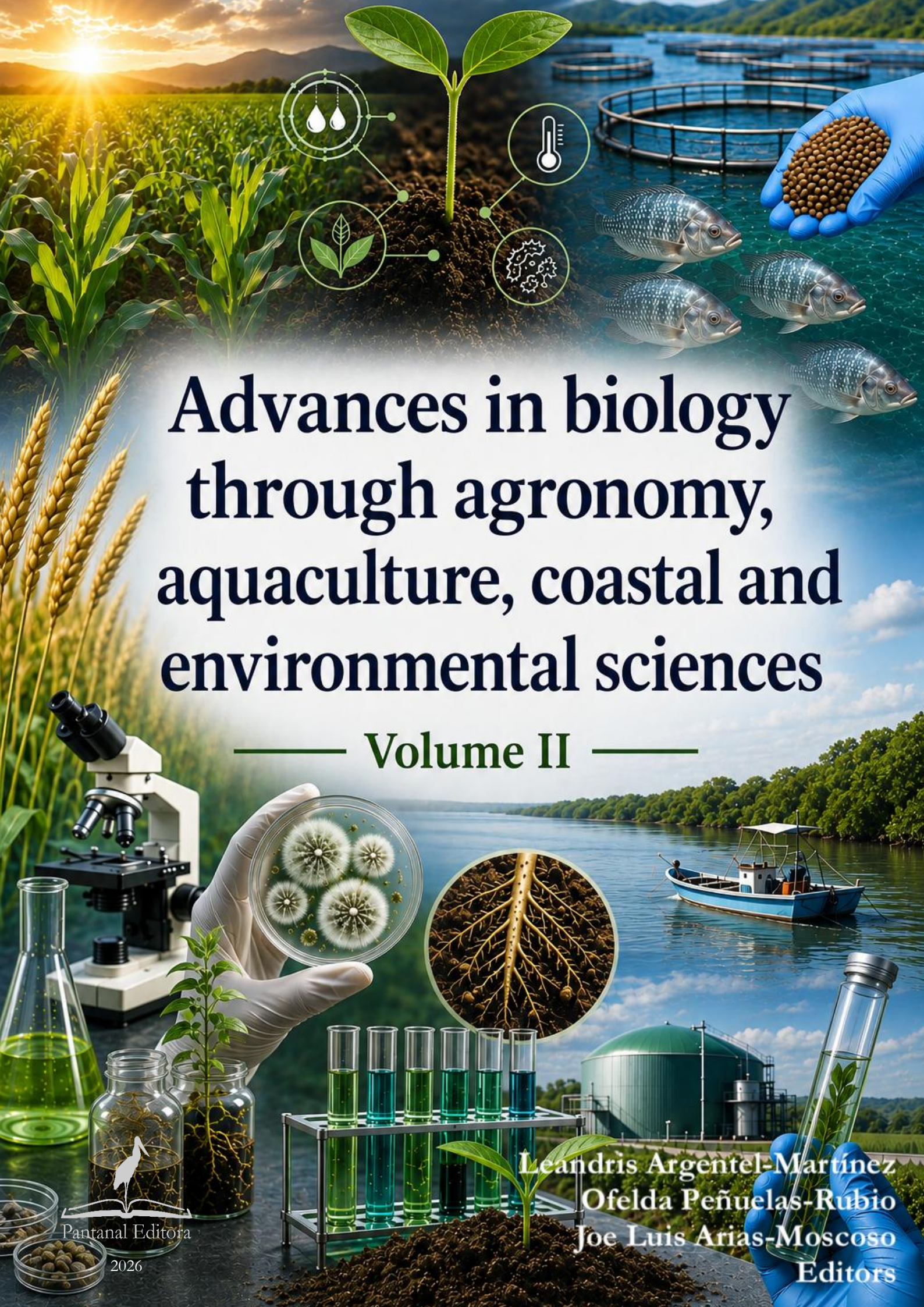




Advances in biology through agronomy, aquaculture, coastal and environmental sciences

— Volume II —

Pantanal Editora

2026

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Editors

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**Advances in biology through
agronomy, aquaculture, coastal and
environmental sciences**
Volume II



Pantanal Editora

2026

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Catalog sheet

Cataloging in publication
Prepared by a Librarian Janaina Ramos – CRB-8/9166

A244

Advances in biology through agronomy, aquaculture, coastal and environmental sciences - Volume II /
Editors Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, Joe Luis Arias-Moscato. – Nova
Xavantina-MT: Pantanal, 2026.
362p. ; il.

