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How Do Milk Farmers' Demographics Affect Their Knowledge of Food Loss in the Milk Supply Chain

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ABSTRACT

The Indonesian government is campaigning actively to increase national milk production. It aims to expand the country's cattle population and implement good farming practices. However, the increase in milk production will lead to high food loss, but the government and supply chain actors' awareness of this issue is low. Therefore, the role and knowledge of local farmers becomes essential in mitigating food loss necessary to support the government targets. This study aims to determine the effects of farmers' demographics on their knowledge of food loss in the milk supply chain. This quantitative study used a set of questionnaires to survey 40 farmers, where the collected data were analyzed using ANOVA. The result showed that farmers' demographics affect their knowledge about food loss. The farmer's knowledge contributes to food loss in the milk supply chain, including pouring milk into a can, milking manually, transporting it with cold chain equipment, storing it in milk storage, and transporting milk under specific road conditions. Therefore, the mitigation strategy shall be developed through effective communication and collaboration with farmers and clear supply chain regulations. The strategy can be started with education about food loss at the farmer level, which is essential to gaining the best farming practices in the milk supply chain.

Keywords: Demography, Farmer Knowledge, Food Loss, Milk, Supply Chain.

1. INTRODUCTION

The world's population will reach 9.9 billion in 2050 [1]. Due to this, food production will be needed to satisfy more than average consumption, leading to high livestock consumption and a rise in wastage in the supply chain stages [2]. In terms of meaning, food loss and food waste are different. Food loss can be described as the decrease in edible food mass from producer to consumer [3]. In contrast, food waste is related to the spillage of edible food mass after harvesting until the post-consumption stages [4]. Food loss is caused by poor product quality, the mismatch between supply and demand, improper handling, and a lack of proper cold facilities [5]. In addition, food loss is especially apparent at the farmer level due to overproduction, lower demand, and non-standard products [6], and the food loss of milk is caused by unmet production potential due to the product not entering the human food chain, and sometimes removed from the company because the standard is low or wasted [7].

In Uganda, food and nutrient loss in the milk supply chain has been estimated at 14% [8]. A portion of the milk spilled on the floor was detected at the farmer level. The milk was categorized as discarded because it cannot be consumed anymore. In the United States, the supply loss of milk

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is around 12% at retail and 20% from cooking, milk spoilage, and waste at the customer stage [9]. Furthermore, the estimated loss in France is around 12% due to milk production facing regulatory restrictions that directly concern human health. They mentioned that the loss was linked to economic optimization and mastitis [10]. Food loss also occurs in developing countries such as Indonesia, even if the national production exceeds milk consumption [11].

The Indonesian government is actively campaigning to increase national milk production through the Ministry of Agriculture. This program implements good animal husbandry practices at the farmer level [12]. It increases quantity and quality by improving the supply chain [13]. Many big companies support this program to produce milk and dairy products in Indonesia because local milk farmers contribute significantly, even though the rest are imported from Australia, the Netherlands, and New Zealand [14].

There are several solutions to achieving the national milk production target. First, the cattle population should be expanded, and good farming practices should be implemented. Then, a cooperative relationship must be developed among the members of the milk supply chain, strengthening the domestic market and boosting the demand for fresh milk [15]. Furthermore, the role of milk cooperatives is essential to improving farmers' skills and providing the needs for dairy farming, such as affordable animal feed and high-quality livestock breeds [16].

Increasing milk production and demand will lead to high food loss [17]. The issue is regrettable because the awareness of the government and supply chain actors is still low [18]. It indicates a less favorable policy for food loss at the farmer level. The government only focuses on developing field extension workers to change farmer behavior related to knowledge of food loss [19].

Due to this, the role of local farmers in the upstream milk supply chain becomes significant in reducing and mitigating food loss [20]. If this role is insufficient, food loss in the milk supply chain will be high, and the government's target will not be achieved. Based on the issues discussed, a study was conducted to understand farmers' knowledge of the causes of food loss in the milk supply chain. This research focuses on milk farmers in Banyumas Regency, Central Java Province, Indonesia, who raise Friesian Holstein cattle that produce high milk with low-fat content [21]. This research adds a new approach to mitigating food loss in the milk supply chain based on farmer knowledge. Furthermore, knowing the source of food loss in the milk supply chain facilitates a more efficient estimation of the amount of food loss. It can help achieve the national production target of fresh milk.

