sustainability

Article

Containerized Grain Logistics Processes for Implementing Sustainable Identity Preservation

Young Joo Kim [1,2] and Byung Kwon Lee [1,*]

[1] Innovative Transportation and Logistics Research Center, Korea Railroad Research Institute, Uiwang 16105, Korea
[2] Department of Transportation Systems Engineering, University of Science and Technology, Daejeon 34113, Korea
* Correspondence: leebk@krri.re.kr; Tel.: +82-31-460-5419

Abstract: Grains are often exposed to unprotected environment during post-harvest logistics processes. Since grains are usually accommodated in silos on farms, when importing grains, they are transported to silos or yards at ports by heavy vehicles, and imported to another country (or region) by bulk carriers. Thereafter the grains are stored at silos and transported in bulk or tone-sacks by heavy vehicles. The grain quality often deteriorates due to unprotected storage and transportation environment through the logistics processes, whereby they become affected by insects, pests, rancidity, discoloration, and so on. This study examines a containerized grain logistics contributing to well-known identity preservation, analyzes the applicability in terms of logistics cost, and discusses potential effects on sustainability improvement by tracing and preserving the grains for a longer duration in well-protected spaces during the logistics processes. This study introduces the necessity of preservation containers to implement the containerized grain logistics to prevent quality deterioration. A comparative cost analysis is conducted to investigate the effect of the containerized grain logistics. According to the comparative analysis, conventional bulk logistics has benefits in shipping (76.2%) and storage costs (89%), whereas the containerized logistics has economic viability in tariff (23.2%) and infrastructure costs (51.2%).

Keywords: grains; logistics processes; preservation containers; logistics cost

Citation: Kim, Y.J.; Lee, B.K. Containerized Grain Logistics Processes for Implementing Sustainable Identity Preservation. *Sustainability* **2022**, *14*, 13352. https://doi.org/10.3390/su142013352

Academic Editors: Paolo Prosperi and Iuri Peri

Received: 25 July 2022
Accepted: 1 October 2022
Published: 17 October 2022

1. Introduction

World grain trade is defined in terms of grain type. Wheat (with 44.7% market share) is the most traded food grain in the world market, followed by beans (24.9%) and maize (15.3%), as per the 2016–2020 statistics queries of Production, Supply and Distribution (PSD) in the United States Department of Agriculture [1].

The basic characteristic of international trades is that the producer country uses the required quantity of grains as the primary consumer and exports the rest of its yield. According to Chatham House's Resource Trade [2], the world grain trade amounted to USD 148 billion in market value and 552 million tons in weight in 2020. The main (representative) trade commodities were typically wheat, maize, rice, and barley. There were various producer and consumer countries for wheat, with none of them being dominant in either category; however, China occupies 59% (in market value) of world trade for soybean import, while the United States is the largest exporter of maize (24.4% in market value) in the world. Mexico and Japan were recorded as the biggest maize importers, 27.9% and 19.2%, respectively, as per market value.

The grain market has a few exporting countries and various importing countries. This implies that international trade is imperative for the grain importing countries to be able to meet their local demand (e.g., foods, biofuels, feedstuff); therefore, the logistics processes need to be clearly identified and improved to enable the efficient import of grains.

Market trade records, plotted in Figure 1, show that, with respect to market value, the global grain trade temporarily declined in 2015–2016, due to oversupply and recovered thereafter; however, the trade quantity, in terms of weight, has been increasing progressively. The continuous growth in market weight has been driven by many countries importing grains.

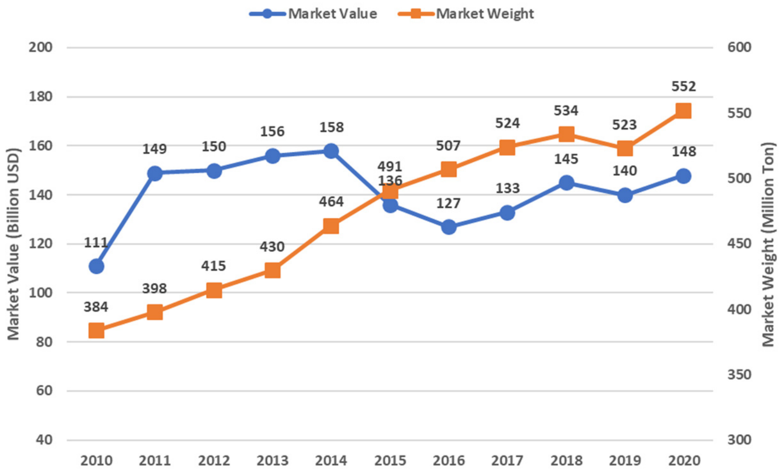

Figure 1. Market trade during 2010–2020 [2].

The market trade records for grains shows that the demand of logistics activities for grains has been continuously increasing, which indicates that the preservation requirement should be subsequently supplemented. To improve grain preservation throughout logistics processes, this study aims:

(1) To review conventional logistics processes, when importing grains from farms to customer markets (Section 3);
(2) To identify conditions and factors diminishing the grain quality (Section 4.1) throughout the logistics chain to specify the requirement of preservation containers (Section 4.2);
(3) To suggest an enhanced logistics process, using preservation containers (Section 4.3);
(4) To investigate and comparatively analyze the logistics cost from various perspectives (Sections 5.1–5.4) to examine the feasibility and efficacy of the enhanced logistics process with preservation containers (Section 6).

This study primarily aims to investigate the practical feasibility of deploying preservation containers as integrated units of storage and transportation during the logistics activities at grain markets. A number of activities of grain logistics would be necessarily revised to fully utilize the advantage of preservation containers in grain quality. To the best of the authors' knowledge, this is the first study to present the comparative cost analysis of using preservation containers in grain logistics. Therefore, this study proposes an enhanced logistics process using preservation containers and analyzes the economic viability.

The rest of this paper is organized as follows: Section 2 reviews the existing relevant literature; Section 3 identifies challenges in the current logistics processes for grains; Section 4 addresses the necessity of preservation containers and the expected effect in improving the logistics processes; Section 5 comparatively analyzes logistics cost for grain import process with and without preservation containers; Section 6 discusses the logistics improvement based on the findings from Section 5; and finally, the discussions and conclusions are presented in Sections 7 and 8, respectively.

2. Literature Review

There is little research in the areas of logistics processes of grains. Fredriksson and Liljestrand [3] extensively reviewed previous studies from the perspective of the four areas of distribution, production, procurement, and relationship management to clarify food logistics and identify research areas. They defined food logistics within a food supply chain context by problematizing food product characteristics and by examining the constellation of food supply chain actors. Mardaneh et al. [4] examined different supply chain pathways for grain logistics by developing a decision support system, and the results showed that on-farm storage reduces harvest duration and yield losses, increasing the total yield, as compared to bulk storage. De Oliveira et al. [5] assessed the efficiency of long-distance logistics routes for soybean export. The results suggested the need for investments in trans-shipment terminals near the production areas as well as the availability of intermodal transportation for the export of soybean. Recent studies have also been conducted to facilitate agri-food supply chains by utilizing blockchain technologies [6–8].