Book in PDF format

ISBN 978-65-85756-79-2

DOI <https://doi.org/10.46420/9786585756792>

1. Biology. 2. Agronomy. 3. Aquaculture. 4. Environmental sciences. I. Argente-Martínez, Leandris
(Editor). II. Peñuelas-Rubio, Ofelda (Editor). III. Arias-Moscato, Joe Luis (Editor). IV. Title.

CDD 570

Index to systematic catalog

I. Biology



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Advances in Biology through Agronomy, Aquaculture, Coastal and Environmental Sciences, Volume II, is an e-book that continues the work of the first version (<https://editorapantanal.com.br/ebooks/2023/advances-in-biology-through-agronomy-aquaculture-coastal-and-environmental-sciences/ebook.pdf>), published in 2023 by Leandris Argente-Martínez and Ofelda Peñuelas-Rubio.

Our e-book compiles 25 manuscripts that present scientific results and reviews based on biological aspects. All of them contribute to explaining the responses of living organisms to agricultural, aquaculture, and coastal ecosystems, as well as those facing fragility or threat of climate change. This e-book was edited by Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, and Joe Luis Arias-Moscato, members of the Consolidated Academic Group ITVAYA-CA-3.

We appreciate the contribution of all authors for their careful attention to the editorial committee's recommendations. The review process was double-blind and conducted by internationally renowned researchers.

Special thanks to the members of the BioSecuraNet International Network for Biotechnology and Innovative Strategies for Global Food Security at the National Technological Institute of Mexico.

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Risk factors in loading and unloading operations of agricultural products in land transport units at a company in Veracruz, Mexico

Received: 19/04/2026

Accepted: 01/05/2026

 10.46420/9786585756792cap9

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ABSTRACT

The present study aimed to identify risk factors in the loading and unloading areas of land transport units at a company located in Veracruz, Mexico. A descriptive approach was applied through the use of validated semistructured instruments to obtain information on operational, organizational, and occupational aspects across three stages: before, during, and after operations. The samples included 12 and 17 units for the unloading and loading of barley malt, respectively, and 5 units for the loading of corn semolina. Data were analyzed using absolute frequencies. The results revealed high levels of compliance in terms of operational procedures, equipment conditions, and documentation management. However, critical deficiencies were identified in the use of personal protective equipment (PPE), particularly the absence of safety helmets and the inconsistent use of goggles and gloves. Additionally, partial compliance was observed in cleaning activities, sealing procedures, and the verification of structural integrity in some transport units. External factors, such as railway disruptions and supply chain constraints, also influenced operational variability. The findings highlight the presence of organizational, operational, and behavioral risk factors that may compromise worker safety, product quality, and process efficiency. Strengthening preventive measures, standardizing procedures, and promoting a safety culture are essential to reduce risks and improve performance in agro-industrial logistics systems.

Keywords: Silos, training manual, industrial safety, operational efficiency

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INTRODUCTION

Transportation and logistics constitute strategic components of the global economy, as they facilitate the efficient flow of goods and services within supply chains (Hesse; Rodrigue, 2004; South Pacific Logistics, 2023). In this context, companies continuously seek to optimize their processes to provide more efficient, safe, and reliable services, thereby increasing their competitiveness in dynamic markets (Gunasekaran et al., 2017).

Within the agro-industrial sector, storage systems in silos represent a key element for the preservation and handling of bulk products, as they help maintain product quality and ensure the continuity of the supply chain. In these infrastructures, loading and unloading operations are particularly important, as they directly influence operational efficiency, process safety, and grain quality (Keklis et al., 2024; Adejumo; Haruna, 2013).

However, inadequate management of loading and unloading operations in grain storage systems can lead to significant occupational risks and product losses, thereby affecting the productivity of agro-industrial systems (Denisov et al., 2023). These operations are not risk-free, as factors such as prolonged waiting times, exposure to physical and mechanical hazards, and the absence or inadequate implementation of standardized procedures constitute recurring challenges that may compromise productivity, worker safety, and product quality (Kines et al., 2010).

In this context, it is essential to identify and evaluate the risks associated with these activities and to establish control measures to minimize their impact. The implementation of preventive strategies based on occupational health and safety management systems contributes not only to the reduction of workplace accidents but also to the improvement of operational efficiency and the strengthening of a safety culture within organizations (Fernández-Muñiz et al., 2009).

Therefore, the objective of this study was to describe the social, organizational, and operational risk factors in the silo area for barley malt and corn semolina in a company located in Veracruz, Mexico.

