0 + \beta_1 SUB + \beta_2 TRN + \beta_3 CON + \beta_4 SINT + \beta_5 INT + \beta_6 EDU + \beta_7 AGE + \varepsilon_i$$

Here, ε_i indicates the stochastic error term of the model.

To study the difference across the farming system, once the model is estimated for the whole dataset, it was estimated separately for each farming system.

4.2 Analysis of the consumer knowledge and attitude

Consumer knowledge and attitude were measured using a five-point Likert scale and it was analyzed. To understand the association between demographic characteristics and consumer knowledge and attitude, Chi-Square tests were performed.

V Results of the dairy producers' survey

This section presents and discusses the results of the producers' survey. In presenting the results, the adoption of food safety practices was discussed in relation to the management system of the farmers: intensive, semi-intensive and extensive systems.

Table 3: Distribution of farms under different farming systems

District	Different farming systems		
	Extensive	Semi-Intensive	Intensive
Kandy	28 (13.40)	36 (28.35)	36 (22.36)
Nuwara Eliya	16 (7.66)	21 (14.79)	63 (39.13)
Badulla	23 (11.00)	28 (19.72)	54 (33.54)
Kurunegala	67 (32.06)	33 (23.24)	4 (2.48)
Anuradhapura	75 (35.89)	24 (16.90)	4 (2.48)
Total	209	142	161

Note: Numbers in parenthesis represent a percentage.

Altogether 209 farms were recognized as extensive, 142 as semi-intensive, and 161 as intensive systems, according to the classification described above. The distribution of management systems across districts is given in Table 3.

5.1 Farm characteristics

The different management systems have significantly different farm characteristics. The average herd sizes of three systems were five, four, and three, under extensive, semi-intensive, and intensive systems, respectively (Table 4). Extensive systems had higher variation in herd sizes across farms compared to the other two systems. All farms in intensive systems had at least one shed for animals and some farmers had more than one shed with smaller land areas. In an intensive system, animals were kept within the shed with stall feeding. In the extensive system, though farmers had sheds, animals were not kept inside the sheds throughout the day.

Table 4: Farm characteristics in different farming systems

Character (unit)	Different farming systems		
	Extensive	Semi-Intensive	Intensive
Herd size (numbers)	5.00	4.00	3.00
Average Milk Production (lit/day)	11.57	11.36	14.83
Percentage of milk used for home consumption (% of average production)	7.90	6.62	5.21
Percentage of farms with Animal shed (%)	80.00	100.00	100.00
Shed with Feeding Line (% of farms)	42.00	77.00	83.00
Breeds	Crossbred animal Indigenous animal Nondescript buffalos Nondescript cattle	Crossbred animal	Crossbred animal Pure exotic breeds

The shed was mainly used for milking. Though stall feeding was not common in the extensive system, occasionally it was done when an animal could not be released for free grazing. Therefore, 42 percent of farmers in the extensive system had sheds with feeding lines. The majority of farmers (83 percent) in the intensive system had built a shed with a feeding line, and some traditional farmers had not constructed a feeding line within the shed. These farmers usually used some other temporary structure for feeding. In the semi-intensive system, 77 percent of farmers had built the shed with a feeding line. In this system, animals free graze in the daytime and in the evening but at night were kept inside a shed for feeding purposes. In each these three systems, if the cow was pregnant, special care was taken in which the animal was kept inside the shed and stall feeding was practiced. The subsidy for building a shed had been received by 34 percent of farmers in the extensive system, 47 percent in semi-intensive, and 26 percent in the intensive system.

The type of animal reared in each system was different. A great majority (86 percent) in the extensive system reared crossbred cattle while 11 percent of farmers reared indigenous cattle and around 1 percent non-descript buffalos and cattle. Farmers in the semi-intensive system reared only crossbred animals. Farmers in the intensive systems had crossbred cattle (43 percent) and pure exotic breed (57 percent).

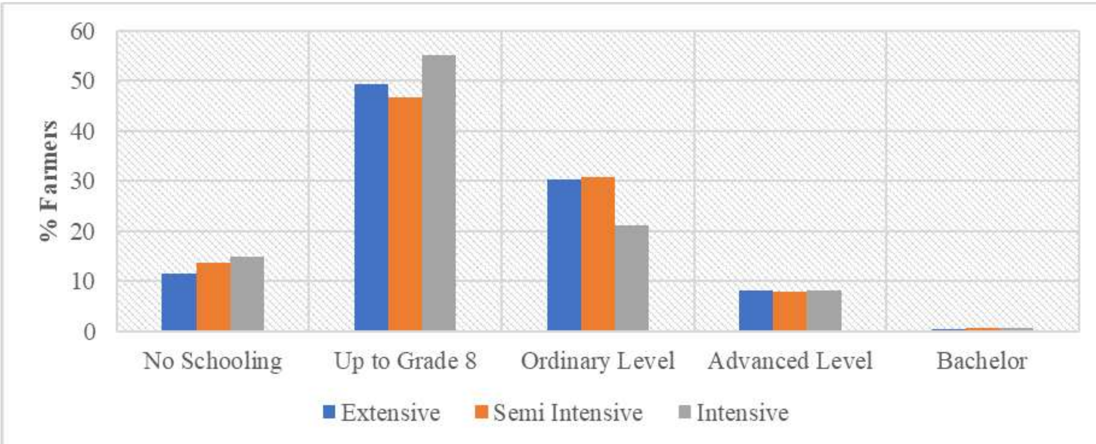
Milk yields differed across management systems. Among the three, the highest milk production per day was reported in intensive systems, with an average value of around 15 liters/day. The production level of the systems varied from 3 liters/day to 25 liters/day.