1.1. Literature Review and Hypotheses Development

Milk is one of the nutritious diet items, posing many challenges in the supply chain. The challenge is reducing food loss, especially in the production or supply [22]. The estimated loss of food and nutrients is caused by the portion of milk spilled on the floor. Some are low quality and are rejected by processors [8]. In some cases, food loss occurs due to mastitis, and antibiotic treatments are based on veterinary decisions [23].

There are some mitigation strategies for food loss at the farm level. One is adopting post-harvest technology to reduce food loss and waste [24]. The adoption of technology needs adequate knowledge and understanding [25]. The knowledge gap becomes challenging in milk farming practices. For example, Nairobi has a knowledge gap in its milk supply chain due to inadequate training programs, lack of access to cold chains, and increased milk adulteration, resulting in milk quality and . Therefore, the collaboration among stakeholders to conduct innovative business models should be improved to process technology and product sustainability [26].

In the milk supply chain, the farmer has an essential role in maintaining the quality and quantity of milk production. Their practices include production, harvesting, transporting, inventory

management, and warehousing. The production process comprises feeding the cattle, checking their animal health, and giving them appropriate food [27]. Farmers face high-cost and low-quality feeds, animal feed competition, animal disease, and a lack of added value in milk production [28]. Then, the next practice is harvesting. This practice starts with milking preparation, pouring into the can, and the milk collection system [27]. This is followed by transportation. If the transportation is delayed, the delivery process will decrease product quality and safety. Transportation aims to access cold storage, ensure the availability of a steady cold chain, and minimize transportation costs [29]. The last practice is a storage facility to store and collect the harvested fresh milk, which includes warehousing and inventory management [30]. Those practices are standard at the farm level, but more knowledge is needed to improve farmers' food loss.

The knowledge is essential in farming. Many post-harvest losses occur due to farmers lacking adequate knowledge and information, and inappropriate farming practices [31]. The lack of knowledge and negative attitudes about milk standards at the farmer level significantly affect food loss [32]. Farmer knowledge is needed to change how farming is practiced and facilitate alternative food systems to gain sustainability and food sovereignty [33]. Therefore, farmers knowledge is one factor in improving post-harvest management to achieve safe and quality products (food security) [34].

Knowledge can be gained from many activities, such as agricultural education. It is essential to disseminate the best farming practices for post-harvest operations of perishable products [29]. The knowledge can be gained from tailored educational extension and training programs. The programs are conducted to manage eco-farming practices and innovate in food loss and waste management[35]. The aim is to meet the specifications and needs of smallholder farmers to increase food production, animal health, and economic well-being [36]. Therefore, knowledge of food loss and waste is essential to reach the best handling practices at the farm level to increase productivity [37].

According to the review of previous studies, there are significant gaps in the research on food loss in the milk supply chain that focuses on farmer knowledge. The existing research mainly focused on food loss mitigation at the farmer level. Therefore, this study attempts to examine the effect of farmer demographics on their knowledge of food loss in the milk supply chain. The study aims to fill the gap in the previous studies about food loss mitigation in the milk supply chain. The study offers significant contributions regarding potential mitigative action from farmers' perspectives and knowledge. Therefore, the following hypothesis is proposed below:

H1: Farmer demographics affect their knowledge of food loss in the milk supply chain.

2. METHODS

The study was conducted in Banyumas, Indonesia. Banyumas Regency was chosen because there is a research center for milk cattle, and most of the cattle are Frisian Holstein (FH) [21]. Food loss is in the milk supply chain, especially at the farmer level. The population size of milk farmers in Banyumas is forty, based on data from MILBA (milk cooperative in Banyumas), and all of them are involved in this study as research respondents. The method used was quantitative, and the data collection period was from January to March 2022. The researchers conducted a face-to-face survey among respondents to collect data using a questionnaire, where their responses were recorded in Google Forms by the researchers.

A questionnaire contains demographics and farmer knowledge. The demographics included the number of productive cattle, daily milk production, cage area, and estimated daily spilled milk.

Twenty items of farmer knowledge questions are divided into five practices: production, harvesting, warehousing, inventory management, and transportation. A 7-point Likert scale was used to measure the farmer's explanation of each criterion, which can be seen in Table 1.

Table 1: Farmer knowledge criteria.