MATERIALS AND METHODS

Study Area

The study was conducted in the silo area for barley malt and corn semolina at a company located in Veracruz, Mexico.

Secondary Sources

The company's database was consulted to quantify the loading and unloading operations of barley malt, as well as the loading operations of corn semolina. Additionally, records of incoming railway units (railcars) were analyzed.

Sampling

The selection of sampled units was carried out randomly. A total of $n = 12$ and $n = 17$ units were evaluated for unloading and loading, respectively, of barley malt. For the corn semolina, a total of 5 loading units were selected.

Instrument Design

A validated semi structured questionnaire was designed as the data collection instrument. It was composed of the following sections: work area, transport unit, documentation, and personnel. The instrument was applied at three stages of the operational process: before the start of the operation, during the execution of activities, and after the completion of barley malt loading and unloading operations.

The questionnaire included dichotomous items (compliance/noncompliance), allowing for an objective assessment of the level of compliance with the established criteria at each stage of the process.

For the corn semolina, a specific validated questionnaire was designed, as the company operates under a different procedure in which only loading activities are performed, with no unloading processes. This second instrument included variables related to the transport unit, documentation, and personnel, with the aim of evaluating operational conditions and associated risk factors.

Data Analysis

Data were analyzed using absolute frequencies with Microsoft Excel Office 2019.

RESULTS AND DISCUSSION

The frequency of barley malt loading operations recorded during 2024 is shown in Figure 1. During the first months of the year, low operational activity was observed, with minimal records in February (1 load) and relatively low values in January, March, April, and May. This decrease in operations indicates a period of lower demand or limited logistical availability, which contrasts with the pattern observed in the second half of the year.

Starting in June, a significant increase in the number of loads was identified (49), followed by an increasing trend in July (53) and August (79), reaching a peak in September (97 loads). This increase can be partly explained by the dispatch of units to specific destinations, such as Monterrey, under double-trailer configurations, which resulted in duplicated records in the system, as each unit was registered as two tickets. Additionally, some of these operations were carried out during night shifts, contributing to the higher recorded operational volume.

In October (38) and November (53), a decrease in the frequency of loads was subsequently observed, suggesting a reduction in operational intensity following the peak reached in the third quarter of the year.

This behavior reflects significant operational variability, where periods of high demand (June–September) involve increased workload, a higher frequency of operations, and the potential execution of activities during extended or night shifts. These conditions may promote the emergence of risk factors such as worker fatigue, operational errors, procedural omissions, and reduced compliance with the use of personal protective equipment (PPE).

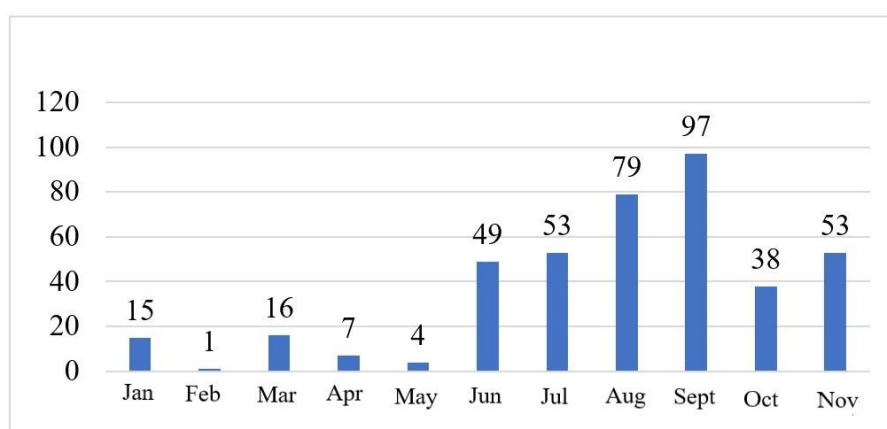


Figure 1. Absolute frequency of barley malt loading operations in 2024.

The frequency of corn semolina loading operations during 2024 is shown in Figure 2, revealing a relatively stable pattern in the first half of the year and a downward trend in the second half. However, this dynamic is not solely driven by internal operational demand but is also influenced by external factors that affect the availability of raw materials.

In particular, events such as railway blockades in the state of Puebla and protests at ports in the United States led to disruptions in the supply chain. These conditions limited the flow of the maize semolina to the company, forcing the implementation of stricter resource management strategies to prevent shortages.

As a result, a restrictive operational policy was adopted, with only one load per day carried out during certain periods. This measure allowed the continuity of the production process to be maintained; however, it directly affected the reduction in the volume of operations, particularly during the second half of the year.