Farmers in the different systems sold milk to different end markets: dairy cooperatives, public and private dairies, households, and restaurants/hotels. Farmers in extensive systems sold milk only to public/private dairies and households. The most favored destination in the three systems were public/private dairy companies such as MILCO (public), Nestle Lanka PLC, and Pelwatte Dairy Industries Private Limited. Ninety-seven percent of farmers in the extensive system, 69 percent in the semi-intensive system and 76 percent in the intensive system sold milk to public/private dairies. About 22 percent of intensive system farmers sold milk to dairy cooperatives.

In terms of the farmer characteristics, the age distribution of the farmers of extensive systems ranged between 22 and 78 years with a mean age of 51 years. More than 90 percent of farmers in the system were male. In terms of the ethnic diversity in the sample, 86 percent of farmers were Sinhalese while only about 32 percent and 11 percent were Islamic and Tamils, respectively.

Majority (86. percent) of farmers were Buddhist, while 3 percent, 9 percent and about 2 percent were Islamic, Hindus and Christians, respectively. Farmer education level was measured through formal education, and 49 percent of farmers had studied up to grade 8 level at school and 30 percent of farmers had a formal education up to Ordinary Level (Figure 3).

Figure 3: Education level of dairy producers in the different farming system



Major income-earning activities of farmers in the systems were dairying (55 percent), sales of livestock products other than milk (4 percent), cultivation (33 percent), casual employment (6 percent), regular employment (1 percent), and business (1 percent) (Figure 4). Data shows that farmers usually gained knowledge on animal husbandry through training programs. However, only 37 percent of farmers participated in the training programs. Of those, 54 percent trained for general dairy training, 20 percent for cleaner milk production, around 10 percent trained on veterinary care and fodder cultivation while only 3 precent of farmers trained on processing (Figure 5).

Figure 4: Main source of income of the farmers in different farming systems

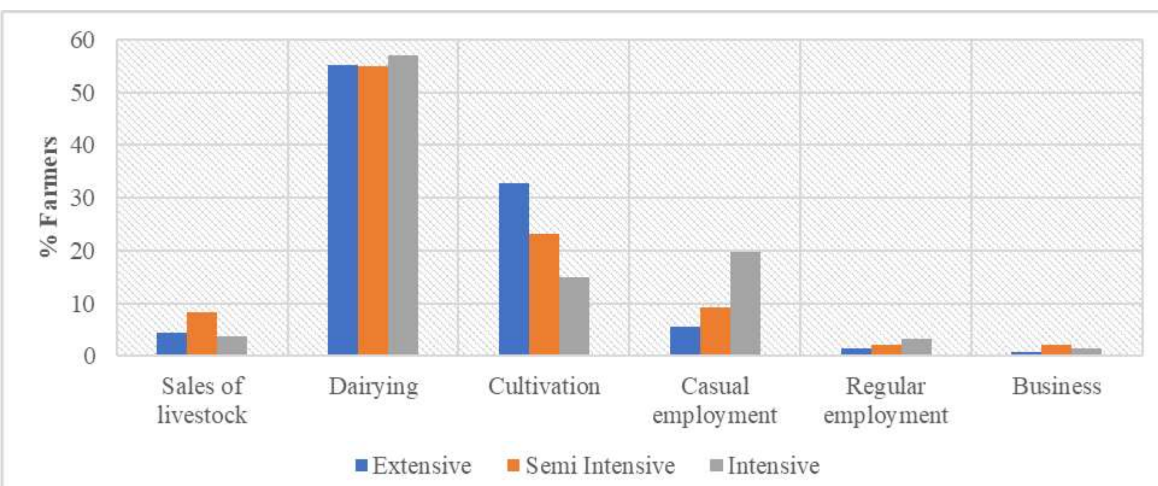
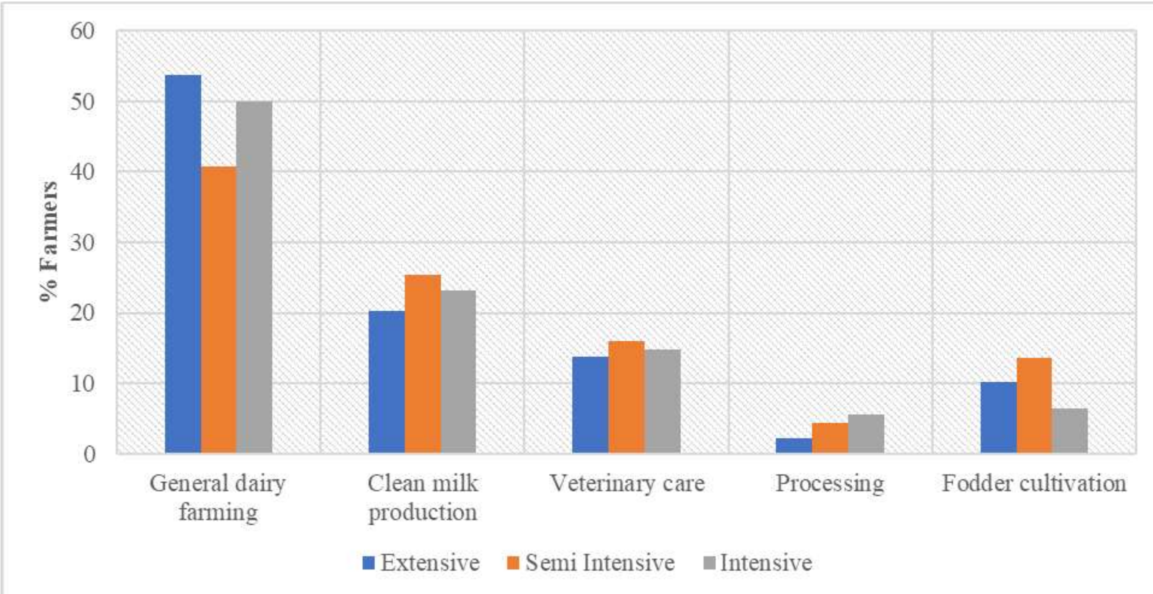


