Powdered over fresh milk preference and hygienic dairy practices in Sri Lanka

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Research

Keywords: coliform counts, bulk tank, milk quality

Posted Date: September 1st, 2020

DOI: https://doi.org/10.21203/rs.3.rs-66182/v1

Abstract

Background

The majority of Sri Lankans may select imported powdered milk over fresh milk, and a significant portion of Gross Domestic Product in Sri Lanka is spent on dairy products imports. Demand for fresh milk may be hindered by consumer preference towards powdered milk consumption and the lack of hygienic standards for fresh milk. The current study was conducted to identify factors contributing to consumer preference for powdered milk and to evaluate hygienic best practices of dairy farms.

Methods

The study took place in Kandy district, Sri Lanka. Two surveys were conducted: the first survey included questions concerning demographics and reasons for milk preference was administered to a randomly selected population (n = 561); the second survey focused on hygienic practices in dairy farms, and was administered to owners of dairy farms (n = 195). Milk samples were collected from individual cows and bulk tanks and analyzed for coliform counts. Regression approaches were used to evaluate associations of demographic variables with milk preference, farm management practices with mastitis history, and coliform counts.

Results

A large consumer preference was observed for powdered milk (86%), and females were 2.2 times more likely to select powdered milk than males (P = 0.03). Availability was the main reason for powdered milk preference, whilst taste was the main reason for selecting fresh milk. Coliform counts were higher in most of the analyzed bulk milk samples and rinsing bulk milk tanks with warm water showed a significant reduction in milk coliform counts. Washing the teats with warm water had a lower mastitis risk when compared to washing teats with regular water.

Conclusions

Study revealed that in order to create a fresh milk drinking culture in Sri Lanka there needs to be a mechanism to make it more accessible to the consumers. Fresh milk marketing strategies need to be focused more on the female consumers. Farmer education on good hygienic practices, elimination of inefficiencies in both milk production and collection process, standardization of milk quality according to the number of microorganisms in milk would improve the quality of dairy products in Sri Lanka.

Background

Over 6 billion people consume milk and milk products worldwide, with the highest per capita consumption in developed countries (1). Sri Lanka is a lower-middle income country with per capita consumption of milk and milk products of 45.2 Liters (L) per annum (2). In 2017, the annual per-capita availability of milk has increased up to 56 L showing an increased demand for milk (3). It is shown in a recent study that adults in Sri Lanka consume over 1.3 servings of milk per day on average (4). This is higher than the average global consumption level of 0.6 servings/day (4). According to the Household Income and Expenditure Survey (HIES) in Sri Lanka, the average monthly household expenditure share on milk and milk products is 8.9% in 2012/2013, and 8.2% in 2016, ranking 4th in food expenditure categories (5). The above factors reflect the importance of dairy products in the Sri Lankan diet. However, only about 1% of consumers drink fresh milk, whilst the majority select the imported powdered milk (6).

Studies have shown that factors such as demographics and lifestyle, availability, health issues, hygienic conditions, attitudes, and beliefs of consumers can influence the selection of milk products (7, 8). Health issues related to consumption of dairy products include lactose intolerance, cow milk allergy, or transfer of human pathogens such as *Salmonella, Escherichia coli, Campylobacter*, and *Listeria* from unhygienic milk (9). The dairy farm environment is one source of fecal contamination that can compromise milk quality and food safety. Microbial contamination of the milk may occur from direct contact of cow feces with the milk, diseases in cows that involve shedding organisms in the milk, bacteria living on the skin of cows, contamination from the environment, and by animal vectors as well as humans that are coming into contact with milk (10). Adherence to good hygienic practices during milking, milk collecting, storing, and processing can significantly reduce the risk of milk contamination.

Milk production in Sri Lanka is mainly dependent on small scale producers. Dairy farming is the major source of income and employment for many rural farmers, where the byproducts of agriculture and free family labor are utilized to produce a value added market commodity (2). A previous study conducted in Jaffna district of Sri Lanka identified poor milk hygiene as a challenge facing producers, with higher than the recommended levels of total bacterial and coliform counts in raw milk (11). Sri Lankan dairy farmers are typically paid according to the milk yield and the fat percentage, with no incentives provided based on the hygienic quality of the milk. Across society, it is not known whether the low preference for cow milk is due to consumer trust in the hygienic quality of the powdered milk, or due to other cultural factors. One objective of this project was to identify reasons for consumer preferences of powdered milk over fresh milk. A second objective was to assess the hygienic dairy management practices in small and medium scale farmers in Kandy district.