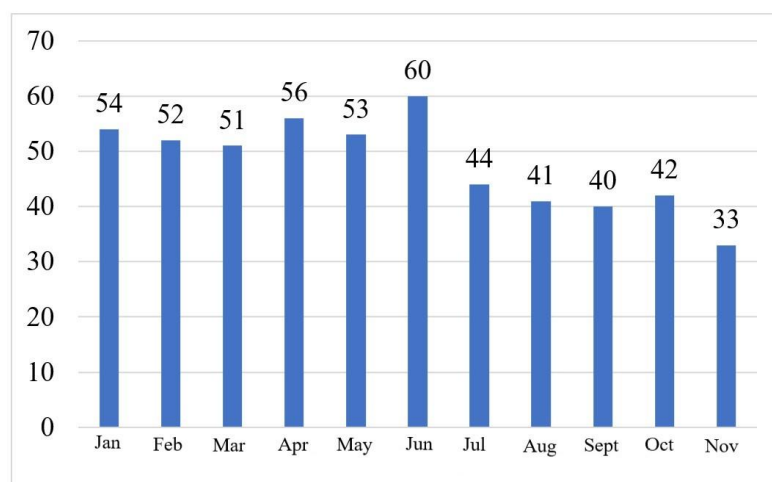


Figure 2. Absolute frequency of maize semolina loads in 2024.

The frequency of incoming railway units (railcars) with barley malt and corn semolina hoppers during 2024 is shown in Figure 3, with a total of 135 recorded units. During the first half of the year, the flow of units remained relatively stable, with values ranging between 12 and 16 hoppers per month. In particular, January (15), February (13), March (13), April (12), May (14), and June (16) reflect a consistent pattern in the supply of raw materials to the company.

However, starting in July (15), a more pronounced downward trend in the number of incoming units is observed, with significant decreases in August (8), September (9), and October (8), representing the lowest values of the analyzed period. A partial recovery is subsequently observed in November, with 12 units.

This decline in hopper flow coincides with external factors that affected the supply chain, such as railway closures operated by Ferrosur and protests at ports in the United States. These conditions limited the arrival of raw materials, creating a scenario of restricted supply.

From a risk management perspective, these results highlight the critical dependence of agro-industrial operations on railway transport infrastructure and on external, uncontrollable conditions. Disruptions in the flow of inputs not only affect operational continuity but also increase the vulnerability of the logistics system, emphasizing the need to implement contingency strategies and diversify supply channels.

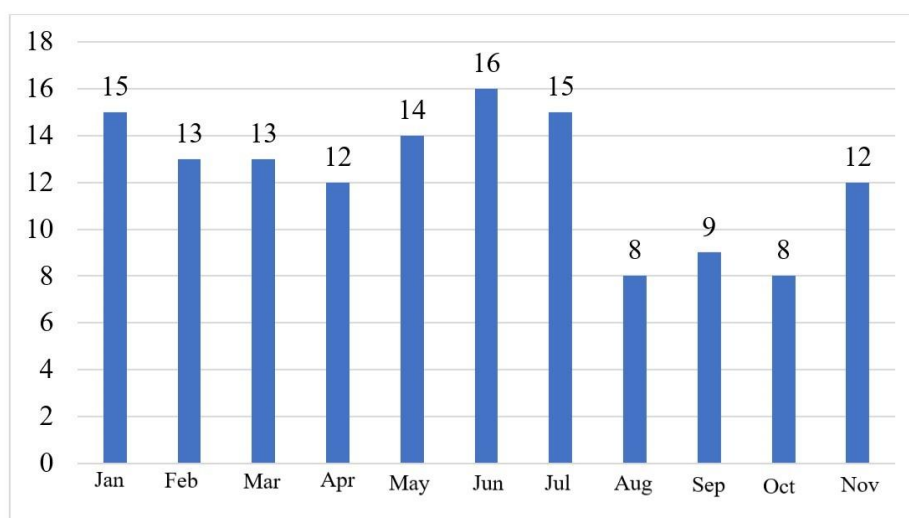


Figure 3. Number of incoming railcars carrying barley malt and maize semolina hoppers in 2024.

As shown in Figure 4, out of a total of 12 unloading operations evaluated, in 11 cases (91.7%), the area met the required conditions, whereas in 1 case (8.3%), it was not in optimal condition.

This high level of compliance suggests that, in general terms, the company maintains adequate working conditions in the area prior to the start of unloading operations, which is favorable from an operational safety perspective. A clean and obstacle-free area contributes to reducing physical risks, such as slips, trips, or interference during the handling of equipment and materials.