Figure 5: Types of training programs attended by farmers under the different farming system



5.2 The level of Adoption of Food Safety Practices

As mentioned in the Methodology Section, the level of adoption of food safety practices was assessed using the FSI (Eqn. 1). In developing the index, adoption of safety practices was obtained from the farmers while the weight of each dimension was obtained from the experts. The weight obtained for each dimension from the four experts are disparate. However, they were not without commonalities. For example, three out of the four experts had assigned a higher value for the dimension which deals with the practices that ensure the biological safety of milk. Despite the differences, since all weights ranged within an acceptable ambit, all were processed to get a final average weight for a dimension.

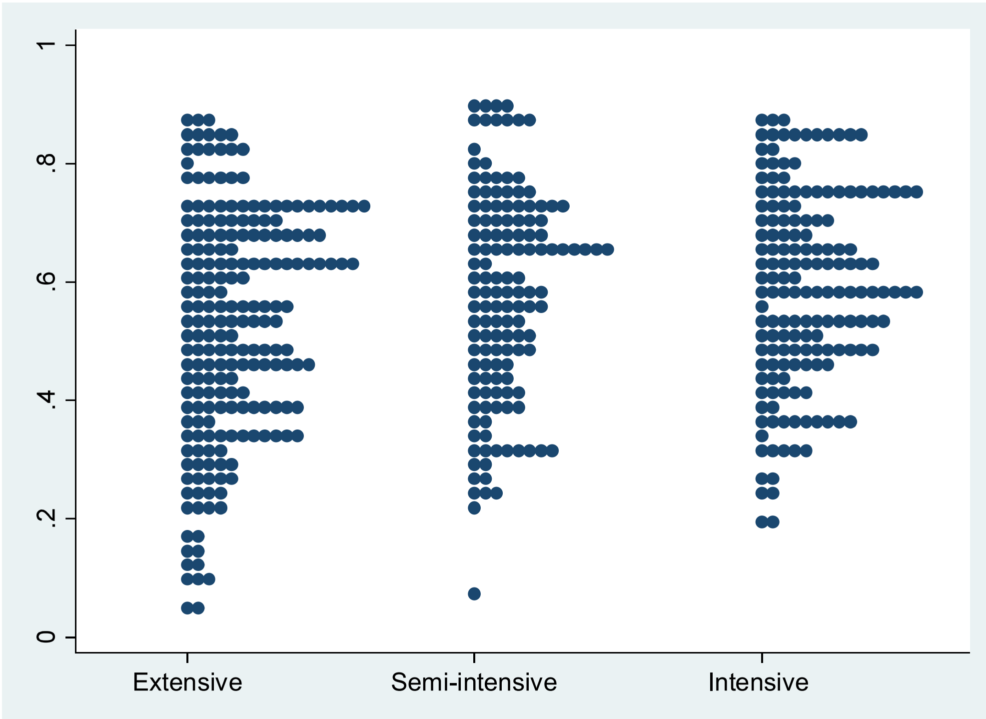
As the importance of each safety measure is not uniform across the cattle management systems, different weights were obtained for each management system. However, in the absence of clear criteria to distinguish management systems, we developed our own criteria for separating farms into the three categories.

Accordingly, the extensive management system is characterized by free grazing and no shed feeding of animals. Intensive systems are recognized as using zero grazing with a small cross and pure exotic breed rearing under in-house conditions. The semi-intensive system is characterized by conditions that are in between intensive and extensive systems. Although animals in both semi-intensive and intensive systems are fed with fodder (green/dry) and concentrates, the concentration amount given in the intensive system is much higher than in the other two systems. More than 1.5kg/animal/day concentrate provision is observed in intensive systems while concentration provisions of less than 1kg/animal/day were observed in extensive systems.