Research has been conducted on the import sustainability of the grain market in Korea, as the grain market is highly imbalanced. The market has a few representative exporting countries and several importing countries. The Korean grain consumption market is highly dependent on international trade; the reported dependency level reached 76.6% (i.e., 7th rank in the world) in 2019 [9]. Yun et al. [10] analyzed the long-term importing trend of grain economics and found that the grain market progressively increased with wheat, maize, and soybean showing 2.0%, 1.8%, and 2.1% of unit price (USD/ton) increases over the period of 2019–2028. Kim et al. [11] suggested that government agencies in Korea need to be aggressively involved in the grain supply chain for import market sustainability.

While the grain market has been growing, post-harvest losses have negatively impacted the grain supply chain [12]. The post-harvest losses during the processes of transport, pre-processing, storage, processing, and packaging accounted for as much as 50% of the grain quantity [13]; for instance, it was estimated that up to 400 million metric tons of grain, constituting about 20% of global grain production, were lost in 2018 [14]. Nourbakhsh et al. [15] discussed that a reduction in post-harvest losses requires costly infrastructure investment and grain processing; hence, it is critical to find the optimal extent of reduction to maximize the overall benefits from different stages of the supply chain. Gardas et al. [16] highlighted that three factors, namely "lack of proper packaging facilities," "lack of proper storage facilities," and "insufficient infrastructure," were the most significant ones leading to post-harvest losses in the fruit and vegetable supply chain in India. Bendinelli et al. [17] empirically investigated the representative factors contributing to post-harvest losses of grains (rice, maize, soybean, and wheat) and found that insufficient post-harvest infrastructure, especially in food storage and food marketing, could lead to higher post-harvest losses. Faibil et al. [18] found that the main drivers of post-harvest losses in raw cashew nuts were the lack (or insufficient use) of proper packaging materials and insufficient drying technologies and materials. Anand and Barua [19] addressed the key factors of post-harvest wastage of fresh fruits and vegetables under five operational features: demand forecasting, production planning, transportation, inventory, and inefficient harvesting. They recommended that traceability is a tool for enhancing safety, quality, and sustainability while lowering the overall cost of the produce by reducing its recall possibilities. Dyck et al. [20] supported the finding that digital twins can enhance traceability in post-harvest logistics. Luo et al. [21] provided an extensive literature review for articles on food loss and wastage during the various stages of the food supply chain, such as production, post-harvest handling and storage, processing, distribution and retail, and consumption, and identified research themes from text mining.

The literature review summarizes that storage and monitoring systems dedicated to grain logistics processes are the primary requirement to prevent quality deterioration and loss, and it is required that these be reviewed, instead of handling the grain in bulk throughout. This research attempts to discuss the logistics process improvement for grains using the newly developed preservation containers. The preservation containers are an emerging prototype that will be deployed to implement identity preservation. Note that the identity preservation is typically known as the practice of segregating crops to maintain their specific traits from the planting and production process through processing, packaging, and ultimately the delivery of the crop to the end market [22].

This research promotes the enhanced logistics process using preservation containers for the identity preservation of grains. The preservation containers could improve the logistics process by promoting traceability and quality control, which is in line with identity preservation. Hence, this research contributes to food sustainability in grain supply chains.

3. Problem Identification: Logistics Processes for Grains

The post-harvest logistics processes include inland transportation in the producer countries, international shipping, and then inland transportation again in the consumer countries. The storage activities are also frequently required along the logistics process of grains.

When investigating major grain-producing countries, as shown in Figure 2, the post-harvest action for grains begins by keeping the grains in storage facilities (e.g., country elevators, silos) on the farms. Thereafter, the bulk cargo (of grains) is transported by heavy vehicles to silos at the seaports for international transportation.

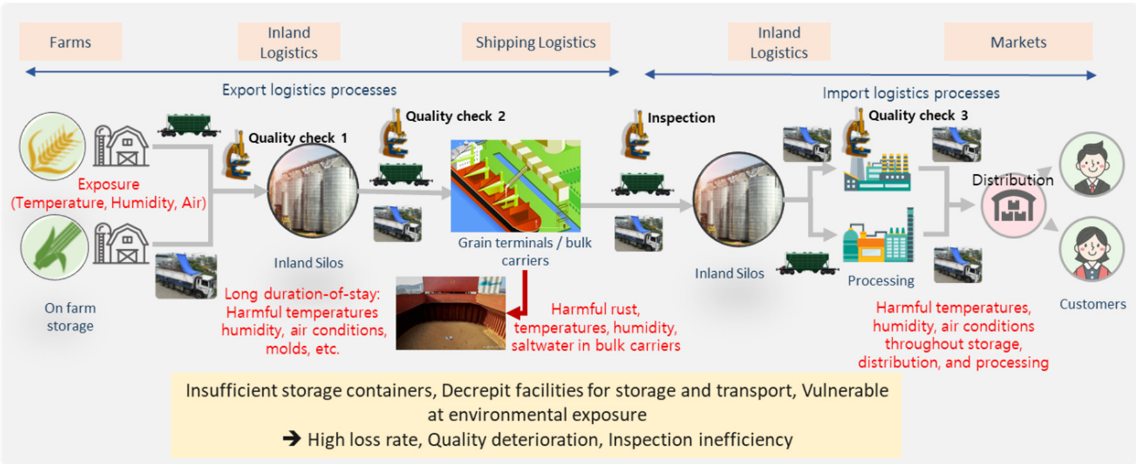

Figure 2. Conventional logistics processes for grains.

Major ports have dry-bulk terminals dedicated to grain cargo handling, wherein dedicated facilities are installed for grain transfer between bulk carriers and storage facilities; however, most of the ports store tons of imported grains at open yards. Bulk carriers are the most representative mode of transportation for international or long-distance domestic logistics. Sometimes barge carriers are used for short-sea logistics, such as, over the Mississippi River for the domestic market in US middle-north farms.

The grain is often kept in the storage/accommodation facilities for an extended period, as operators want to optimally utilize the capacity of transporters (i.e., heavy vehicles, bulk carriers). The lengthened duration could often lead to deterioration in grain quality, as they are damaged by insects, pests, rancidity, discoloration, and so on, due to long exposure to the natural environment. It is often reported that pesticides are used to mitigate the quality deterioration over the post-harvest processes, and the sprayed pesticides often remain on the grains for delayed chemical decomposition.

As depicted in Figure 3, there are several drawbacks as the grain is transported, using a series of modes of transportation, throughout the import process. The natural accommodation on a bulk carrier likely involves uncontrolled temperatures and humidity caused by saltwater. Silo accommodation is also unsafe. It was reported that farmers in New South Wales in Australia encountered rat infestation at grain silos (https://www.express.co.uk/news/world/1435154/Australia-rat-plague-crops-farmers-news-latest-video-New-South-Wales-vn (accessed on 16 June 2022)). Ports often accommodate the imported grains in the open at storage yards. Heavy vehicles also transport grains in bulk with simple fabric covers (or without covers).

Figure 3. Representative drawbacks of natural accommodation for grains. Link in figure accessed on 30 September 2022.