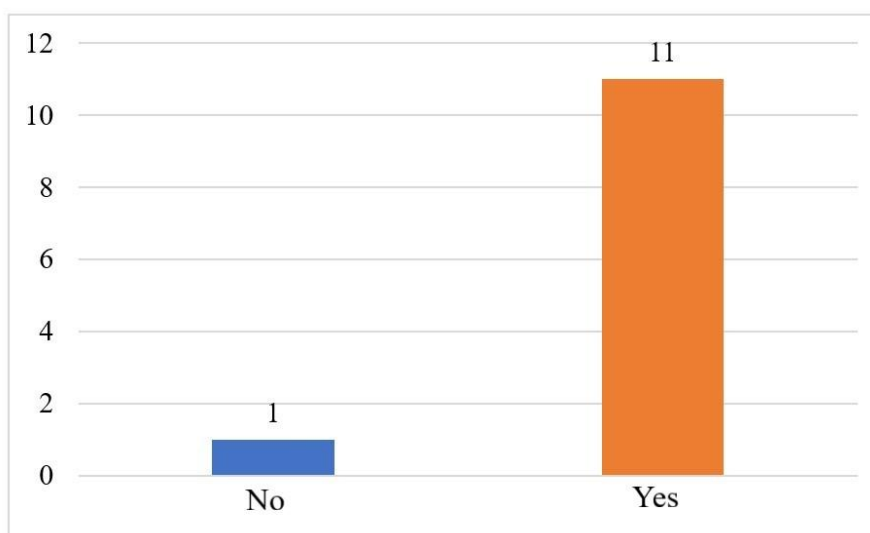


Figure 4. Evaluation of conditions in the barley malt unloading area.

The results indicate that, out of a total of 12 units evaluated, a 100% compliance rate was recorded in the presentation of the ticket, delivery notes, product quality information, and unit cleaning certificate (Figure 5). However, partial noncompliance was identified in the documentation related to the bill of lading, where 2 units (16.7%) did not have this document in full.

These findings suggest that although most documentation processes are standardized and properly implemented, specific deficiencies persist in the management of the bill of lading. According to the information collected, this situation occurred primarily in subcontracted units, in which drivers did not have a document because of administrative limitations on the part of the service provider.

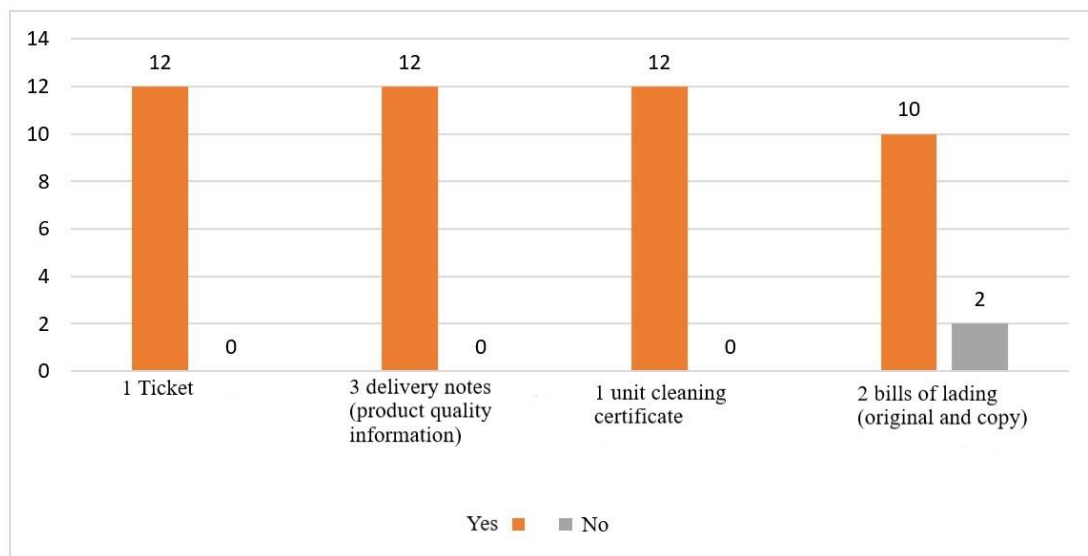


Figure 5. Assessment of source documentation for barley malt as an organizational risk factor.

As shown in Figure 6, in 100% of the units evaluated, all the equipment was in optimal operating condition prior to the start of operations, with no cases of noncompliance recorded.