In all the systems, worker hygiene is more critical and animal hygiene comes next. Utensil hygiene is more crucial for the semi-intensive system, while worker hygiene is considered a priority to ensure biological safety in milk in an extensive system. Furthermore, experts have given a higher value for shed management and proper usage of chemicals. The weight assigned for medicine used is higher in intensive while it is the lowest in the extensive system. For the sub-category among practices "use of chemicals for milking" received a higher weight in experts' views compared to other two in the extensive system.

With respect to the calculated values of FSI, for the extensive system, the mean value was 0.54 while the semi-intensive was 0.59. The highest value, 0.62, was obtained for the intensive system. This implies that farmers in intensive systems adopted a considerably higher number of food safety practices compared to extensive and semi-intensive systems. With the range of values, it is obvious that the dispersion of the FSI value was low in the intensive system, while it was equal in the other two systems. Figure 6 also confirmed this dispersion.

Figure 6: Distribution of the FSI for different farming systems



5.3 Determinants of the level of adopting of food safety practices at the farm level

As witnessed by the FSI score, reported in the earlier section, farmers differed in terms of the degree of adoption of food safety practices. To investigate the determinant of this variation, the study estimated a linear regression considering farm characteristics and farmer characteristics as possible determinants of the level of compliance with food safety practices at the farm level.

Table 5 presents the descriptive statistics of each variable included in the econometric model given in Table 6, which presents the coefficients estimated through the model.

Table 5: Descriptive statistics of the key variables

Variables	Units	Different farming systems			Overall
		Intensive	Semi-intensive	Extensive	
Food Safety Index (mean value)	..	0.588	0.575	0.526	0.559
Percentage of respondents those who are educated above grade 8	%	85.00	85.40	87.38	86.08
Percentage of respondents those who have received a subsidy	%	24.38	37.23	23.79	27.83
Percentage of respondents those who have received training program on safety	%	33.13	48.91	36.89	38.97
Household consumption as a percentage of total production	%	7.90	6.62	5.21	6.48
Age	years	51.55	50.48	51.00	51.04
Number of farms	..	161	142	209	494

Table 6: Determinants of factors affecting food safety.

	Pooled sample (fixed effects for farming systems)	Different farming systems		
		Intensive	**Semi-intensive**	**Extensive**
Education	1.419	-8.027*	6.132*	6.458
	(2.44)	(4.241)	(3.363)	(4.164)
Subsidy	5.055***	2.807	7.134**	4.082
	(1.784)	(2.841)	(2.952)	(3.274)
Training	3.162*	3.574	9.868***	-0.922
	(1.714)	(2.956)	(2.920)	(2.879)
Consumption	0.266`*	0.168	-0.032	0.477**
	(0.127)	(0.225)	(0.212)	(0.207)
Age	-0.059	-0.007	0.158	-0.257**
	(.0726)	(0.109)	(0.132)	(0.115)
Semi Intensive	3.343 (2.048)	..	..	..
Intensive	5.381*** (1.916)	..	..	..
Constant	50.681***	62.618***	36.934***	56.955***
	(4.681)	(7.524)	(7.290)	(7.180)
R^2	0.0589	0.0443	0.1634	0.0742
Observations	494	155	135	204

Note: ***denotes significance at 1%, **denotes significance at 5%, and * denotes significance at 10%

As shown in Table 6, having a training on dairy and being a recipient of the subsidy program had a positive and significant association with the degree of compliance with food safety practices at the farmer level. Farmers who had participated in a training program were better at adopting safety practices than farmers who had not. This reflects the importance of equipping farmers by imparting training for the importance and ways of producing safer milk.

With respect to subsidies as determinants of the level of food safety compliance, as revealed in field surveys, farmers had received these subsidies to construct their cattle shed and these sheds need to be constructed as per the donor guidelines. As expected, subsidy recipients were better adopters of safety practices than non-recipients. Having properly designed cattle shed, which ensures a better waste management system and proper hygiene, could contribute significantly to reducing environmental contamination. Furthermore, it was observed that farmers, who use a larger proportion of their production for home consumption, were more likely to adopt food safety practices. This could be due to greater valuation of possible health effects when it is self or own family consumption their higher stakes.

In terms of the differences among farming systems, farmers in intensive systems were likely to adopt more food safety practices than farmers in the extensive and semi-intensive systems. The objectives of milk production and end markets demands were stronger determinants for delivering on food safety practices. The association of education with the adoption of food safety practices was ambiguous, however; in some farming systems, it had a positive effect whereas in others it was either negative or insignificant.

VI Results of the dairy consumers

To explore the association between knowledge, attitude, and behavior of consumers with the sector of residence (urban, rural, estate), the income level of the people, and their dairy production status, households were classified into subcategories. In classifying households into urban, rural, and estate, the official definition was used.[1] Households were further categorized based on monthly income level: households those who earned less than Rs. 30,000 were classified in the low-income group, those with an income between Rs. 30,001 and Rs. 60,000 were categorized as middle-income, and the rest (income above Rs. 60,001) were classified as high-income category (Table 7).