Practice	Code	Criteria
Production [27]	P1	Adequate animal feed
	P2	Animal health conditions
	P3	The given animal feed
Harvesting [27]	H1	Milking preparation
	H2	Hand milking activity
	H3	Pouring milk into the milk can
	H4	Collection system type
	H5	Hand milking
	H6	Transferring milk to a cooling tank
Warehousing [38]	W1	Storage infrastructure
	W2	Cold storage infrastructure
	W3	Storage activities
	W4	Storage handling activities
Inventory management [38]	I1	Material handling equipment
	I2	Manual handling
	I3	Storing milk into cooling tanks
Transportation [38]	T1	Transport conditions
	T2	Cold chain transport equipment
	T3	Transport handling
	T4	Road condition

Moreover, the researchers tested the validity and reliability of the data. Pearson's Correlation was used to test validity, while Cronbach's Alpha was used to test reliability. The researchers also performed a normality test to check whether the data followed a normal distribution. The effect between farmer demographic and their knowledge criteria was analyzed using ANOVA.

3. RESULTS AND DISCUSSION

3.1 Demography of Respondents

The total number of respondents for this study is 40, from two milk farmer groups and one cooperative. The milk farmer group is Tumiyang and Kemutug Lor. Most respondents have between one and four productive cattle, with a daily production of about 1 to 30 liters. The cage area is between 1 and 30 m^2 (35%), and the most spillage that occurred among the farmers studied was around 501 to 1000 cc/day (42.5%) (Table 2).

Table 2: Farmer demography.

Factor	Amount	N	Percentage (%)
Productive cattle	1-4	31	77.5
	5-8	6	15.0
	9-12	2	5.0
	>13	1	2.5
Daily milk production (Liter)	1-30	23	57.5
	31-60	8	20.0
	61-90	4	10.0
	>91	5	12.5
Area (m^2)	1-30	14	35.0
	31-60	9	22.5
	61-90	7	17.5
	91-120	7	17.5
	>121	3	7.5
Spillage (mL)	0-500	11	27.5
	501-1000	17	42.5
	1001-1500	7	17.5
	>1501	5	12.5