Methods

Study setting and sampling

The study was conducted in Kandy District, Central Province in Sri Lanka, which has a tropical climate with a dry season from December to April and a monsoon rainy season from May to August. To evaluate milk preferences, a consumer survey was verbally administered to local consumers in their mother tongue

between June to August of 2013 by interviewing a randomly selected population of 561 Sri Lankans living in Kandy district. The interview was used to collect a range of sociodemographic data including income, education, gender, family composition, geographic information, and dietary data on milk such as preferred milk type (fresh milk or powdered milk) and reasons for consumption or lack of consumption (See Questionnaire S1, Additional File 1 for survey questions). During this study period, a total of 35 fresh milk samples were collected directly from the cows and bulk tanks (from 6 small and 5 medium scale farms) for microbial analysis. Farm sizes were categorized according to the cattle herd size and small farms were defined as less than 5 animals while the farms which had 6 to 50 animals were defined as medium farms (12).

The second study component focused on dairy farms in the Kandy district. A verbal survey was conducted from June to August 2013 and from February to August 2014 by interviewing 195 randomly selected small and medium scale dairy farmers in the Kandy district. This survey included questions concerning milking processes and hygienic practices utilized on their dairy farms as well as production and animal health parameters (See Questionnaire S2, Additional File 1 for survey questions). In addition, fresh milk samples were collected directly from bulk tanks of 51 small and medium scale farms for microbial analysis.

Laboratory Analysis

Milk samples were transported on ice to the microbiology laboratory at the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya for analysis within two hours from collection. Fresh milk samples collected from individual cows and bulk tanks were tested for coliform counts as a measure of milk quality and possible fecal contamination. Fresh milk samples from bulk tanks cleaned with varied protocols before milking (n=51) were also tested for the coliform counts. Enumeration of coliforms in milk samples was done on MacConkey agar (Difco^{TM}, Dickinson and Company, MD 21152 USA). Inoculated plates were incubated at 37°C for 24 hours. After incubation, typical pinkish and centrally red colonies were counted with colony counter and Total Coliform Count was calculated using the equation, $N = C/(n_1+0.1n_2)d$ (C = the sum of colonies counted on all of the dishes retained, n_1= the number of dishes retained in the first dilution, n_2 = the number of dishes retained in the second dilution, d = the dilution factor corresponding to the first dilution).

Statistical Analysis

The consumer and farmer survey data, milk quality data, farm practices and animal health information were compiled to allow for comparisons across study components. Descriptive data summaries were established and then regression approaches were used to evaluate associations between predictor variables and outcome variables. For the milk preference survey, demographic variables of gender (male, female), age (<25 years, 25-55 years, >55 years), education (primary, secondary, graduate or post graduate) and household number (<3 people, 3-5 people,>5 people) were evaluated for association with milk preference using binary and then multivariable logistic regression approaches in a forward stepping

manner. Similarly, for farm management practices of washing hands prior to milking, washing teats prior to milking and farm factors such as farm size, types of bedding, presence of a drainage system, a logistic regression was used to evaluate the association with reported mastitis in milking cows. To evaluate the association of farm management practices with milk quality, a negative binomial regression approach was used to individually evaluate predictor variable (bulk tank cleaning methods) associations with a continuous coliform count outcome, followed by significant predictor variables included in a multivariable model. Data was analyzed by Stata IC 14 (StataCorp LP, College Station, Texas, U.S.) using a P values ≤ 0.05 as significant.

Results

Among the participants of milk preference survey, 86% reported drinking powdered milk, 8% preferred fresh milk, and 7% did not drink milk. Demographics of the survey participants are given in Table 1. Logistic regression analysis of milk preference outcome associated with age, education, gender, and number of members in the household variables showed a significant association only with the gender, as females were 2.2 times more likely to prefer powdered milk than males (P = 0.03).

Analysis of the reported reasons for drinking fresh or powdered milk identified availability as the most common reason for powdered milk preference. Desirable taste was the most common reason reported for preference of fresh milk. The next most popular reasons for powdered milk selection were habit, followed by easier storage/preparation, and then taste. Lastly, the other reasons reported for fresh milk selection were habit, nutritional properties, and the belief in quality and hygiene (Table 2). Interestingly, the main reason for not drinking any type of milk was health issues, followed by habit.