Table 7: Distribution of dairy consumers

Classification criteria		Kandy	Nuwara Eliya	Badulla	Kurunegala	Anuradhapura	Total
Sector	Urban	22	40	5	4	0	71
	Rural	172	45	135	190	196	738
	Estate	4	114	58	0	0	176
	Total	198	199	198	194	196	985
Income	Lower	63	77	80	65	67	352
	Medium	104	110	107	99	103	523
	High	29	12	11	18	25	95
	Total	196	199	198	182	195	970
Milk production status	Producers	51	85	84	21	17	258
	Non-producers	147	112	114	174	179	726
	Total	198	197	198	195	196	984

6.1 Demographic profile of dairy consumers in Sri Lanka

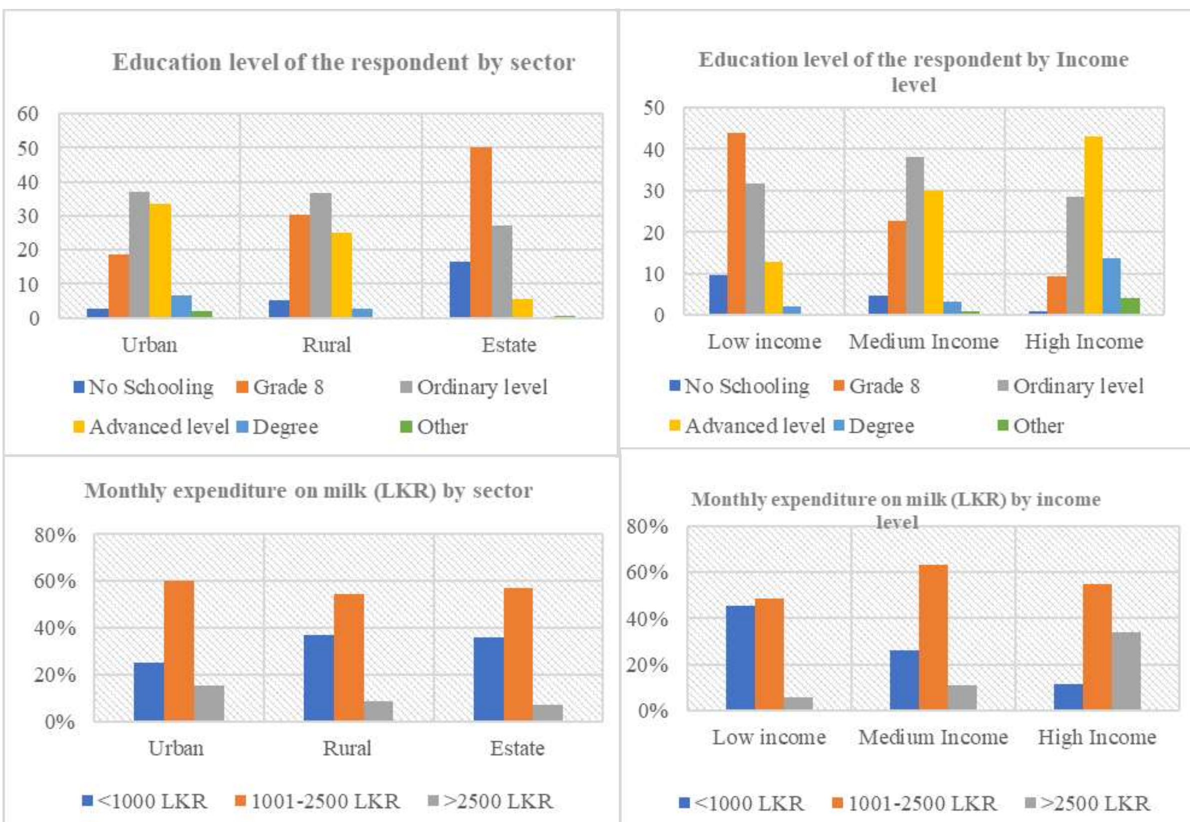
The average respondent's age was 46 years. Close to 60 percent of the respondents were women. The average household size was four persons. While 89 percent of respondents had at most a school-level education, 4 percent of respondents had a graduate or postgraduate degree. Disparities among sectors revealed that a great majority of the estate sector households either had not gone to school or had been educated only up to Grade 8. Education levels of the respondents in the other two sectors were relatively higher as compared to estate dwellers (Figure 7). In terms of the employment status, 27 percent of farmers engaged in farming, while 24 percent were not employed, 18 percent were self-

[1] The urban sector defines all areas administered by municipal and urban councils that constitute the urban sector. The estate sector consists of all plantations which are 20 acres or more in extent and with ten or more resident laborers. All areas other than urban and estate comprise the rural sector (Department of Census and Statistics).

employed, and the rest comprised wage labor. Nearly seventy-four percent of the households in the sample were non-dairy producers.

On average, the average income of respondents was Rs. 29,449.40 per month. Of it, they spent Rs. 1,554 on milk and milk products, i.e., 5 percent of their total expenditure. The expenditure on milk was comparatively high among urban consumers, in which 16 percent spent more than Rs. 2,500 on milk and milk products (Figure 7). The most widely consumed dairy product was powdered milk. Among the respondents, 78 percent were consuming powdered milk. The majority of them said they consume milk in powdered form due to availability (38 percent) and food safety concerns (26 percent).