These findings suggest adequate operational planning and coordination between the client company and the service provider, ensuring that equipment is properly prepared in advance through cleaning, disinfection, and technical inspection processes. Maintaining equipment under optimal conditions significantly reduces the likelihood of mechanical failure, process interruption, and potential workplace incidents during unloading operations.

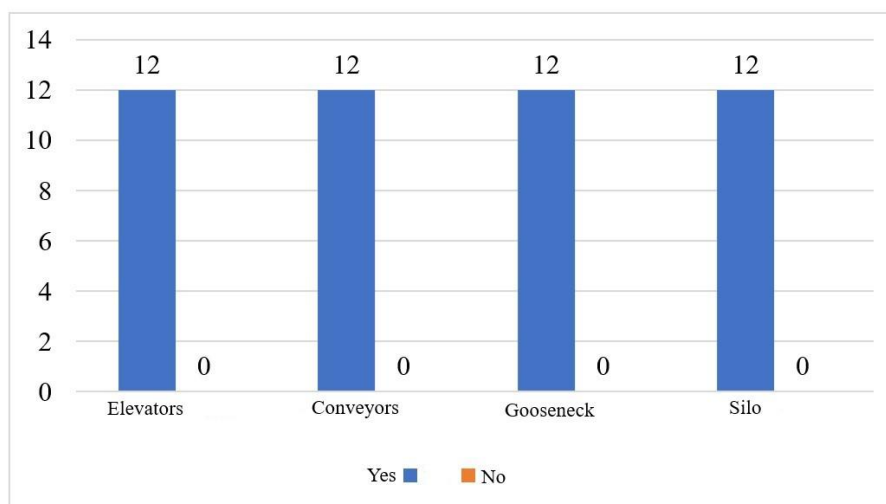


Figure 6. Assessment of the condition of receiving (unloading) equipment as an operational risk factor.

The results show full compliance (100%) in the use of gloves, safety boots, and masks across the 12 units evaluated (Figure 7). However, significant deficiencies were identified in other protective equipment. In the case of safety helmets, total noncompliance was recorded (0% usage), as none of the evaluated units had personnel equipped with this item, which is associated with a lack of provision by the company.

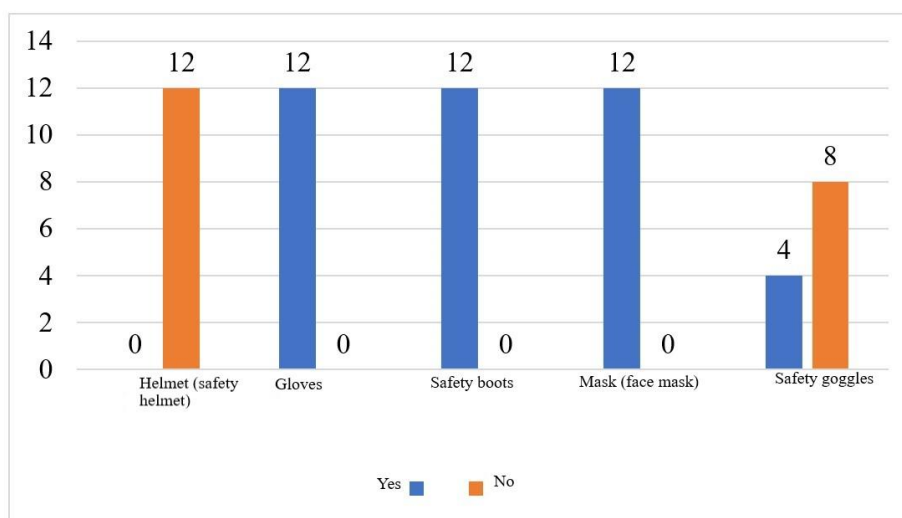


Figure 7. Level of compliance with the use of personal protective equipment (PPE) during unloading operations.

On the other hand, the use of safety goggles showed partial compliance, with only 4 out of 12 units (33.3%) using this equipment, while in 8 cases (66.7%), it was not used, despite having been provided. According to the information collected, this situation is related mainly to behavioral factors, such as perceived discomfort during task execution or voluntary omission by personnel, derived from habitual practices without the use of this type of protection.

These findings highlight the presence of organizational and behavioral risk factors, as the lack of helmet provisions and the inconsistent use of safety goggles increase exposure to physical hazards such as impacts, falling objects, and airborne particles.