The survey of dairy farm management and hygienic practices showed different methods of washing hands, teats and the bulk tank. When cleaning the bulk tank before milking equal number of farmers preferred to use warm water or regular water with soap or a detergent. However, few farmers used warm water (~ 120-140^{0}F water temperature) to clean the bulk tank after removal of milk (Fig. 1). Negative binomial regression of bulk tank cleaning method associated with coliform counts showed that cleaning the bulk tank with regular water had nearly a 6 times greater likelihood of having higher coliform counts than cleaning them with warm water (P = 0.004). Negative binomial regression analysis of the coliform counts found in bulk tanks and individual cows showed that the milk directly taken from the cows had nearly an 83 times greater probability of having higher coliform counts than milk in the bulk tank (P = 0.001).

The majority of the surveyed farmers washed their hands using soap or detergent before milking (Fig. 2). Warm water was used by most farmers for washing the cow teats before milking, and 22% used a detergent or soap for washing the teats with either warm or regular water (Fig. 2). Out of surveyed dairy farmers, 91% did not perform any form of post milking teat dipping and none of them did pre-milking teat dipping. Only 9% of the surveyed farmers used post milking teat dipping substances such as

iodine/betadine and vinegar. Washing teats with regular water had 2.5 times greater chance of having mastitis than washing teats with warm water (P = 0.04).

According to the survey, many farms had concrete floors (93%), but most of them was broken. There are only a few farms had the floors made up with either wooden, stone, or soil. Many farms were maintained an adequate floor slope (65%) and a proper drainage system (74%). Most of the farmers reported cleaning the dairy house walls and floors at least once per day. The majority of them used only regular water (86%), eight farmers (4%) used water and a detergent, whilst one farmer (1%) used magnesium sulfate ($MgSO_4$). There were 14 farmers (7%) who only cleaned the manure, and five farmers (3%) did not clean the stalls at all. Most of the farmers reported milking their cows twice daily. After collecting milk, majority transported it to the collecting centers. Some farmers preferred to store the milk in the refrigerator and transport the milk later. Two farmers boiled the evening milk before storage, and one farmer sold the evening milk to the neighbors (Table 3).

Discussion

There is a significantly higher demand for powdered milk over the fresh milk in Sri Lanka. In 2014, the government imported 71,000 metric tons of milk and milk foods (except infant milk foods) spending around 44 billion rupees while in 2018, 105,000 metric tons of milk and milk products excluding infant milk food were imported spending around 54 billion rupees (5). In order to increase the consumer demand for fresh milk and to popularize it as healthy and a nutritious beverage it is important to identify the factors that lead them to select milk powder over fresh milk. Results of the survey confirmed that there is a strong preference for powdered milk (86%) over fresh milk (8%). Age, education, and household size did not show an association with powdered milk preference. Gender-dependent difference was observed in the surveyed group, with females showing a significant higher preference for powdered milk. Gender-dependency of food choices are reported in several studied conducted in other countries, and food selection and preparation were identified as mainly in the domain of women (13, 14). This indicates that if the fresh milk consumption is to be increased in Sri Lanka, females would be a priority target group to be addressed in marketing programs. When considering the reasons for the preference of powdered milk both male and female groups gave similar reasons. Availability was reported as the main reason for powdered milk preference. Therefore, to make fresh milk more popular there should be government or private sector sponsored initiative to improve access for consumers. Taste was reported as the main reason for fresh milk preference. Quality and hygiene were the fourth reason for fresh milk preference. This indicates that conditions that maintain the flavor and hygienic quality of fresh milk are important for promoting the fresh milk market. For not drinking any type of milk, health issues were the main reported reason, and diabetes, high cholesterol, stomach problems, nausea, and increased phlegm after drinking milk and concerns on weight gain were the given reasons.