Figure 7: Education level and monthly expenditure on milk by households across sectors and different Income level



6.2 Consumer knowledge about food safety

It is believed that food handling practices at home contribute significantly to foodborne diseases. Having a sound understanding of the possible health hazards associated with the consumption of food items, possible means of food contamination, and effective ways to reduce food risk determines food safety at the consumer end.

To gauge awareness, we assessed knowledge on pasteurization, melamine contamination in powdered milk, attitudes toward organic dairy products, knowledge about milk contamination sources, awareness about milk fortification, and knowledge on some good practices on ensuring milk hygiene and safety. To assess the association between consumer safety awareness and the sector of their residence, income level and the Chi-Square test were performed. To understand whether there is a difference in awareness levels between milk producers and consumers in terms of the safety of milk, a Chi-Square test was performed. The proportion of respondents under each category are given in Table 8. Categories that are significantly different from others, as evident by the Chi-square test, are marked with an asterisk.

Table 8: Knowledge of dairy consumers on food safety (share of consumers aware of food safety concepts)

Source of contamination of milk	Units	All	Sector			Income level			Source of milk	
			Urban	Rural	Estate	Low	Medium	High	Own production	Market
Contamination on farm	%	22.9	27.78	23.52	19.21	20.06*	22.86	36.84*	19.77	24.52
Adulteration of water	%	83.7	80.56	82.8	90.39*	80.79*	86.25	84.21*	89. 92*	82.78*
Contamination from fodder	%	16	16.67	16.26	15.25	9.32	18.77	25.26	17.44	15.7
Contamination from medicine	%	4.3	2.78	4.03	6.21	1.69	6.32	3.16	4.65	4.27
Pasteurization	%									
Aware	%	16.23	22.6*	17.6	6.7*	11.85	15.34	37.5	12.2	17.8
Not aware	%	77.6	61.5*	76.3	89.6*	83.89	77.89	52.27	81.7	76
Partially	%	6.17	12.5*	6.2	3.7	4.26	6.77	10.23	6.1	6.2
International certification	%									
ISO	%	51.7	62.7*	63.6*	29.1*	48.5	60.9*	71.4*	34.9*	65.1*
HACCP	%	10.3	6.6*	0.6*	4.2*	16.8	32.5*	4.3*	2.1*	34.9*

*Note: To indicate the group/groups that was/were different from other groups asterisk marks were used. *** indicates that difference is significant at the 1% significance level, ** indicates that the difference was significant at 5% significance level and * indicates that the difference is significant at 10% significance level.*

The survey indicated that there was a lack of consumer knowledge about pasteurization. Seventy-eight percent of respondents in the sample were not aware of the concept. Only 16 percent were fully aware of it, while 6 percent were partially aware. A significantly higher proportion of urban consumers had knowledge of pasteurization than estate sector consumers. Nearly fifty-two percent of consumers were aware of ISO certification, while 10 percent were aware of HACCP. For ISO certification, the high-income groups recorded the highest awareness (71 percent), and the estate sector recorded the lowest (29 percent).

Even though organically produced milk guarantees that milk is free from chemical contamination, it does not guarantee that milk is free from microbial contamination, which may pose a greater threat. However, most respondents (68.58 percent) believed that the highest food safety standard that can be achieved is organic milk. More alarmingly, some (10 percent) had the impression that milk is organic simply because it came from local breeds.

One of the other areas in which consumer knowledge was investigated relates to awareness about the point of contamination of milk. Even though milk can be contaminated at any point in the supply chain, the possibility of contamination at the farm is usually high for raw milk. In this regard, the majority (69 percent) of the respondents stated that most contamination occurs at the farm. Among those who stated that off-farm constitutes the main sources of contamination, 43 percent believed that the biggest source of contamination was due to adulteration of milk by water.

Although water is the most common adulterant found in milk in Sri Lanka, it may be less harmful (unless the water is contaminated with a high microbial load) than other adulterants of chemical contamination such as urea, starch, or hydrogen peroxide. Only a small percentage of respondents (16 percent) believed that milk can be contaminated through the feed/fodder offered to animals. Given the fact that most Sri Lankan farmers feed animals with crop residues which could contain agrochemicals, there is a possibility for chemical contamination of milk, especially in the dry zone and upcountry. Research done in one of the agriculture areas (Magasthota) illustrates this. As per the findings, milk contained agrochemical residue, but it had not reached the toxic level with respect to the analyzed chemicals (Chaminda *et al*, 2013). Only 19 percent of consumers in the sample held the belief that milk could be contaminated with antibiotic and hormone residuals. Even though countrywide studies are unavailable, the available literature suggests that due to the wide usage of antibiotics in the treatment and prevention of animal diseases, milk is not free from antibiotic residues (Hathurusinghe, *et al*, 2001).

Finally, only 58 percent of respondents were aware of the recent issue of melamine contamination, notwithstanding the widespread publicity about the melamine issue in China. Against this, it can be concluded that people's awareness of possible sources of contamination is low in Sri Lanka.