Besides the open storage space, a tone-sack is known to be a popular storage unit for grains, as depicted in Figure 4. A tone-sack is a giant sack that can carry bulk cargo in tons. It is cheap and convenient to handle but is also easily damaged. The grain storage with tone-sacks at outdated facilities does not offer protection from inadequate temperature and humidity, harmful disease, insects, and so on, and hence accelerates the deterioration of grain quality during the storage process. One of the reasons for these shortcomings in the process is that many firms in the grain storage and transportation industry are small-and-medium enterprises (SMEs); therefore, they are unlikely to maintain high standards of operational practices or facilities for grain logistics, due to limited resources.

Figure 4. Grain storage and handling processes with tone-sacks.

Grains often stay in open spaces (e.g., on bulk carriers, on heavy vehicles, and tone-sacks) without any preservation support for long durations throughout the import process, which is the key cause of quality deterioration. Two different government agencies, the Animal and Plant Quarantine Agency (QIA, https://www.qia.go.kr (accessed on 30 September 2022)) and the Ministry of Food and Drug Safety (MFDS, https://www.mfds.go.kr (accessed on 30 September 2022)), conduct quarantine and inspection activities, respectively, for all imported grains in Korea.

QIA aims to prevent insect and pest infestation when importing grains. If insects and/or pests beyond a certain level are discovered, quarantine actions are exercised as shown in Table 1, for crop protection. MFDS inspects all the imported foods, food supplements, packages, and so on by methods like paper screening, field inspection, close inspection, and random sampling inspection to check if the imported products meet the MFSD standard protocols.

Table 1. QIA quarantine protocols and exercises.

<table>
<tr><th rowspan="3"></th><th colspan="4">Regulated Pests/Insects</th><th rowspan="3">Potentially Regulated Pests/Insects</th></tr>
<tr><th colspan="3">Quarantine Pests/Insects</th><th rowspan="2">Regulated Non-Quarantine Pests/Insects</th></tr>
<tr><th colspan="2">Forbidden Pests/Insects</th><th>Manageable Pests/Insects</th></tr>
<tr><td>Protocols</td><td>Laws (73 clauses)</td><td>Notices (2 clauses)</td><td>Notices (1994 clauses)</td><td>Notices (49 clauses)</td><td>Political-risk assessment (PRA) listing</td></tr>
<tr><td>Exercises</td><td colspan="2">Prohibition</td><td>Disinfection Disposal</td><td>Disinfection Disposal</td><td>Disinfection Disposal</td></tr>
</table>

Source: QIA Plant Protection Act (enforcement regulations).

Unfortunately, the inspection process is usually not known to be too reliable; for example, 64.1% was paper screening, 13.6% was close inspection, and 5.3% was random sampling inspection in 2019, as shown in Table 2.

Table 2. Inspection record in 2019.

	Paper Screening	Field Inspection	Close Inspection	Random Sampling Inspection	Defects Identified	Total
Number of inspections	473,259	125,391	110,532	38,900	1295	738,082
Proportions	64.1%	17%	13.6%	5.3%	0.2%	100%

Source: QIA inspection results in 2019.

The subsequent section further identifies the elements of quality deterioration and suggests a new technology to preserve the grains during the processes of storage and transportation.

4. Methodological Requirement and Solution: Enhanced Logistics Processes with Preservation Containers

This section identifies the factors that diminish the quality of grains during the logistics processes (i.e., transportation, storage), addresses the necessity of preservation containers, and discovers the requirement of improving logistics processes in terms of quality controls.

4.1. Factors Affecting Grain Quality

The grain quality is attributed to the following four factors:

- *Physiological factors*: The respiration rate is attributed to temperatures, oxygen density, and percentages of moisture content. Controlling the oxygen density could help grains retain the quality as well as the percentage of moisture content regardless of temperatures. Trimble [23,24] reported that 5% oxygen density reduces the respiration rate in fruits, and 3% of oxygen density helped restrain pest development in grains.

- *Chemical factors*: The degrees of oxidation and (effect of oxygen and carbon dioxide on) pH levels, respectively, are known to cause acidification and discoloration. Lee [25] tested MA (modified atmosphere) packaging, which resulted in eliminating harmful insects from grains packed in less than 1% of oxygen density. Keum et al. [26] reported that direct sunshine, external high temperature, rains, and wind were of little significance to the quality when the rice was packed in airtight storage. Kim et al. [27] found that a pack of rice retains its desired color hue (chromaticity) and percentage of moisture content for the range of temperatures 10–30°C, when kept in a hermetically sealed space, that is, completely airtight.
- *Physical factors*: Inconsistent temperatures in the storage space and the package negatively contribute to air ventilation, moisture, and humidity, worsening over time. According to Ha et al. [28], the sealed space and control of gas (i.e., oxygen, carbon dioxide, and nitrogen) content and combination provide relatively consistent degrees of relative humidity and respiration rates. Choi et al. [29] found that the respiration rate of rice increases when moisture content and temperature increase.
- *Biological factors*: Typical examples are bacteria, mold, and harmful insects. Their appearance could also be prevented by controlling the combination of gases [30].

Grains are organic products and hence it is required to manage respiration rates to retain their quality. The gas combinations (i.e., oxygen, carbon dioxide, and nitrogen) need to be controlled according to the grain type. Therefore, long-term storage and distribution activities have an insignificant impact on quality deterioration if appropriate technologies are utilized.

Packaging technologies, in the sector of food distribution, are categorized into controlled atmosphere (CA) and modified atmosphere (MA) technologies. CA uses control devices to autonomously control the atmosphere to slow down the respiration speed and prevent microorganisms to retain quality, while MA sets initial atmosphere conditions in the package without devices [26]. The use of CA packages requires sealing of the package immediately after packing and controlling the atmosphere through the desired combination of oxygen, carbon dioxide, and nitrogen as per product type. Likewise, when removing the product, careful ventilation is required to protect the products from sudden changes in the environment.

4.2. Preservation Containers

The high loss rate of grains due to quality deterioration is a representative concern throughout the logistics process. A preservation container is an alternative solution to the problem, by applying the concept of CA packages to grains, in favor of dividing bulk into discrete units for storage and transportation and hence, facilitating logistics processes.

Figure 5 conceptualizes the improved import process for grains. There are various representative advantages of using preservation containers: (i) significant reduction in the need for silo implementation; (ii) avoiding long storage at the yards or silos through use of small-sized container ships for sea-bone trades; and (iii) increased degree of preservation due to shortened duration-of-delivery.

The containerization of grain transportation has been gaining popularity over the last few decades. Around 12% of farm products (e.g., grains, oilseeds) was loaded onto containers in 2012; also, about 12–15% of grains was reportedly being imported from Australia to Asia via containerization, and this trend is expected to grow, according to the USDA [1]. This could be because the concept of "identity-preservation", or differentiating commodities, with strict separation from each other, is being widely adopted for various farm products, and containerization in the shipment process is required to implement the necessary practices for this purpose [31]. In line with the increasing popularity of identity preservation, small quantity transportation in international shipping is beneficial for small markets where giant bulk carriers are not preferable for relatively small-scale grain market stakeholders. They likely use the existing container shipping network (i.e., hub-and-spokes) to import grains via feeder containerships, without establishing service lines for bulk carriers.

Apart from container ships or bulk carriers used for international shipping, the containers used for local surface transfers by heavy vehicles also need to be controlled to achieve the desired level of identity preservation. The necessary control technologies depend on the types of grains and the duration of preservation. The logistics processes could be improved significantly with the introduction of relevant technologies. The next subsection discusses the expected process improvement for grains.

