Systematic review on mitigation of food loss and waste in the milk supply chain

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Abstract. One of the challenges of food security programs is reducing food loss and food waste in the supply chain. Food loss and waste (FLW) are not only about quantity loss but also quality loss throughout the milk supply chain. Therefore, a mitigation program is necessary to prevent FLW. This article discusses a systematic literature review on food loss and waste mitigation in the milk supply chain. The review is based on the ROSES (Reporting Standard for Systematics Evidence Synthesis) standard. The study selects articles from two primary databases, Web of Science and Scopus, and three additional databases: Science Direct, Google Scholar, and Dimensions. The review was divided into three themes based on the causes of food loss and waste: animal health, actor performance, and managerial approach. This paper suggests several significant contributions to the body of knowledge and practice. The findings highlight that collaboration among supply chain stakeholders is essential to mitigate FLW. This review gives new insight into FLW phenomena in the milk supply chain and it offers an alternative for the supply chain actors to identify the mitigation strategies.

1 Introduction

The human population is expected to reach 9.8 million in 2050, and food security should be maintained [1]. Due to this, one of the challenges of food security programs is reducing food loss and waste (FLW) at the supply chain level [2]. Food loss occurs due to a mismatch in product quality between supply and demand, lack of proper cold transportation and, improper handling [3]. In contrast, food waste is related to the spillage of edible food mass after harvesting until the post-consumption stages [4]. This study used the milk supply chain as a case because it is an important source of essential nutrients [5]. The loss of milk from primary production accounts for 5.6-8.2% of the whole supply chain [6].

The milk supply chain is facing many challenges in preventing FLW, especially in consumption (demand side) and production (supply side) [7]. In the United States, the supply loss of milk was around 12% at retail and 20% from cooking, milk spoilage, and waste at the customer stage [8]. In France, the estimated loss is around 12%. High milk loss

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was caused by mastitis (inflammation of cattle breast) and resulted in additional medical treatment costs in production. [9]. In Uganda, food and nutrients lost in the milk supply chain were estimated at 14%. At the farmer level, this was due to split milk.

According to the review of previous studies, there are significant gaps in research on mitigating FLW in the milk supply chain. Few studies about specific FLW prevention strategies in the milk supply chain were mentioned. Therefore, this study reviews the mitigation of FLW in the milk supply chain. The review is guided by the main research question, "*What are the mitigation strategies to combat food loss and waste in the milk supply chain*? The study aims to fill the gap in the previous reviews about FLW mitigation. The study offers significant contributions regarding the mitigation strategies that can be used by actors in the milk supply chain, including farmers, processors, the milk industry, and the government.

2 Methods

2.1 The ROSES as the review protocol

This study was conducted based on reporting standards for the systematic evidence synthesis (ROSES) review protocol. ROSES aimed to help the reviewer gain relevant methodological information about the reviewed articles [10]. The authors conducted the review process, which included searching, screening, eligibility, critical appraisal, and data abstraction and analysis according to the review protocol that can be seen in Figure 1.

Fig. 1. Systematic searching steps.

2.2 Search strategies

The search strategies were divided into five steps, as shown in Figure 1. The first step was the identification, and this research identified any synonyms and related terms of the main keywords of "mitigation" and "milk supply chain." The keywords were suggested by journal databases such as Scopus and Google Scholar. This study managed the keyword into search strings in two primary databases (SCOPUS and Web of Science) (Table 1).

Table 1. The search strings.