Standards for dairy products were established by the Codex Alimentarius Commission (Codex) which was collaboratively formed by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) to develop food standards, guidelines and codes of practice (15). If the

hygienic standards of dairy products in Sri Lanka are shown to be within recognized safety limits, that could play an important role in gaining consumer trust. Using the second survey, the hygienic practices in small and medium scale dairy farms were evaluated. All surveyed farmers used manual milking, which may be due to the smaller herd size, simplicity, higher expenses related with the machine milking process (equipment and the power) and unfamiliarity. All of the farmers washed their hands before milking, and the majority used soap and regular or warm water. All the farmers washed the teats before milking and majority used regular water or warm water; 22% used a soap or detergent to wash the teats. None of the surveyed farmers performed pre-milking teat dipping and only 9% did post-milking teat dipping. Maintaining proper pre-milking hygiene routines is essential to reduce the udder bacterial contamination from the environment and infected animals; and as well as to reduce the transmission of pathogens to humans via milk. Therefore, it is recommended to wash the hands with detergent, wash the udder and dry the teats with a clean cloth and use teat dipping methods such as Iodine, Chlorhexidine prior milking. Gleeson *et al.*, discussed the importance of use of disinfectant products for teat preparation as they identified a significant reduction in the staphylococcal and streptococcal counts on teats after teat preparation with chlorhexidine teat foam, disinfectant wipes, and chlorine compared to washing and drying of teats or no preparation at all (16). It was also observed in this study that washing teats with warm water reduced the risk for mastitis when compared to washing with regular water. Farmers prepare warm water by boiling the water and then letting the temperature reaches down to a level that would not scald the udder skin. Boiling is the oldest and cheapest method of disinfecting water and properly boiled water stored in clean utensils would have very low doses of water borne microbes. Studies have also shown that use of warm water in teat washing is more comfortable to the animal and increases the milk let-down reflex (17).

Coliforms are commonly associated with manure contamination of udders and teats, and the proposed cut off of coliform count for good quality milk is defined as ≤ 50 colony-forming units per milliliter (CFU/mL) (18, 19). The majority (82%) of the bulk tank milk samples analyzed in the current study had coliform values that were higher than the cut-off limit and indicated poor milk hygiene. The main reasons for higher coliform counts include soil contaminated udders or dirty equipment. Even though most health risks from coliforms will be removed by pasteurization, drinking raw milk or a pasteurization failure could lead to conditions such as hemorrhagic diarrhea (20). In this study, there was a more significant chance to have higher coliform counts in milk collected from individual cows when compared to milk sampled from the bulk tanks. This is possible when some milk samples are collected from cows that had soil and manure on their teats that is not thoroughly removed before milking. In the bulk tank these high individual numbers can be diluted when mixed with milk from several animals .

Whole milk can adhere strongly to the surface of the bulk tank and form milk biofilms, and if allowed to dry these films are difficult to clean and will be a source for bacterial growth. Therefore, proper cleaning of the bulk tank plays an important role in minimizing the bacterial counts in the raw milk. All the farmers surveyed in this study used manual cleaning of bulk tanks. Farmers used different practices of bulk tank cleaning, such as regular water, warm water and soap/detergent with regular/warm water. Interestingly, there was a small percentage of farmers that did not clean the bulk tank before or after milking. This

study showed significantly low levels of coliform counts in bulk tank cleaned with warm water when compared to cleaning the bulk tank with regular water. Previous studies have shown that manual rinsing of bulk tank immediately with warm water that is around 100-110^{0}F removes most of the residual milk on the tank surface especially with the fat residues in the milk biofilm not being soluble in regular water (10).

Cleanliness of the dairy shed floor shown to have a significant impact on the animal health, and the milk quality. Ito *et al.*, indicated that cows spent approximately 11 hours/day lying although it is varied from as few as four hours to 19.5 hours per day (21). Therefore, soiled, unhygienic dairy shed floors can trigger bacterial contamination of the udder and the milk. Depending on the economic status, farmers maintain different types of floors on cow sheds, thus, practice various cleaning methods. According to this study most of the farmers that have dairy sheds with concrete floor cleaned the floor at least once per day with regular water. However, the concrete floors were broken and uneven in many dairy sheds observed in the current study. Dairy sheds with improper floors can allow accumulation of wastewater containing manure and urine. A previous study indicated that *Escherichia coli*, common bacteria found in the environment, and intestines of people and animals, can infect the udder when cows are lying on a muddy floor after milking (22). Furthermore, Gunawardana *et al.*, identified an association of mastitis with an uneven floor containing cracks and crevices (23). Farms without proper flooring (grass, soil, wood) removed the manure but did not clean the floor with water.

Most farmers transported milk to the collecting centers without chilling. However, in many areas only morning milking was collected and farmers had problems in storage of evening milk. A proper milk collection system for both morning and evening milking would benefit the farmers and also improve the milk storage quality, flavor, and freshness of milk.