4.3. Improved Logistics Process for Grains

Regarding the technological requirement, the preservation container could provide sufficient environmental controls throughout the logistics processes for grains by monitoring the air condition, controlling nitrogen quantity, and self-provided power supply. A real-time monitoring platform is essential for stakeholders to check the quality status, observe oxygen concentration, and link to the transaction data repository via low-battery wireless communication. It also requires a convenient but minimally exposable structure for sampling, inspection, and quarantine. As for quality management requirements, the preservation container needs to block out open air and humidity, prevent fungal toxins and oxidation, insects, minimize antiseptic treatment, and prohibit rodents. The specification of the preservation is presented in Appendix A.

With the introduction of the preservation container and adoption of the technologies mentioned, the import processes are expected to become simplified, more efficient, and safer, as the storage and transportation activities get significantly reduced. Figure 5 depicts the shortened logistics processes of importing grains. Containerization aids not only in quality management by preserving grains but also in efficiently transporting the grains from one country to another. When it uses inland transportation, the preservation container provides convenience in processing, storing, and distributing the grains.

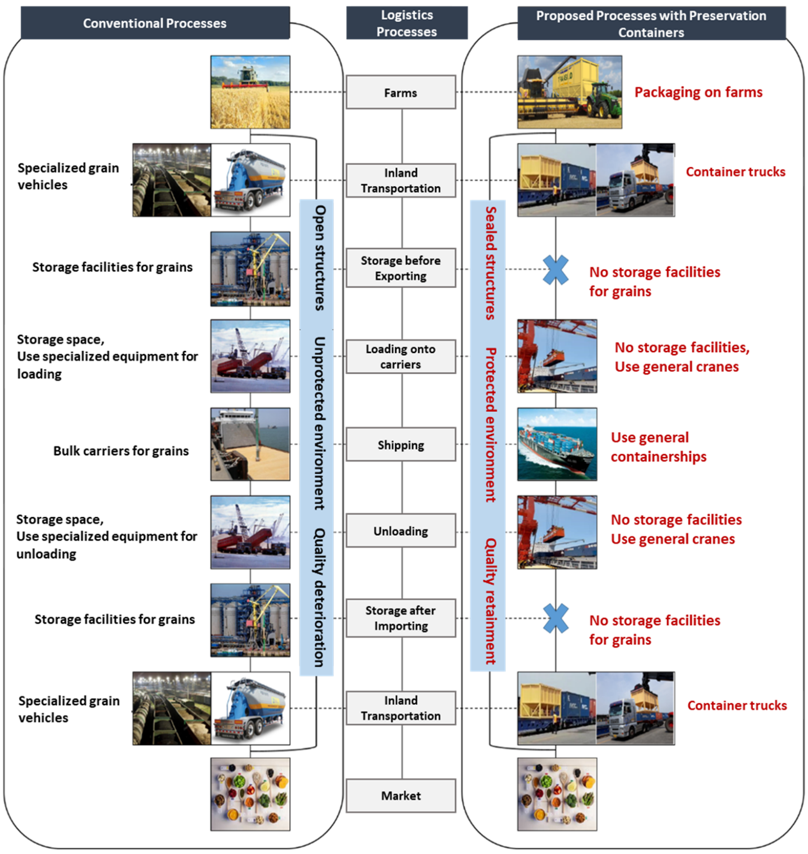

Figure 5. Grain logistics processes with preservation containers.

5. Materials and Methods: Logistics Cost Data and Calculation

Production and logistics costs are the major determinants of market prices, besides margins throughout the pre- and post-harvest processes. Since preservation containers might have insignificant effects on any component of the production cost, this section comparatively analyzes the four logistics cost components to examine the economic viability of the proposed preservation container based logistics process compared to the traditional bulk logistics process for grains. The logistics cost includes international shipping costs, cargo tariffs, and storage and infrastructure costs.

Sections 5.1–5.4 investigate the relevant data for the four cost components, respectively, by providing the reliable references. The cost analysis is then conducted for the same amount of grains to fairly compare the required cost to each other.

5.1. Shipping Cost

Shipping liners use a TEU (20 ft equivalent unit) as the pricing unit for container shipping costs. The shipping cost consists of many elements, but this section considers ocean freight charge (O/F) and terminal handling charges in origin and destination (O/TCH and D/TCH, respectively). Tables 3–6 summarize the shipping cost for reefer and dry containers, for 20 and 40 ft sizes.

As can be observed in Tables 3–6, the shipping cost depends, to a large extent, on the size and types of containers, as well as on the shipping liners. For example, CMA CGM requires KRW 11,594,560 and KRW 10,496,600 for a unit of 20 ft reefer and dry containers, respectively, to transport the unit from Busan to Long Beach by a container ship, whereas Ocean Network Express requires KRW 8,570,000 and KRW 8,101,600 for the two types of containers for the same route. However, a 20 ft dry container (KRW 8,021,700 on average) is the cheapest among the four options, followed by 20 ft reefer (KRW 8,847,211.43 on average), 40 ft dry (KRW 10,024,623.33 on average), and 40 ft reefer (KRW 11,483,549.09 on average) containers.

Table 3. Shipping cost for 20 ft reefer containers.

Shipping Liners	Effective Dates	Container Sizes (In Feet)	Container Types	O/F (In USD)	O/THC (In KRW)	D/THC (In USD)	Total (In KRW)
CMA CGM	18 June 2022	20	Reefer	8377	232,000	500	11,594,560
COSCO	10 May 2021	20	Reefer	4600	232,000	0	6,120,000
HAPAG-LLOYD	15 June 2022	20	Reefer	4866	230,000	0	6,458,480
HAMBURG SUD	15 September 2021	20	Reefer	10,273	370,000	0	13,519,440
MAERSK	1 July 2020	20	Reefer	2110	140,000	500	3,480,800
Ocean Network Express	10 June 2022	20	Reefer	6500	250,000	0	8,570,000
OOCL	1 August 2021	20	Reefer	9340	232,000	0	12,187,200

Note: the shipping cost data were retrieved from https://www.tradlinx.com accessed on 21 Jun 2022, with the service route from Busan to Long Beach, and the exchange rate of 1280 applied to convert USD to KRW. The same goes to Tables 5–7. This study assumed that the shipping cost is the same for the opposite direction of sailing, though it is expected that there is a minor difference in THC.

The shipping cost with bulk carriers is not reported in public, but the Baltic exchange dry index (BDI) (https://www.balticexchange.com/en/data-services/market-information0/dry-services.html (accessed on 30 September 2022)) is widely referred to as the reference for indirectly estimating the cost according to the industry references. The grains are carried by Panamax and Neopanamax ships together with iron ore and coal and calculated in the Baltic Panamax index (BPI). According to an interview with field operators, the cost estimation between Busan and Long Beach is nearly the same as the cost between Mississippi (United States) and Qingdao (China), or between Santos (Brazil) and Qingdao (China). The cost is estimated at USD 79.55 (KRW 101,824) and USD 69.77 (KRW

89,305.6) per ton, respectively, in June 2022, by referring to Shanghai Shipping Exchange (https://en.sse.net.cn (accessed on 30 September 2022)).

Table 4. Shipping cost for 40 ft reefer containers.