Database	Search string
Scopus	TITLE-ABS-KEY (("food loss*" OR "food waste*" OR "food loss* and waste*") AND ("mitigation" OR "prevention" OR "reduce*" OR "minim*" OR "imply*" OR "impact*" OR "fight*" OR "combat*" OR "concern*" OR evaluat* OR convers* OR "measur*" OR "treat*" OR "secur*" OR "asses*" OR "manag*") AND ("supply chain") AND ("dairy" OR "milk" OR "breast" OR "cow"))
Web of Science (WoS)	TS= (("food loss*" OR "food waste*" OR "food loss* and waste*") AND ("mitigation" OR "prevention" OR "reduc*" OR "minim*" OR "imply*" OR "impact*" OR "fight*" OR "combat*" OR "concern*" OR evaluat* OR convers* OR "measur*" OR "treat*" OR "secur*" OR "asses*" OR "manag*") AND ("supply chain") AND ("dairy" OR "milk" OR "breast" OR "cow"))

This literature review used a Boolean operator, truncation, and a wild card to enrich the

search method. Moreover, this review added three additional databases (Google Scholar, Science Direct, and Dimensions) to gain more manuscripts related to the subjects. The resulting documents were 73 documents. The next step was screening. In this step, the study inserted the limitation and chose the documents related to the research question. The authors excluded the records published before 2013 and eliminated books, book chapters, and non-English documents. This review also eliminated duplicate documents from those databases. There were 45 remaining articles (Figure 1). The third step was eligibility. The authors manually checked to ensure that the remaining articles followed the criteria. The step was completed by reading the title and the abstract. The review eliminated the articles that did not focus on mitigating FLW in the milk supply chain; the remaining articles were 23. The next step was the quality appraisal to ensure the quality of the articles and 20 articles remained. The last step was data abstraction and analysis. The authors used to synthesize and analyze integrative data, and the remaining articles were 18 documents.

3 Results and discussion

3.1 Selected articles background

All the selected articles were published between 2013 and 2023. Four articles focused on the effect of animal health on milk production. Meanwhile, five studies focused on the actor's performance and waste, and nine concentrated on the managerial approach within the milk supply chain.

3.2 Article themes

3.2.1 Animal health

Animal health studies emphasized veterinary treatment, which can affect milk quality and spillage. Most veterinary treatments are for mastitis disease, an inflammation of the breast due to infection [11] and it constitutes around 76% of all animal diseases. Other diseases are uterine disorders and cattle lameness [9]. Applying veterinary medicine for mastitis shall follow the relevant standards to maintain milk quality, and udder health can be maintained by increasing farmer knowledge through education or training and economic incentives from the government [12], and the program can be achieved by collaboration among farmer groups or cooperatives as a farm advisory service [13].

3.2.2 Actor performance

The second cause of FLW in the milk supply chain is actor performance. The actor performance is divided into two: upstream and downstream. Upstream starts from producer to processor, and downstream emphasizes the retailer until the customer stage [4]. At the upstream, the source of food loss is farmers' financial stability [14]. Some researchers found that the lack of farmer access to producers and poor distribution systems influence the loss and waste [15]. At the downstream, it was revealed that actor performance at the retail level can influence milk loss and waste. The waste can be caused by post-purchase awareness by the customer, promotion sales, and product turnovers [16]. Some of them are less familiar with nutrition loss knowledge within the supply chain [17].

3.2.3 Managerial approach

Managerial approaches refer to a lack of technology and automation, less order quantity, employee expertise, fewer product variations, and a lack of optimal storage capacity [18]. Some scholars emphasize that the cause of FLW in the milk supply chain is a lack of storage and handling due to inadequate cooling tanks and a lack of cold chain management [19]. By working on a cold chain system, there is the possibility to measure food waste reduction measurement based on some methodological considerations in food loss and waste [20]. Therefore, implementing those systems will reduce wastage, decrease financial losses, and minimize environmental impact [21].

3.3 Discussion

This review discusses FLW mitigation strategies in the milk supply chain. This review divides the thematic analysis into animal health, actor performance, and managerial approach. Each level of the milk supply chain has different mitigation strategies due to its complexity. Australia shows that from 8,554 million liters of produced milk, FLW most occurs at the manufacturing stage (Figure 2) [22].