Conclusions

Consumer educations on the benefits of fresh milk, and farmer education on production of hygienic milk, are both very important to further develop the dairy industry. For dairy products in Sri Lanka to come up to international hygienic standards, it is essential to have regular monitoring of microbes in raw milk and to incentivize production of high-quality milk. Main problem faced by the consumer is the non-availability of fresh milk whilst farmers face the problem in storage and transport of milk to collection centres. Therefore, establishment of community based milk collection and sale centres would benefit both consumers and small scale dairy farmers in Sri Lanka.

Abbreviations

L: Liters; HIES: Household Income and Expenditure Survey; ^{0}F: Fahrenheit; $MgSO_4$: Magnesium sulfate; FAO: Food and Agriculture Organization of the United Nations; WHO: World Health Organization; CFU/mL: Colony-Forming Units per milliliter.

Declarations

Acknowledgements

Mr. Sampath Bandara and the staff of the microbiology laboratory in the Department of Veterinary pathobiology, University of Peradeniya. Department of Animals Production and Health in Sri Lanka and all the participants enrolled in the surveys.

Authors' contributions

RM and AS prepared and conducted the milk preference survey. RM, MM, AM, RKR prepared and conducted the dairy farm hygiene survey. RM, MM, AM, RKR collected the milk samples for laboratory analysis. MM, AM, AS performed the laboratory analyses under the supervision of RJ. RKR analyzed the data and drafted the manuscript. RJ designed the protocol for coliform analysis in milk, reviewed and edited the manuscript. WAS, SW designed and supervised the study, contributed to the data analyses and interpretation of results, and reviewed and edited the manuscript.

Funding

Research conducted by Ryen Morey and Michelle Miller was supported by Students Training in Advanced Research (STAR) program at University of California Davis.

Availability of data and materials

Soft copies of the questionnaires and the survey results entered in to excel sheets are available.

Ethics approval and consent to participate

Study protocols for this study were reviewed and approved by the University of California, Davis Institutional Review Board (IRB ID 474828-1).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Demographics of milk preference survey participants (n=561)

	Category frequency (%)	Prefers powdered milk (number of participants (%))	Prefers fresh milk (number of participants (%))	Do not drink milk (number of participants (%))
Gender				
Male	327 (58)	274 (84)	32 (10)	21 (6)
Female	234 (42)	207 (88)	11 (5)	16 (7)
Age Group (years)				
<25	241 (43)	209 (87)	20 (8)	12 (5)
25-55	253 (45)	218 (86)	16 (6)	19 (8)
>55	67 (12)	54 (81)	7 (10)	6 (9)
Education Group*				
Primary	23 (4)	20 (87)	1 (4)	2 (9)
Secondary	324 (58)	270 (83)	30 (9)	24 (7)
University	214 (38)	191 (89)	12 (6)	11 (5)
Household Size				
<3 people	49 (9)	42 (86)	3 (6)	4 (8)
3-5 people	406 (72)	340 (84)	35 (9)	31 (8)
>5 people	106 (19)	99 (93)	5 (5)	2(2)

*Primary is up to grade 5, secondary is ordinary level or advanced level (high school education), tertiary is graduate or post graduate level.

Table 2 Participant reasons for their choice of milk preference (n=561)

Reason for milk preference	Prefers powdered milk (number of participants (%))	Prefers fresh milk (number of participants (%))	Do not drink milk (number of participants (%))
Availability	162 (29)	6 (11)	1 (3)
Habit	125 (23)	11 (20)	10 (31)
Easy to store and prepare	89 (16)	2 (4)	0 (0)
Taste	68 (12)	14 (25)	5 (16)
Health Issues	30 (5)	2 (4)	11 (34)
Nutrition	27 (5)	11 (20)	0 (0)
Cost	16 (3)	2 (4)	2 (6)
Public Perception/advertising	12 (2)	0 (0)	1 (3)
Quality and Hygiene	11 (2)	8 (14)	1 (3)
Odor	6 (1)	0 (0)	0 (0)
Milk Solubility	3 (1)	0 (0)	0 (0)
Other reasons	1 (0)	0 (0)	1 (3)
Total	550 (100)	56 (100)	32 (100)

Table 3 Procedures followed by the dairy farmers after milking (n=85)