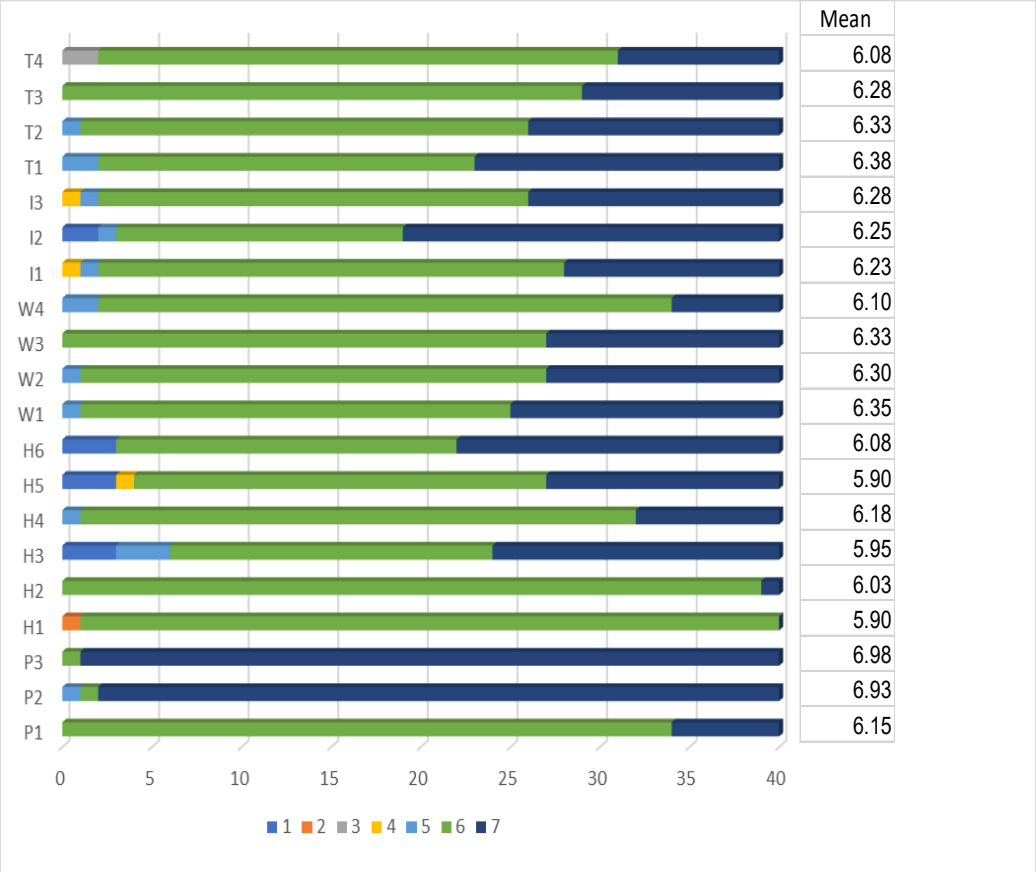
3.2 ANOVA Result

Before conducting ANOVA, this study tested the data's validity, reliability, and normality. Table 3 shows that all criteria except P3, H1, H2, and H4 are valid. Therefore, the researchers eliminated those responses and then calculated the reliability test. The results showed that all practices are reliable because Cronbach's alpha values are more than 0.7. Furthermore, the researchers retained inventory management even though the value was less than 0.7 because it was considered moderate and acceptable, respectively [39].

Table 3: Results of validity and reliability of data.

Practice	Code	Validity Person correlation (p-value)	Reliability (Cronbach's alpha)	Skewness	Kurtosis
Production	P1	0.000	0.7813	-1.58	4.87
	P2	0.000			
	P3	0.921			
Harvesting	H1	0.808	0.8592		
	H2	0.808			
	H3	0.000			
	H4	0.090			
	H5	0.000			
	H6	0.000			
Warehousing	W1	0.000	0.7602		
	W2	0.000			
	W3	0.000			
	W4	0.006			
Inventory management	I1	0.007	0.6635		
	I2	0.000			
	I3	0.000			
Transportation	T1	0.000	0.7495		
	T2	0.004			
	T3	0.002			
	T4	0.000			

The normality test result referred to skewness and kurtosis values. The skewness was -1.599, and the kurtosis value was 4.812. If the kurtosis values were between -2 and +2, it is considered acceptable to prove normal distribution [40]. The data was regarded as a normal distribution if the skewness was -2 to +2 and the kurtosis was -7 to +7 [41], [42]. Therefore, the data of this study fulfill standard distribution requirements.



Note: mean between 1-3= low, 4-5= medium, 6-7= high

Figure 1: Questionnaire summary result.

Figure 1 depicts the mean score of each response regarding food loss in the supply chain. Based on farmer opinions, the milk supply chain's most common causes of food loss are cattle health (P2) and cattle feed (P3). Based on the farmer's opinion, the less common causes of food loss are manual milking (H5) and milking preparation (H1).

Table 4: ANOVA results.

Demography	Criteria	P-value
Cage Area	Pouring milk into milk can	0.014
	Hand milking	0.005
	Cold chain transport equipment	0.009
	Road condition	0.003
Daily Milk Production	Storing milk in cooling tanks	0.012
	Cold chain transport equipment	0.009
	Road condition	0.007
Spillages	Storage infrasturcture	0.021
	Road condition	0.006
Productive cattle	Pouring milk into the milk can	0.000
	Hand milking	0.001

Table 4 shows a significant correlation between demographics and farmer knowledge in the milk supply chain. In the cage area, there are four significant responses. It means that different cattle areas affect the pouring milk (H3), manual milking (H5), cold chain transport equipment (T2), and road conditions (T4).

Most cage areas are 1-30 m^2 to 31-60 m^2. This means that farmers have limited space for milk pouring and manual milking. Furthermore, the cattle are both productive and non-productive, male and baby cattle. Therefore, the farmer needs more space for hand milking and pouring into the milk can. Those reasons have a similar significant response to many productive cattle factors. Various productive cattle significantly affect pouring milk (H3) and manual milking (H5).

Other challenges for the cattle area are cold chain equipment and road conditions. Each farmer relies on the provided cold chain by the milk cooperatives. Therefore, they must distribute the milk soon after the milking and canning process. Unfortunately, the farmer has no additional cold chain equipment to maintain the milk quality.

In daily milk production, there are three significant responses, which indicate that different amounts of milk production have a significant response to proper storage (I3), cold chain transport equipment (T2), and road conditions (T4). Furthermore, the daily schedule for milking production is in the morning and afternoon. The number varies based on the cattle's capability. Therefore, farmers respond differently regarding proper storage, cold chain transport equipment, and road conditions. The supporting infrastructure must be well developed to increase supply chain efficiency. Most farmers produce 1-30 Liters daily; the rest make more than 30 Liters. Farmers must support cold chain transport equipment, storage, and proper road conditions to maintain their milk quality. It is similar to the spillage factor and represents a different amount within farmer practice that significantly responds to adequate storage infrastructure (W1) and road conditions (T4).