The results shown in Figure 8 indicate a high level of compliance under operational conditions, as 100% of the units sampled the agricultural product, verified that it met the quality parameters, followed the established unloading procedure, ensured that the unloaded product remained free of impurities or damage, and continuously monitored the process to detect potential anomalies.

However, a specific instance of noncompliance was identified regarding the presence of security seals on the unit gates. In this case, 1 out of the 12 evaluated units (8.3%) did not have these seals, whereas 11 units (91.7%) complied with this requirement. Although minor, these findings represent a relevant issue from the perspective of operational safety and product traceability, as the absence of seals may compromise integrity control during transport.

Overall, the results demonstrate adequate control in the execution of unloading operations; however, the lack of compliance in the use of security seals highlights the need to strengthen preoperational inspection and documentation supervision mechanisms to ensure full compliance with protocols and reduce risks associated with the handling and control of barley malt.

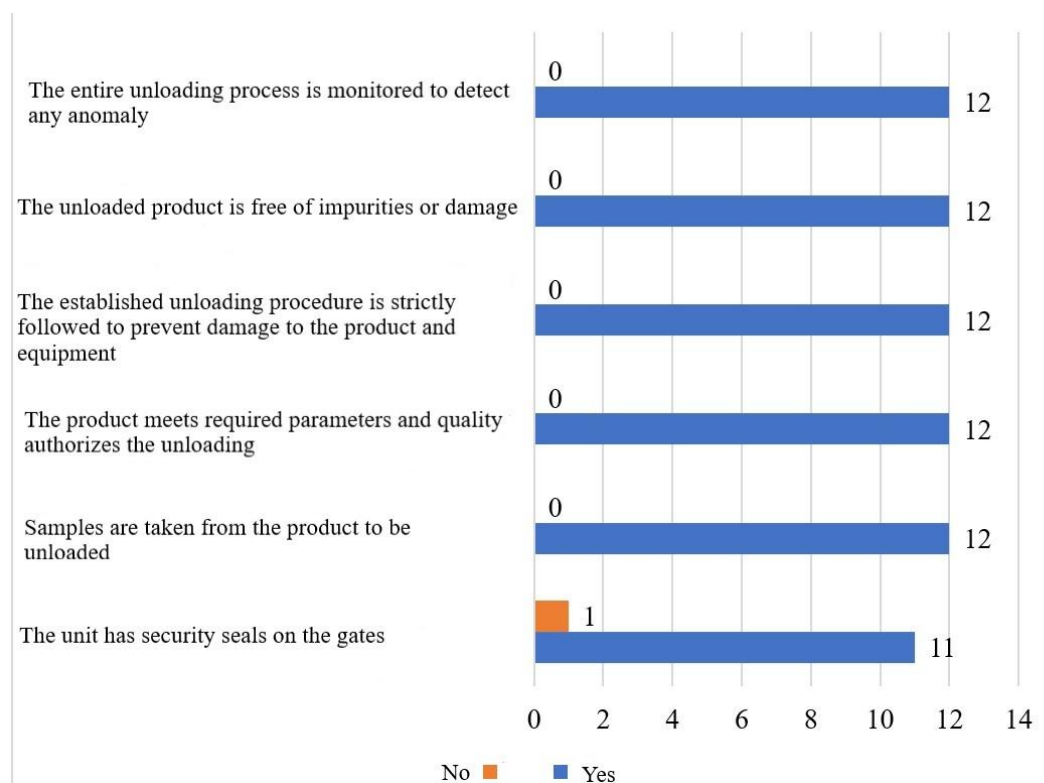


Figure 8. Verification of operational conditions during barley malt unloading as a risk control factor.

The full compliance (100%) in the recording of operations is shown in Figure 9, as all 12 evaluated units correctly completed unloading data, including date, time, unloaded quantity, and granulometric analysis results.

However, deficiencies were identified in other critical closing activities. In particular, 83.3% of the units complied with valve closure and disconnection of the unloading equipment. Similarly, a low level of compliance was observed in the thorough cleaning of the unloading area and the equipment used, with only 33.3% performing this activity, whereas in 66.7% of the cases, it was not carried out completely.

These results reveal the presence of operational and organizational risk factors, particularly in post unloading activities, where the omission of gate closure may lead to product spills, affecting both workplace safety and process efficiency. Similarly, incomplete cleaning of the area and equipment may result in residue accumulation, increasing the risk of contamination and hindering optimal conditions for subsequent unloading operations.