Procedure	Number of farms (%)
Immediately transport to collecting center	61 (72)
Store in the refrigerator (both morning and evening) for later transportation	13 (15)
Morning milk is transported to collecting centers, evening milk is stored in refrigerator	8 (9)
Morning milk is transported to collecting center, boil and keep the evening milk for household consumption	2 (2)
Morning milk is transported to collecting center, evening milk is sold to the neighbors	1 (1)

Figures

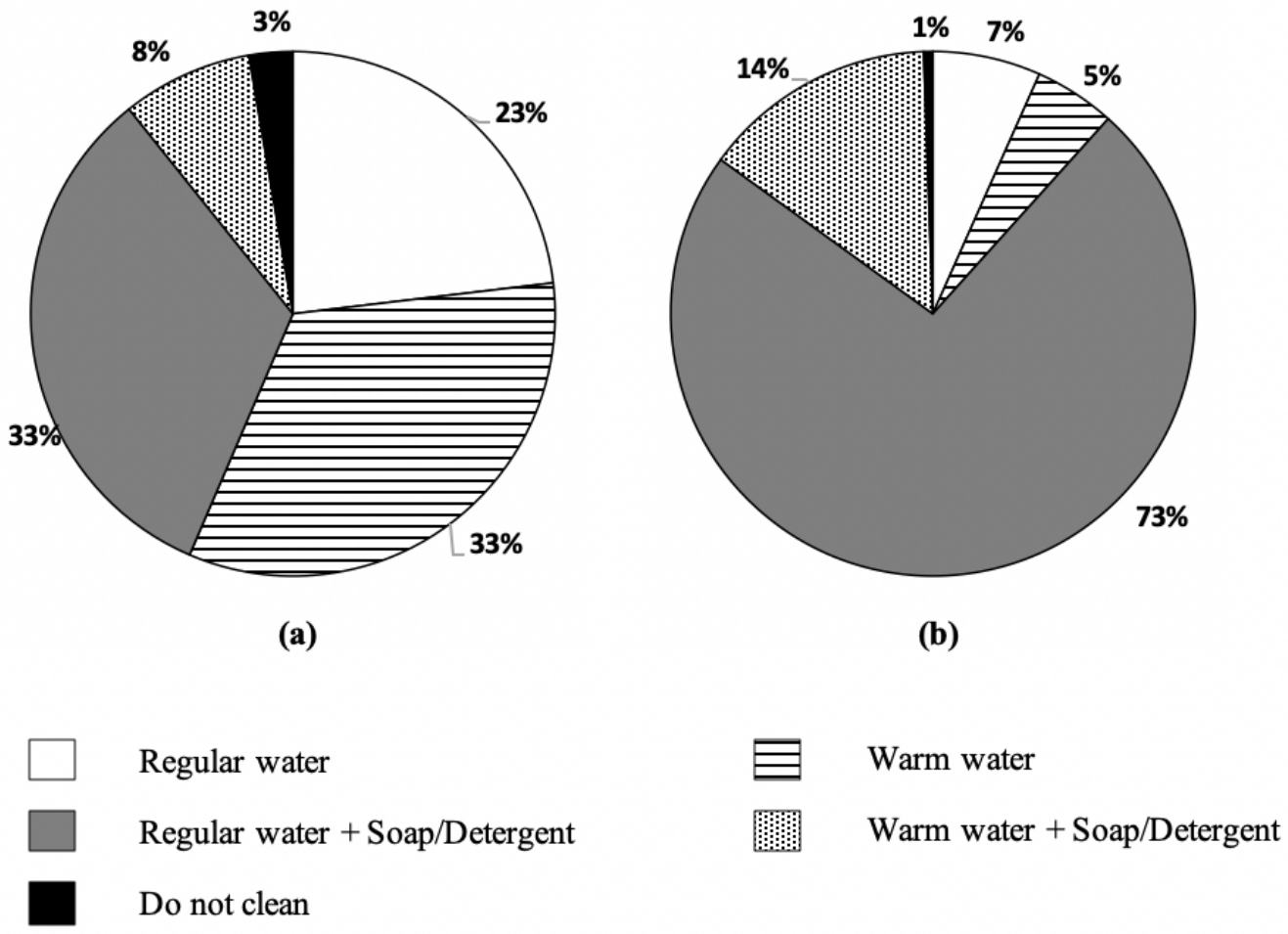

Figure 1

Powdered over fresh milk preference and hygienic dairy practices in Sri Lanka. a) Pie chart illustrating methods of cleaning bulk tank before milking (n=195); b) Pie chart illustrating methods of cleaning bulk tank after milking (n=195)