Shipping Liners	Effective Dates	Container Sizes (In Feet)	Container Types	O/F (In USD)	O/THC (In KRW)	D/THC (In USD)	Total (In KRW)
CMA CGM	18 June 2022	40	Reefer	8397	326,000	600	11,842,160
COSCO	1 June 2022	40	Reefer	9000	345,000	0	11,865,000
EVERGREEN	1 September 2021	40	Reefer	11,605	330,000	833	16,250,640
HAPAG-LLOYD	15 June 2022	40	Reefer	5863	345,000	0	7,849,640
HMM	15 June 2022	40	Reefer	9000	345,000	0	11,865,000
HAMBURG SUD	1 October 2021	40	Reefer	10,273	370,000	0	13,519,440
MAERSK	15 June 2022	40	Reefer	5300	370,000	0	7,154,000
Ocean Network Express	10 June 2022	40	Reefer	7700	365,000	0	10,221,000
OOCL	1 August 2021	40	Reefer	9072	345,000	0	11,957,160
SM Line	20 June 2022	40	Reefer	8550	346,000	0	11,290,000
YANG MING	15 June 2022	40	Reefer	9500	345,000	0	12,505,000

Table 5. Shipping cost for 20 ft dry containers.

Shipping Liners	Effective Dates	Container Sizes (In Feet)	Container Types	O/F (In USD)	O/THC (In KRW)	D/THC (In USD)	Total (In KRW)
CMA CGM	17 June 2022	20	Dry	7595	135,000	500	10,496,600
COSCO	24 May 2022	20	Dry	6480	130,000	0	8,424,400
EVERGREEN	1 September 2021	20	Dry	4909	130,000	370	6,887,120
HAPAG-LLOYD	15 June 2022	20	Dry	5501	130,000	0	7,171,280
HMM	15 June 2022	20	Dry	6560	135,000	0	8,531,800
HAMBURG SUD	13 April 2022	20	Dry	7875	140,000	0	10,220,000
MAERSK	15 June 2022	20	Dry	4359	140,000	0	5,719,520
MSC	17 June 2022	20	Dry	5320	135,000	0	6,944,600
Ocean Network Express	10 June 2022	20	Dry	6220	140,000	0	8,101,600
OOCL	1 August 2021	20	Dry	5381	130,000	0	7,017,680
SM Line	20 June 2022	20	Dry	6060	135,000	0	7,891,800
YANG MING	15 June 2022	20	Dry	6800	150,000	0	8,854,000

Table 6. Shipping cost for 40 ft dry containers.

Shipping Liners	Effective Dates	Container Sizes (In Feet)	Container Types	O/F (In USD)	O/THC (In KRW)	D/THC (In USD)	Total (In KRW)
CMA CGM	17 June 2022	40	Dry	7550	187,000	600	10,619,000
COSCO	24 May 2022	40	Dry	8250	180,000	0	10,740,000
EVERGREEN	1 September 2021	40	Dry	6335	180,000	833	9,355,040
HAPAG-LLOYD	15 June 2022	40	Dry	7446	180,000	0	9,710,880
HMM	15 June 2022	40	Dry	8000	180,000	0	10,420,000
HAMBURG SUD	13 April 2022	40	Dry	9883	190,000	0	12,840,240
MAERSK	15 June 2022	40	Dry	5448	190,000	0	7,163,440
MSC	17 June 2022	40	Dry	6650	190,000	0	8,702,000
Ocean Network Express	10 June 2022	40	Dry	8290	190,000	0	10,801,200
OOCL	1 August 2021	40	Dry	6881	180,000	0	8,987,680
SM Line	20 June 2022	40	Dry	7575	180,000	0	9,876,000
YANG MING	15 June 2022	40	Dry	8500	200,000	0	11,080,000

5.2. Cargo Handling Tariff

Table 7 summarizes the public tariff announced by Busan Newport Container Terminal in 2022. As reefer containers require specialized facilities to control the temperature, the extra cost is added to the general (dry) container tariffs.

Table 7. Cargo handling tariff 2022 by Busan Newport Container Terminal.

Container Type	Container Size (Full/Empty)	Public Tariff (KRW)	Remarks
Dry	45 (F)	198,900	
	45 (M)	179,200	
	40 (F)	176,900	
	40 (M)	159,400	
	20 (F)	124,200	
	20 (M)	110,200	
Reefer	45 (F/M)	83,100	Monitoring/Operational Reefer Powered (24 h)
	40 (F/M)	70,600	
	20 (F/M)	40,100	
	45/40/20	37,500	Pre-trip inspection (PTI)/Pre-cooling
	Surcharge	50%	Long PTI
	Surcharge	100%	

Gunsan port has the largest grain terminal in Korea, operated by Sun Kwang Co., Ltd. (http://www.sun-kwang.co.kr/ (accessed on 30 September 2022)), where the cargo handling tariff for bulk carriers was KRW 8082 in 2021 according to the interview.

5.3. Storage Cost

The storage cost has two sub-cost components: demurrage and detention for import and export containers. Both are charged for shipments wherein customers have exceeded the standard free time applicable both in the import and export cycles. The demurrage is levied if a forwarder (or a hauler service provider) holds a shipper's containers at a terminal for longer than the agreed free days and is applicable to all containers remaining at the terminal longer than the agreed free time. The detention is levied when a freight forwarder, or forwarding agent, holds a shipper's containers outside a terminal longer than the agreed free time and is applicable throughout the duration of the forwarder's possession of the shipper's containers in its custody, until its safe return to the shipper.

The demurrage and detention costs depend on shipping liners, terminals, container yards, regions, and so on. This section refers to a shipping liner (SM lines, https://esvc.smlines.com (accessed on 30 September 2022)) to investigate the costs (Tables 8 and 9).

Table 8. Demurrage and detention (in KRW) for export (20/40 ft) containers.

	Container Type	Destination	Free Time	Charges beyond Free Time
Demurrage	Dry	Asia, America	14 days	10,000/15,000
	Reefer	Asia, America	5 days	45,000/65,000
Detention	Dry	Asia, America	8 days	7000/10,000
	Reefer	Asia, America	5 days	15,000/20,000

Table 9. Demurrage and detention (in KRW) for import (20/40 ft) containers.

	Container Type	Destination	Free Time	0–10 Days beyond Free Time	11–20 Days beyond Free Time	21 Days Onward beyond Free Time
Demurrage	Dry	Asia	8 days	10,000/15,000	15,000/24,000	25,000/35,000
		America	8 days	10,000/15,000	20,000/30,000	30,000/40,000
	Reefer	Asia	8 days	10,000/15,000	15,000/24,000	25,000/35,000
		America	8 days	10,000/15,000	20,000/30,000	30,000/40,000
Detention	Dry	Asia	6 days	10,000/15,000	15,000/24,000	20,000/30,000
		America	6 days	10,000/15,000	15,000/23,000	28,000/35,000
	Reefer	Asia	6 days	10,000/15,000	15,000/24,000	20,000/30,000
		America	6 days	10,000/15,000	15,000/23,000	28,000/35000

As for the bulk commodities, a representative gain terminal operator, Sun Kwang co., ltd., running the biggest silo in Korea is referred to investigate the storage cost via interview. The free storage time is set to 15 days; KRW 55 per ton will be levied 1–5 days beyond the free time limit, and subsequently, KRW 82.5 per ton will be applied beyond the 6th day.