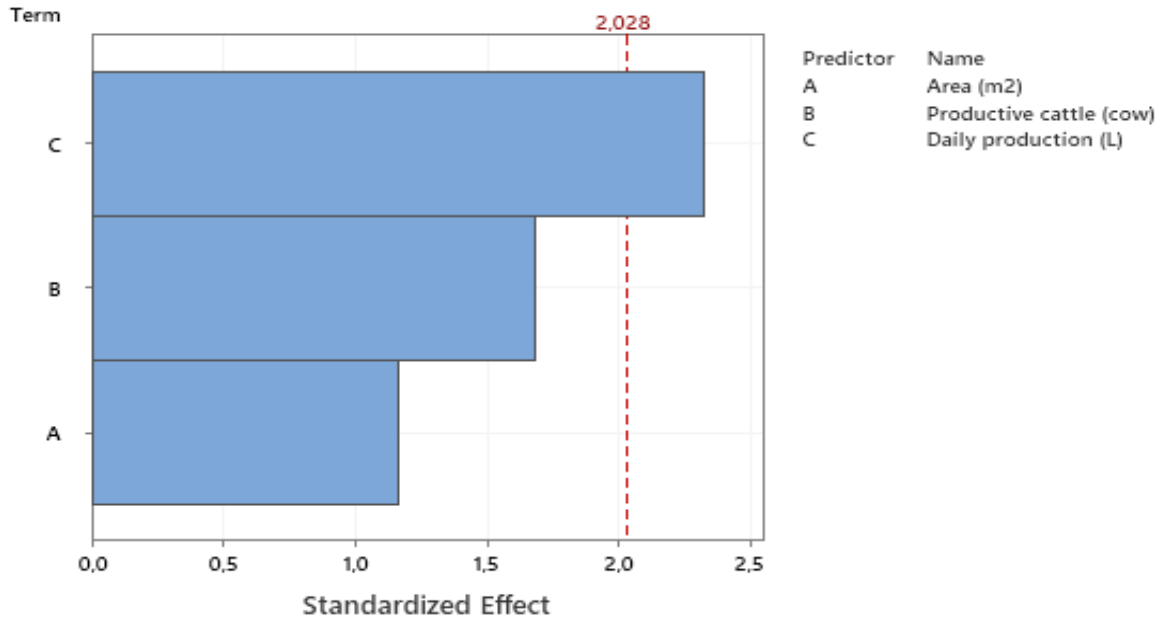


Figure 2: Pareto chart of standardized effects from spillage response.

Figure 2 shows the amount of milk spillage that is affected most by daily production. Other predictors, such as cattle area and the number of productive cattle, do not affect milk spillage. According to farmers involved in this study, the activities that caused the spillage most were pouring milk into a milk can, manual milking, transferring milk from a milk can into a cooling

tank, and hand milking (Table 5). The cause of the most spillage is the manual milking process, with 31.2%, and pouring milk into the milk can be 29.2%.

Table 5: Production practices and milk spillage.

Production practice	Mean	CI (95%)	Percentage (%)
Pouring milk into a milk can	267.5	209.4-325.6	29.2
Manual milking causes	286.3	216.7-355.8	31.2
Transferring milk to a cooling tank	187.5	134.9-240.1	20.4
Manual milk handling	176.3	132.2-220.3	19.2

3.3 Practical Implications and Contributions

The milk supply chain in Indonesia starts with farmers whose supplies are collected by a cooperative. The milk will be stored in a cooling tank at the cooperative and then transferred to the milk industry using a milk truck. After producing specified products, the milk will be distributed to retailers, wholesalers, and customers [43]. The milk industry requires high-quality fresh milk. Therefore, farmers should produce milk according to industry standards.

Based on the statistical results, several main factors caused food loss in the milk supply chain. The first factor is the space limitation of the cattle area. Java Island, Indonesia, has limited land for cattle raising. As a result, farmers use cattle sheds and do not allow their cattle to graze freely. Therefore, farmers should clean the area before milking to keep the process hygienic [23].