6.3 Attitudes on some select aspects related to food safety of fresh milk.

The study shows that respondents' perceptions of food safety and milk safety specifically, varied widely. About half of the respondents believed that, among all the risks they face in life, food safety risks were rather insignificant. Only about eight percent disagreed with that, while 36 percent were neutral about the statement. This implies that for a great majority of farmers, food safety may not be a focal issue.

Most consumers (66 percent) had a higher degree of trust in the safety of the milk they consumed. In measuring the degree of trust, consumers were asked to score for the safety of milk. Most who were consuming powdered milk scored higher on value for safety.

In terms of the fresh milk consumers, dairy producers were more confident that the milk they consume is safe than non-producers. Estate-sector households were more confident about the safety of the milk they consume (70 percent). Compared to male respondents, female respondents had a higher trust in the milk safety (male: 45 percent; female: 55 percent).

About 30 percent of consumers believed that fresh milk is not hygienic. More than 15 percent consider bacterial contamination a threat to the safety of fresh milk. About six percent of respondents were of the view that fresh milk is contaminated with external particles and is not safe. Taste and nutrition are less common concerns. The proportion of people with this belief (29 percent) was significantly higher in the high-income group than in the other two groups (middle-income: about 20 percent; low-income: 10 percent). Further, urban and estate dwellers were more suspicious about the safety of fresh milk than rural consumers.

In terms of consumer attitudes toward the agent responsible for food certification, a large majority (93 percent) believed that the government should take responsibility for food certification. Local bodies like farmer organizations were other agencies mentioned by some respondents as who should be responsible for certifying food. A very small proportion (0.5 percent) stated that an international agency is more suitable for doing the certification.

6.4 Consumer behavior toward food safety

Individuals make rational decisions about their behavior when they are aware of associated risks and health problems. These decisions are based on their knowledge about the associated health risks and their attitudes (judgments) about the perceived risks (Wilcock, *et al*, 2004).

In terms of the risk-minimizing behavior, the respondents were asked about strategies to reduce food hazards, particularly relating to feeding fresh milk to their children. Accordingly, 33 percent of consumers responded that they boil milk before feeding it to their children, and 16 percent refrigerate it. Twelve percent of respondents stated that they use clean containers to store milk. Importantly, 14 percent stated that they fed their children powdered milk to avoid the risks associated with fresh milk.

Behavioural response to the episode of Dicyandiamide (DCD) in powdered milk

In this study, consumer behavior toward food safety was measured in terms of behavior change when faced with the news on Dicyandiamide (DCD) contamination in imported milk powder and day-to-day risk-minimizing activities. With the news that powdered milk brands coming from a New Zealand company were contaminated with DCD, powdered milk consumers adopted different strategies. Notably, in Sri Lanka there were no reported deaths or illnesses due to consumption of that powdered milk brand.

In response to the widespread news on DCD contamination of imported milk powder, the Sri Lankan government took measures to eliminate the risk. Industrial Technological Institute (ITI) tested the presence of DCD in imported and local milk powders and confirmed that four of the imported milk powders were contaminated with DCD. With this, imports from New Zealand were temporarily suspended and the exporting companies were told they could supply the product to the market only when the subsequent samples tested at ITI confirmed that milk was not contaminated with DCD.

Since then, in Sri Lanka, every shipment of full cream powdered milk and skim milk are tested for radioactivity levels and one in four consignments are tested for the presence of microbiological contaminants and fat content, the origin of fat contents and DCD contamination. Every shipment of infant milk is tested for radioactivity parameters and one in four consignments are tested for the presence of microbiological contaminants (Ministry of Health, 2020). This incident compelled Sri Lanka to amend its food safety Act No26, 1980. Food (Melamine in milk products) Regulation 2010 regulates the maximum allowable melamine content that can be present in milk to be 1 mg/kg of milk products.

In terms of consumer response, as revealed by the survey, only 56 percent of respondents were aware of this incident. Among those who were aware, 56 percent had not changed their choices in any way. All who were aware of the episode may not have consumed the powdered milk brands in question; it might not follow that all ignored the hazard.

Among the consumers who consumed the brand in question, about 47 percent did change their brand. However, importantly, a sizable 42 percent of these consumers did not. Lack of awareness, no recorded illnesses, as well as a possible lack of alternative options might have contributed to this. Also, as discussed above the outcomes were not that intense. Only about 4 percent switched to fresh milk consumption from powdered milk consumption. Eight percent of respondents changed the powdered milk brand for children only. Further analysis revealed that it was the low-income families who mostly changed the consumption pattern of children.

VII Conclusions and Recommendations

As indicated by the scores for the FSI, which measures the level of commitment to ensure food safety in milk by farmers, in all three management systems, the adoption of food safety practices lies at a moderate level in Sri Lanka. The degree of adoption is lowest among farmers in the extensive system, while it is highest among farmers in the intensive system.

Farmers, in general, were seen practicing some safety measures, such as washing their hands before milking and keeping the animal shed clean. However, concerning some other practices, the level of adoption was comparatively low. The latter comprises practices that are needed to avoid biological and chemical contamination of milk.