5.4. Infrastructure Cost

The previous subsections assumed that the necessary infrastructures are prepared in advance. By referring to Sun Kwang's internal report, the piling construction required KRW 20 billion for a silo of accommodating 130,000 tons of grains, with the silo building cost at KRW 80 billion, which amounts to nearly KRW 615,384.6 per ton. This subsection only considers the silo building cost.

6. Results

This section conducts a comparative cost analysis and provides the economic advantages and disadvantages of the containerized logistics compared to the traditional bulk logistics. The economic merit of containerization against bulk transportation of grain cargo is addressed in terms of the four cost components. A 20 ft dry container is the benchmark for this analysis and the cost for bulk logistics is assumed to be proportional to the quantity.

Table 10 shows a comparative analysis of unit bulk cost for different tons of weight. When shipping grains by bulk carriers or container ships, as the container cost is not dependent on the weight, it is obvious that bulk shipping is the economical choice. For the 20 tons of weight in bulk, which requires almost a full 20 ft container, the shipping cost is 76.2% lower when transported in bulk, rather than in containers. Note that the unit cost for bulk is the average unit shipping cost referring to Shanghai Shipping Exchange and the unit cost for containerization is the average of a 20 ft dry container shipping cost, investigated in Section 5.1.

Table 10. Comparative shipping cost analysis.

	Bulk		Container (20 ft Dry)	
Weight (Ton)	**Unit Cost (KRW/Ton)**	**Cost (KRW)**	**Unit Cost (KRW/Ton)**	**Cost (KRW)**
17	95,565	1,624,602	8,021,700	8,021,700
18		1,720,166		
19		1,815,731		
20		1,911,296		
21		2,006,861		
22		2,102,426		

Table 11 shows the tariff analysis. The container handling tariff is not dependent on weight, whereas the bulk tariff is associated with it. The result shows that containerization has a higher benefit than bulk, as the container tariff is 23.2% cheaper than that for 20 tons of weight in bulk. Note that the container tariff might be discounted with its quantity as well as a contract between a terminal and a shipper.

Table 11. Comparative tariff analysis.

	Bulk		Container (20 ft Dry)	
Weight (Ton)	**Unit Cost (KRW/Ton)**	**Cost (KRW)**	**Unit Cost (KRW/Ton)**	**Cost (KRW)**
17	8082	137,394	124,200	124,200
18		145,476		
19		153,558		
20		161,640		
21		169,722		
22		177,804		

Table 12 analyzes the storage cost beyond the free time limit for bulk and a container. The demurrage and detention for a container are the same as investigated in Table 9. Since the two free time limits are different for 15 and 8 days for bulk and containers, respectively, the analysis on only days 1, 2, and 3 beyond the free time are fairly comparable. As for 20 tons of weight stored beyond the 1st, 2nd, and 3rd day, the average bulk storage cost is 89% cheaper than container storage.

Table 13 analyzes the unit infrastructure cost associated with tons of weight. For example, the 20 tons of weight in bulk needs KRW 12,307,692 for infrastructure. The price of a new 20 ft dry container is priced roughly in the range of KRW 6,000,000 to KRW 10,000,000, depending on manufacturers and quality, according to the market investigation. From this result, containerization could save up to 51.2% of infrastructure costs as compared to bulk.

Table 12. Comparative storage cost analysis.

Weight (Tons) \ Days beyond Free Time		1	2	3	4	5	6	7	8	9	10
Bulk—15 Days of Free Time	17	935	1870	2805	3740	4675	6078	7480	8883	10,285	11,688
	18	990	1980	2970	3960	4950	6435	7920	9405	10,890	12,375
	19	1045	2090	3135	4180	5225	6793	8360	9928	11,495	13,063
	20	1100	2200	3300	4400	5500	7150	8800	10,450	12,100	13,750
	21	1155	2310	3465	4620	5775	7508	9240	10,973	12,705	14,438
	22	1210	2420	3630	4840	6050	7865	9680	11,495	13,310	15,125
Container (20 ft Dry)—8 days of free time		10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000

Table 13. Comparative infrastructure cost analysis.

	Bulk		Container (20 ft Dry)	
Weight (Ton)	Unit Cost (KRW/Ton)	Cost (KRW)	Unit Cost (KRW/Ton)	Cost (KRW)
17	615,384.60	10,461,538	6,000,000–10,000,000	6,000,000–10,000,000
18		11,076,923		
19		11,692,307		
20		12,307,692		
21		12,923,077		
22		13,538,461		

7. Discussion

When using preservation containers in grain logistics to improve its processes, the primary feature should be economic viability. Sections 5 and 6 analyzed the four logistics cost components between the traditional bulk logistics and the containerized logistics processes. This study presents a comparative cost analysis of using preservation containers in grain logistics processes for identity preservation.

It was found that the shipping cost was favorable to the traditional bulk logistics (76.2%) for the same amount of grain cargo, as the cargo logistics in bulk could enjoy the benefit of the economies of scales, and hence, the lower cost can be applied to the same amount of grain cargo than that of grain cargo logistics in containerization. It was also found that that the storage cost in bulk logistics, as expected, is preferable (89%) compared to the containerized logistics. Together with the shipping cost, the storage cost also measures the benefits to the economies of scales.

Regarding the shipping cargo tariff, the containerships generally have advantage of lower tariff rate than that of cargo by bulk carriers. This difference comes from the fact that the international maritime cargo trade is mostly achieved by containerships and the shipping liners have strong marginal power. However, the bulk carriers are relatively smaller-scale businesses in the international trade compared to containerized trade. This study assumes that the grain market can possess the advantages of container shipping in general, so that the same tariff rate is applied to the analysis. Nevertheless, the result found that the tariff (23.2%) was favorable to the containerized logistics process. The representative cost reduction in containerized grain logistics comes from saving infrastructure cost. The infrastructural facilities (i.e., silos) require great capital cost, because the capital cost includes land prices and construction cost. Since the containerization does not need built-in infrastructures, for the same amount of grain cargo, the saving (51.2%) is invaluable when industry considers its adoption.

Apart from the economic viability, the peripheral effects are also important. When considering the application of containerized grain logistics, the standardized containerization likely helps shippers carry various types of cargo including grains by containerships. Even though the bulk grain logistics provides economic merit in shipping cost, from the perspective of shippers, the cost would be sufficiently mitigated by consolidation on a long-term basis. The storage space cost is another measure of logistics process. Since the bulk grain is barely preferable in favor of grain inventory management, preservation containers likely contribute to introduce stock-keeping-units (SKUs) to grain storage activities. Furthermore, the shipping and storage processes can be serialized without decoupling the logistics process. In that regard, giant infrastructural facilities could likely be replaced with the stacks of preservation containers such as stacking blocks at a container yard of a seaport.