The high number of cattle will affect cattle shed expansion. Farmers are raising males and calves to regenerate fresh milk productivity. Farmers cannot use the automated milking process because of area limitations. In addition, their milking farm runs on individual management practices. Farmers handle everything by themselves, from production to depositing to a cooperative.

Furthermore, the challenges for farmers are a shortage of cold chain transport equipment to maintain milk quality and bad road conditions. Farmers found it hard to obtain proper storage after the milking process on a daily milk production basis. Farmers need adequate storage to maintain milk quality and quantity. The other responses are cold chain equipment and road conditions, challenging the appropriate milk supply chain process. The government, as policymakers, can support cold chain equipment and improve road conditions to solve the farmers' problems. Therefore, farmers need an appropriate transportation system to access cold storage and chain availability [29].

According to farmers' studies, most think the food loss within the milk supply chain is only on a quantity-basis. They mentioned four main activities that caused the most food loss. These include pouring milk into a can, manual milking, transferring to a cooling tank, and handling after harvesting. Most food loss occurs during pouring and manual milking, accounting for over 60% of milk spillage. At this point, the farmers mentioned food loss due to milk quality and safety. The farmers follow only routine processes such as milking, transferring to the cooperative, and getting the payment according to the deposited milk volume. Therefore, farmers should be educated about milk quality loss, which refers to cold chain, hygiene, animal health, and safety training [28].

However, farmers had insufficient training or education about maintaining milk quality and safety. They just focused on how to get the milk for maximum volume in the morning and afternoon. The farmers had less training in minimizing food loss in the milk supply chain. Training and educational programs can be achieved to improve food safety and nutritional status, reduce

environmental impact, improve productivity and economic growth, and enhance awareness of processing techniques [44]. In this situation, the farmers focus on productivity and economic growth only.

Nevertheless, the training can improve farmers' knowledge, attitude, and practice. The improvements are achievable with cooperation among stakeholders in the supply chain. The program can be enhanced through a sustainable intervention strategy relying on intensive public-private partnerships and incentives for small stakeholders [29].

Moreover, the supply chain collaboration will lead to sustainability and innovation in the milk industry supply chain [26]. The awareness of food loss, both quality and quantity, could become a trigger for the development of mitigation initiatives [20]. Stakeholders can work with farmers to develop concepts that support the government's target. The government can work as policymakers, and farmers can explain the product to customers to better understand it. Therefore, the mitigation strategy shall be conducted through collaboration to minimize cost and gain customer value [45]. One of the approaches is that the supply chain actor can develop effective communication and cooperation with farmers by adopting lean waste production and implementing clear supply chain regulations [46]. The strategy can be started with education about food loss in the milk supply chain, which is essential to learn the best agricultural practices for post-harvest milk activities [29].

4. CONCLUSIONS

The primary purpose of this study is to examine the effect of demography on farmers' knowledge of food loss in the milk supply chain. The study found several factors that influence food loss. These factors include the cattle shed area, daily production, spillages, and productive cattle. The results show that farmer knowledge contributes to food loss in the milk supply chain. The knowledge is about includes pouring milk into a can, milking it manually, transporting it with cold chain equipment, storing it in milk storage, and transporting milk under specific road conditions.

Moreover, the results inform us which activities cause the most food loss. Based on farmers' opinions, they mentioned four activities: pouring milk into a milk can, manual milking, transferring into a cooling tank, and manual handling. All the opinions mentioned are related to milk quantity loss instead of quality loss. However, they must maintain knowledge of high quantity and quality standards before transferring or distributing milk into a cooperative. The mitigation strategy shall be conducted by developing effective communication and collaboration with farmers by implementing clear supply chain regulations. The strategy can be started with education about food loss in the milk supply chain, which is essential to gaining the best agricultural practices in the milk supply chain.

Therefore, to achieve the national target, the government and stakeholders must develop guidelines and strategies to mitigate and minimize food loss by identifying the supply chain activities where the most food loss occurs. This can be achieved through optimizing field extension workers to guide and educate farmers on the best practices to maintain milk quality and safety.

Future research can focus on farmers' understanding of food loss quality and quantity in the milk supply chain. The research can include cooperatives as the leading actors in maintaining the milk standard before distributing it to the milk processing industry. In addition, farmers shall gain sufficient training about food loss standards and safety instead of only quantity and economic growth. The training should improve farmers' practices, understanding, and attitudes by measuring effectiveness. Moreover, there is a need to investigate the negative impact of training and awareness to gain more comprehensive knowledge about food loss in the milk supply chain.

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