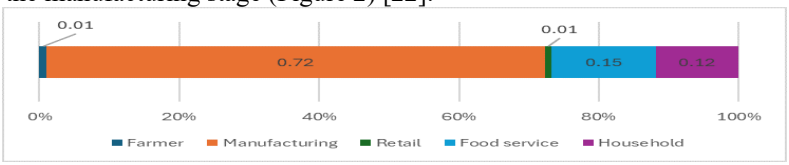

Fig. 2. Food loss and waste in each stage of the milk supply chain.

For farmers, the leading supply chain practices are production and harvesting. Food loss and waste can be mitigated by veterinary treatment and by developing integrated strategies for animal disease management [23]. The most common disease is mastitis which results in 0.6% of produced milk being rejected due to antibiotic contamination [11]. It is aligned with the World Organisation for Animals, which mentions that animal disease management can control diseases at animal sources, early disease detection, and rapid response mechanisms such as vaccination to mitigate food loss and waste [24]. Furthermore, farmers should improve their farming practices and adopt technology such as automatic milking machines to reduce production and harvesting loss [25]. On average, the automatic milking machine produced 1 kg per day more milk than conventional ones but there is no effect of the fatty acid concentration from milk content [26]. However, the challenge is insufficient knowledge for farmers and the availability of small farm sizes [27]. It can be approached by advisory services [13], harvest machinery improvement, and new harvest strategies [28].

At the processor level, they conduct cold storage and practice good distribution, which is essential. The role is to mediate farmers and the milk industry to maintain quality and quantity [29]. They must minimize the loss in milk storage and improve milk handling activities by providing storage facilities and cold chain systems and installing harvesting technologies at the farmer level [30]. The actual process of storage and distribution is simple. The milk is transported and inserted into cooling tanks and it is stored at a temperature not higher than 4^0C [31].

At the milk industry level, cold storage and the implementation of a sound distribution system are essential to reach the retailer at the right time and quantity. The industry can provide efficient packaging to reduce wastage [32]. It aligns with developing sustainable packaging to extend milk shelf life, reduce material usage, and make it biodegradable to be profitable for economic and environmental reasons [33]. The milk industry must also sell appropriate products by considering the product life cycle, designing optimal logistics

services, and developing regional coordination in the supply chain [34]. Furthermore, at the consumer level, the essential thing is customer behavior. They should buy milk based on their needs and avoid misleading expiry dates to prevent food waste. It can increase their awareness of buying safe food products for a long time from 1% to 1.19% [35].

Moreover, these systematic reviews show the significant contribution to the mitigation strategies of the cause of FLW in the milk supply chain. This review gives new insight into FLW phenomena in the milk supply chain. Collaborating with stakeholders offers an alternative for the supply chain actors to identify the mitigation strategies for FLW in the milk supply chain. Then, it is essential to enhance their awareness of its social, economic, and environmental impact. Most of the reviewed articles positively impact mitigating FLW in the milk supply chain. Future scholars can investigate the negative appraisal if the mitigation programs are applied. For example, adopting new technology for automation to improve milk storage capacity will place a financial burden on the producer or farmer level.

4 Conclusions

The primary purpose of this review is to find mitigation strategies to prevent food loss and waste in the milk supply chain. The review is divided into three themes: animal health, actor performance, and managerial approach. The review shows that the mitigation strategy for animal health is veterinary treatment. Then, the mitigation strategies for actor performance are collaboration among all supply chain actors, and the managerial approach is adopting technology that supports product quality and collaboration among supply chain stakeholders. This review is significant for scholars to gain new perspectives about mitigating FLW in the milk supply chain. Scholars can use the gap to research food loss and waste mitigation. This review gives new insight into food loss and waste phenomena in the milk supply chain. It offers an alternative for the supply chain actors to identify the strategy of mitigations for FLW in the milk supply chain. Future research can focus on each supply chain activity that causes food loss and waste from farmers to customers. The activity can be divided into upstream and downstream supply chain levels. Furthermore, the negative impact of implementing existing recommendations shall be measured to gain more comprehensive knowledge about challenges in mitigating FLW in the milk supply chain.

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