The greatest impact of introducing containerized grain logistics is that users would trace the grain quality throughout logistics processes using preservation containers. This benefit is in line with the concept of identity preservation that refers to the ability to maintain traits and/or attributes (e.g., food safety, country of origin, GMO, organic, kosher, halal, "free-range" livestock, contamination by allergens or microorganisms, animal welfare, dolphin free, fair wage and trade, low carbon footprint) [32]. Identity preservation of grains from harvest to use (on farm or ethanol plant) requires a possible solution of assuring targeted grain quality but is a major challenge when trying to introduce or adopt trait-specific grain varieties. The current grain handling and storage infrastructure do not support separating grain sources based on nutritional or other traits. Hence, a promising system of logistics needs to be flexible, given the inherent uncertainties surrounding regional growing conditions [22].

Two important considerations in identity preservation are traceability and quality control. Traceability in grain logistics cannot retain the quality, but it can be used to associate each unit of grain product information concerning physiological, chemical, physical, and biological factors, discussed in Section 4.1, which allows a specific and economic value to be assigned. The grain quality control during the process of logistics activities requires a solution of monitoring status and controlling air conditions. The proposed logistics process with preservation containers is proposed based on capability from linking traceability with quality control via an application of information technologies. The proposed logistics process would help managers/forwarders implement identity preservation via deploying the preservation containers that contribute to sustainability in grain supply chains.

8. Conclusions

The grain market has been increasing but the amount of loss throughout the post-harvest process is significant. This study discussed a way of enhancing the logistics process using preservation containers for grains and estimated the improvement in logistics costs against the conventional logistics process in bulk. The introduction of preservation containers meets the demand for identity preservation and the containers could efficiently manage the grain preservation to resist the quality deterioration during post-harvest logistics processes (i.e., processes of transport, pre-processing, storage, processing, and packaging). Prior to introducing the concept, this study also identified the categorized elements leading to grain quality deterioration, showing how preservation containers help preserve quality by controlling a combination of gases (i.e., oxygen, carbon dioxide, and nitrogen).

After proposing the enhanced logistics process in importing grains, the four components of logistics cost are comparatively analyzed to understand the economic viability. It was found that the improved logistics process with preservation containers is advantageous in reducing tariff (23.2%) and infrastructure costs (51.2%), comparatively, on average, while the traditional bulk logistics process is more beneficial in lowering shipping (76.2%) and storage costs (89%), on average. Due to containerization, the unit logistics cost in shipping and storage would be naturally increased compared to non-containerization, but the market cost disadvantage would be mitigated after considering the grain quality deterioration caused by bulk shipping and storage. However, containerization provides economical efficacy by saving tariff and infrastructure cost in the improved logistics processes, as the tariff rate in containers is generally low and containerization does not require infrastructural facilities (e.g., silos), thus saving capital cost.

Implementing identity preservation requires technological adoption and logistics improvement to accomplish traceability and quality control. The proposed grain logistics process with preservation containers could contribute to implementing identity preservation to help food sustainability in grain supply chains.

This research is a fundamental study estimating the benefit of introducing preservation containers into the logistics process. Admittedly, the study has limitations: The loss rate has not been considered for cost analysis; the feasibility of replacing the shipping route of bulk carriers with ships with preservation containers should be informative; and the business cases need to be identified in practice.

Author Contributions: Conceptualization, Y.J.K.; methodology, Y.J.K.; validation, Y.J.K.; formal analysis, Y.J.K.; investigation, Y.J.K., B.K.L.; resources, Y.J.K.; data curation, Y.J.K., B.K.L.; writing—original draft preparation, Y.J.K., B.K.L.; writing—review and editing, B.K.L.; visualization, B.K.L.; project administration, Y.J.K.; funding acquisition, Y.J.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by a grant from R&D Program (PK2202C3, Development of core technologies for digital rail freight stations) of the Korea Railroad Research Institute, Republic of Korea.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Prototype of Preservation Containers

A preservation container should be the size of a general dry container, typically used in shipping logistics. The proposed prototype aims to implement the suggested technologies effectively for it to be applied to actual operational practices.

The prototype development considers the following requirement:

- Retention of oxygen (i.e., 1–3%) and humidity to prevent physiological quality deterioration.
- Storage duration of more than 4 months, considering the stages from farming to crop-processing.
- Environmental maintenance facilities (e.g., nitrogen tank, depressurizer, control valve, relief value, sensors power supply) attachable to international containers.

The prototype consists of top (i.e., loading) and bottom (i.e., discharging) doors. The interior air pressure is set to a maximum of 1.5 atmosphere. The illustration of the prototype is drawn in Figure A1.

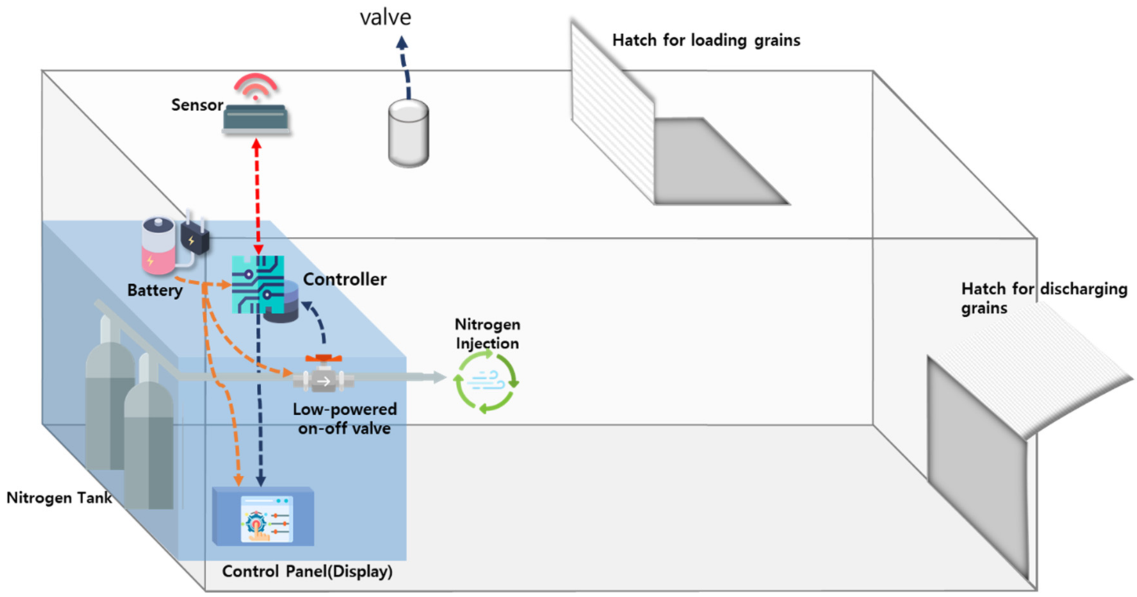

Figure A1. Components of a prototype preservation container.