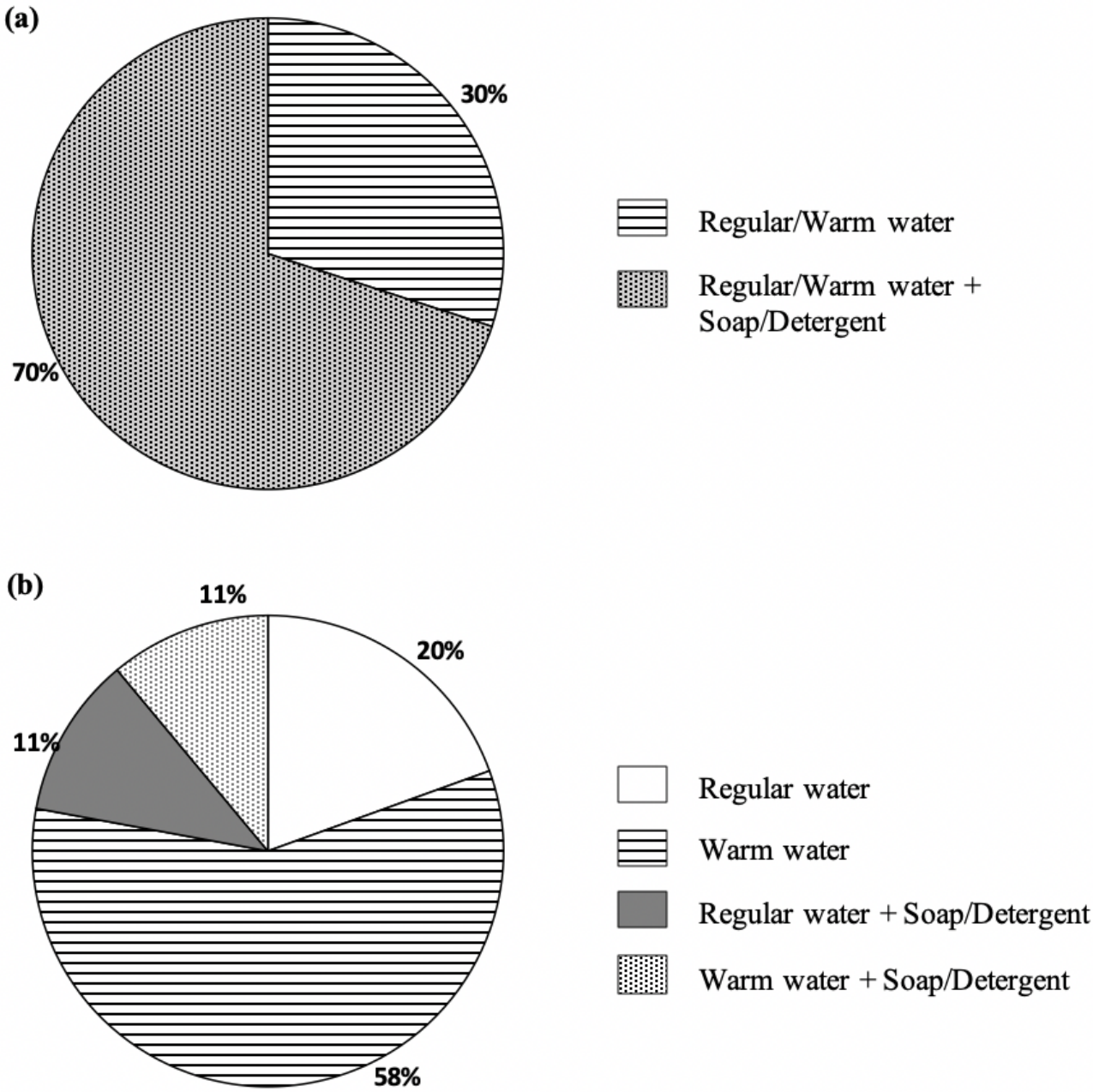

Figure 2

a) Pie chart illustrating the hand washing methods used in the surveyed dairy farms (n=195); b) Pie chart illustrating the teat washing methods used in the surveyed dairy farms (n=195)

Supplementary Files

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- AdditionalFiles.docx