This may be partially due to a lack of knowledge on avenues of biological contamination. Concerning the practices that are essential to avoid chemical contamination, farmers do not adhere to the recommended milk withholding period after the administration of antibiotics to animals.

In profiling the farmers based on the level of compliance with food safety practices, importantly, farmers who had undergone a training program adopted relatively more safety practices than farmers who had not. This reflects that gaps exist in information and knowledge, and some farmers do not adopt safety measures most likely due to lack of information about them. It follows that training sessions for farmers to educate them on these measures may improve the outcomes. Additionally, giving subsidies to construct animal sheds is also likely to improve outcomes in terms of farmers adopting more safety practices. This shows that farmers' behavior can be changed through incentives. This may signal the importance of resource endowment to convert the knowledge into behavior.

Finally, farmers who use a higher percentage of milk for home consumption were found to adopt more safety measures than others. This indicates that farmers behave more responsibly when they are also affected by their behavior. Moreover, to improve the quality of milk, market could pay a crucial role. In this scenario, price of the milk sold will be determined by the quality of milk produced and whether it meets the necessary safety requirements. This may be one of the incentives for farmers to adopt safety measures. However, in practice, this will not be an easy task since it requires measuring the level of impurities in milk.

Milk collecting agents can create an incentive system to reward individual farmers who produce and bring safer milk to them. This will increase the tendency of farmers to follow safer milk production, milking, and storage practices. Collecting agents can test milk regularly for contaminants and reward farmers who bring safer milk, or they can penalize farmers who bring unsafe milk to milk collecting centers.

Furthermore, relevant authorities need to assist farmers in identifying animals with zoonotic disease; routine surveillance programs that diagnose animal diseases might be a good option for this. Routine assessment of farm hygiene at predefined intervals by an extension officer can also reduce the contamination at the farmer level.

The findings from the consumer survey indicate that consumer knowledge on the safety of milk and source of contamination remains low. More alarmingly, the majority of consumers do not consider foodborne diseases to be a serious issue and most people believe that the milk they consume is safe. This is a barrier to creating a demand-pull for the market to produce and sell safer milk. Since the study indicates that estate sector dwellers and low-income people have lower awareness about these issues, awareness and educational campaigns can target them.

Additionally, survey results on consumers' attitude about fresh milk consumption shed some light on one of the barriers to promoting fresh milk in Sri Lanka. Even though the Sri Lankan government has taken several initiatives, such as launching promotional campaigns to promote fresh milk or setting up milk retail outlets, fresh milk is still not very popular among consumers. As revealed by the consumer survey, consumers are skeptical about the safety of fresh milk over powdered milk and some even believe consuming powdered milk eliminates food risks associated with dairy products. This may have caused consumers to consume powdered milk, which could be inferior in quality compared to raw milk, in the first place.

All in all, an integrated approach (farm to table) is needed to assure the safety of milk in the supply chain, new regulations need to be introduced or implementation of existing regulations need to be strengthened at all the nodes in the supply chain for safer milk consumption, while increasing the knowledge and awareness of supply chain actors on milk safety.

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Annexure

Table A1: Weights given for each sub-category

System	Criteria	Weight for the three main dimensions			Biological			Physical		Chemical	
		Biological	Chemical	Physical	Utensil Hygiene	Worker Hygiene	Animal and milk Hygiene	Shed Hygiene	Waste Management	Usage of Medicine	Usage of chemicals Milking
Intensive	Microbiologist	0.72	0.08	0.2	0.24	0.48	0.28	0.88	0.13	0.88	0.13
	Animal Scientist	0.67	0.09	0.24	0.6	0.28	0.12	0.83	0.17	0.83	0.17
	Animal Scientist	0.7	0.07	0.23	0.32	0.35	0.33	0.88	0.13	0.88	0.13
	Veterinary Doctor	0.32	0.45	0.23	0.11	0.29	0.6	0.83	0.17	0.88	0.13
	Average	0.6	0.17	0.23	0.32	0.35	0.33	0.85	0.15	0.86	0.14
Semi intensive	Microbiologist	0.72	0.07	0.21	0.24	0.44	0.32	0.875	0.125	0.875	0.125
	Animal Scientist	0.65	0.19	0.16	0.44	0.32	0.24	0.75	0.25	0.75	0.25
	Animal Scientist	0.7	0.07	0.23	0.33	0.33	0.33	0.875	0.125	0.875	0.125
	Veterinary Doctor	0.44	0.24	0.32	0.33	0.33	0.33	0.875	0.125	0.83	0.17
	Average	0.63	0.14	0.23	0.34	0.36	0.31	0.84	0.16	0.83	0.17
Extensive	Microbiologist	0.75	0.08	0.17	0.24	0.44	0.32	0.875	0.125	0.875	0.125
	Animal Scientist	0.71	0.19	0.1	0.32	0.45	0.23	0.75	0.25	0.75	0.25
	Animal Scientist	0.7	0.07	0.23	0.33	0.33	0.33	0.875	0.125	0.875	0.125
	Veterinary Doctor	0.32	0.24	0.44	0.12	0.48	0.4	0.875	0.125	0.5	0.5
	Average	0.62	0.15	0.24	0.25	0.43	0.32	0.84	0.16	0.75	0.25

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