References

1. United States Department of Agriculture, Foreign Agricultural Service—Production, Supply and Distribution. Available online: https://apps.fas.usda.gov/psdonline/app/index.html#/app/home (accessed on 23 June 2022).
2. Resource Trade Data, Chatham House. Available online: https://resourcetrade.earth/ (accessed on 3 September 2022).
3. Fredriksson, A.; Liljestrand, K. Capturing food logistics: A literature review and research agenda. *Int. J. Logist. Res. Appl.* **2015**, *18*, 16–34. [CrossRef]
4. Mardaneh, E.; Loxton, R.; Meka, S.; Gamble, L. A decision support system for grain harvesting, storage, and distribution logistics. *Knowl. Based Syst.* **2021**, *223*, 107037. [CrossRef]
5. de Oliveira, A.L.R.; Marsola, K.B.; Milanez, A.P.; Fatoretto, S.L.R. Performance evaluation of agricultural commodity logistics from a sustainability perspective. *Case Stud. Transp. Policy.* **2022**, *10*, 674–685. [CrossRef]
6. Zhao, G.; Liu, S.; Lopez, C.; Lu, H.; Elgueta, S.; Chen, H.; Boshkoska, B.M. Blockchain technology in agri-food value chain management: A synthesis of applications, challenges, and future research directions. *Comput. Ind.* **2019**, *109*, 83–99. [CrossRef]
7. Liu, P.; Long, Y.; Song, H.-C.; He, Y.-D. Investment decision and coordination of green agri-food supply chain considering information service based on blockchain and big data. *J. Clean. Prod.* **2020**, *277*, 123646. [CrossRef]
8. Saurabh, S.; Dey, K. Blockchain technology adoption, architecture, and sustainable agri-food supply chains. *J. Clean. Prod.* **2021**, *284*, 124731. [CrossRef]
9. Byeon, J.Y. Analysis of Grain Supply and Demand Stabilization Projects and Policies. National Assembly Budget Office, Korea. 2021. Available online: https://viewer.nabo.go.kr/streamdocs/view/sd;streamdocsId=72059249403238614 (accessed on 23 June 2022).
10. Yun, J.R.; Park, J.W.; Shin, K.S.; Kang, D.H.; Kim, J.J. Market Trend and Outlook for Grain Import Market. Research Report of Korea Rural Economic Institute. 2019. Available online: https://aglook.krei.re.kr/main/uEventData/1/download/781/6335/pdf (accessed on 23 June 2022).
11. Kim, J.J.; Kim, S.H.; Lee, Y.G.; Choi, J.H. Analysis on Value Chains for Importing Grains. Research Report of Korea Rural Economic Institute. 2021. Available online: http://library.krei.re.kr/pyxis-api/1/digital-files/63a398f8-7684-4b7b-ad1e-c0c73f520a53 (accessed on 23 June 2022).
12. International Water Management Institute. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*; International Water Management Institute: London, UK, 2007; pp. 1–645. Available online: http://www.iwmi.cgiar.org/assessment/Publications/books.htm (accessed on 23 June 2022).
13. Popp, J.; Pető, K.; Nagy, P. Pesticide productivity and food security. A review. *Agron. Sustain. Dev.* **2013**, *33*, 243–255. [CrossRef]
14. Mesterházy, Á.; Oláh, J.; and Popp, J. Losses in the grain supply chain: Causes and solutions. *Sustainability* **2020**, *12*, 2342. [CrossRef]
15. Nourbakhsh, S.M.; Bai, Y.; Maia, G.D.N.; Ouyang, Y.; Rodriguez, L. Grain supply chain network design and logistics planning for reducing post-harvest loss. *Biosyst. Eng.* **2016**, *151*, 105–115. [CrossRef]
16. Gardas, B.B.; Raut, R.D.; Narkhede, B. Evaluating critical causal factors for post-harvest losses (PHL) in the fruit and vegetables supply chain in India using the DEMATEL approach. *J. Clean. Prod.* **2018**, *199*, 4761. [CrossRef]
17. Bendinelli, W.E.; Su, C.T.; Péra, T.G.; Filho, J.V.C. What are the main factors that determine post-harvest losses of grains? *Sustain. Prod. Consum.* **2020**, *21*, 228–238. [CrossRef]

18. Faibil, D.; Agyemang, M.; Amponsah, O.; Gupta, H.; Kusi-Sarpong, S. Assessing drivers of post-harvest losses: Tangible and intangible resources' perspective. *Environ. Dev. Sustain.* **2021**, *23*, 15785–15829. [CrossRef]
19. Anand, S.; Barua, M.K. Modeling the key factors leading to post-harvest loss and waste of fruits and vegetables in the agri-fresh produce supply chain. *Comput. Electron. Agric.* **2022**, *198*, 106936. [CrossRef]
20. Dyck, G.; Hawley, E.; Hildebrand, K.; Paliwal, J. Digital Twins: A novel traceability concept for post-harvest handling. *Smart Agri. Tech.* **2023**, *3*, 100079. [CrossRef]
21. Luo, N.; Olsen, T.; Liu, Y.; Zhang, A. Reducing food loss and waste in supply chain operations. *Transp. Res. E: Logist. Transp. Rev.* **2022**, *162*, 102730. [CrossRef]
22. Martin, N.P.; Russelle, M.P.; Powell, J.M.; Sniffen, C.J.; Smith, S.I.; Tricarico, J.M.; Grant, R.J. Invited review: Sustainable forage and grain crop production for the US dairy industry. *J. Dairy Sci.* **2017**, *100*, 9479–9494. [CrossRef]
23. Trimble, S. Oxygen in Post-Harvest: Monitoring & Control. 2019. Available online: https://felixinstruments.com/blog/oxygen-in-post-harvest-monitoring-control/ (accessed on 23 June 2022).
24. Trimble, S. Respiration and Pest Management in Grain Storage. 2021. Available online: https://felixinstruments.com/blog/studying-respiration-during-storage-with-gas-analysis/ (accessed on 23 June 2022).
25. Lee, S.J. MA (modified atmosphere) package technologies for agricultural products. *Korean J. Air-Cond. Refrig. Eng.* **1998**, *10*, 3–13.
26. Keum, D.H.; Kim, H.; Kim, D.C. Airtight storage characteristics of rough rice. *J. Biosyst. Eng.* **2000**, *25*, 33–38.
27. Kim, O.W.; Kim, H.; Han, J.W.; Lee, H.J. Storage characteristics of milled rice according to milling system types. *Korean J. Food. Preserv.* **2014**, *21*, 308–314. [CrossRef]
28. Ha, K.Y.; Park, H.K.; Ko, J.K.; Kim, C.K.; Choi, Y.H.; Kim, K.Y.; Kim, Y.D. Effect of storage period and temperature on the characteristics related with rice quality. In Proceedings of Korean Society of Medicinal Crop Science; Spring: Berlin/Heidelberg, Germany, 2006. pp. 386–387.
29. Choi, Y.H.; Jeong, E.G.; Choung, J.I.; Kim, D.S.; Kim, S.L.; Kim, J.T.; Lee, C.G.; Son, J.R. Effects of moisture contents of rough rice and storage temperatures on rice grain quality. *Korean J. Crop Sci.* **2006**, *51*, 12–20.
30. Son, Y.; Kim, Y.; Kim, Y. Control effect of a stored grain insect pest, tribolium castaneum, by 'CATTS' postharvest treatment. *Korean J. Appl. Entomol.* **2010**, *49*, 363–369. [CrossRef]
31. United States Department of Agriculture. USDA Coexistence Factsheets—Identity Preserved. 2015. Available online: https://www.usda.gov/sites/default/files/documents/coexistence-identity-preserved-factsheet.pdf (accessed on 23 June 2022).
32. Dabbene, F.; Gay, P.; Tortia, C. Traceability issues in food supply chain management: A review. *Biosyst. Eng.* **2014**, *120*, 65–80. [CrossRef]