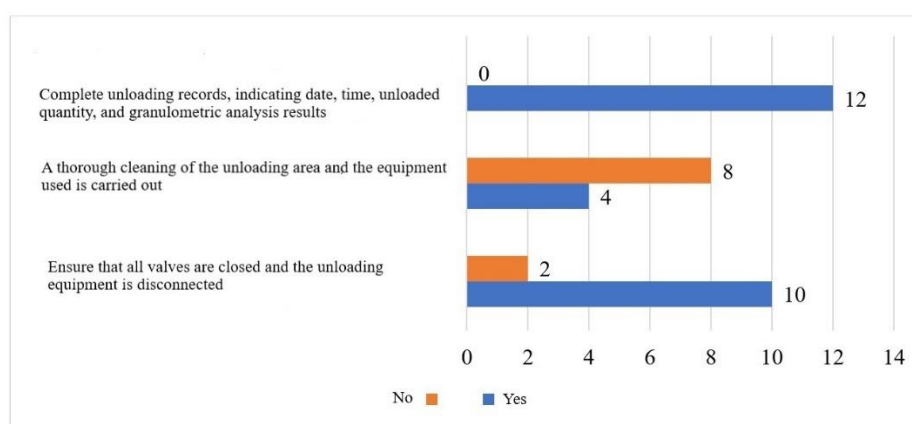


Figure 9. Verification of critical activities at the end of barley malt unloading as operational risk factors.

The level of compliance in the delivery of documentation to the carrier upon completion of unloading operations is shown in Figure 10. The results indicate 100% compliance, as in all cases, the delivery note, a copy of the weighbridge ticket, and the original bill of lading were properly provided.

These findings indicate that the documentation closing process is adequately standardized and controlled, ensuring product traceability, verification of delivered weights, and compliance with administrative and regulatory requirements in freight transport. Furthermore, the proper delivery of this documentation helps prevent inconsistencies in records and potential conflicts among the parties involved in the operation.

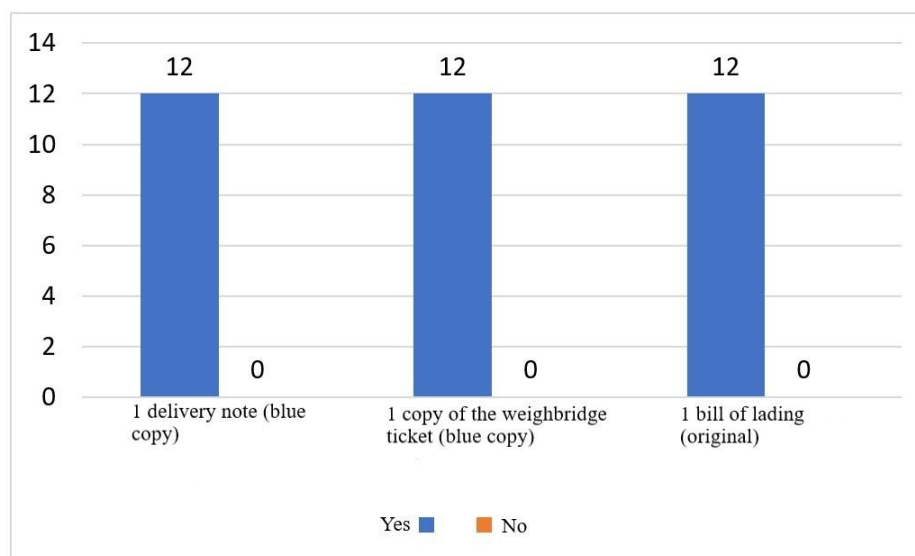


Figure 10. Compliance with the delivery of documentation to the carrier upon completion of barley malt unloading.

The evaluation of preoperational conditions prior to the start of barley malt loading operations, which is based on a checklist applied to 17 transport units, is presented in Figure 11. The results indicate a high level of compliance across most of the evaluated criteria, as in 100% of the cases, operators had a bill of lading, and it was verified that the vehicle floor was in suitable condition to prevent contamination, spillage, or damage to the bulk product.

However, partial noncompliance was identified in the cleanliness condition of the units, where 88.2% were clean, dry, and free of contaminants, while 11.8% did not meet this requirement. According to the recorded observations, residues such as branches and leaves were detected inside the cargo compartments of these units, indicating a potential risk of product contamination.

These results indicate that although documentation controls and structural inspection of the vehicles are well implemented, operational risk factors related to unit cleanliness persist. This aspect is critical, as the presence of physical contaminants may compromise product quality and affect food safety standards. Therefore, strengthening preloading inspection and cleaning procedures and enhancing supervision are recommended to ensure full compliance with the established criteria.

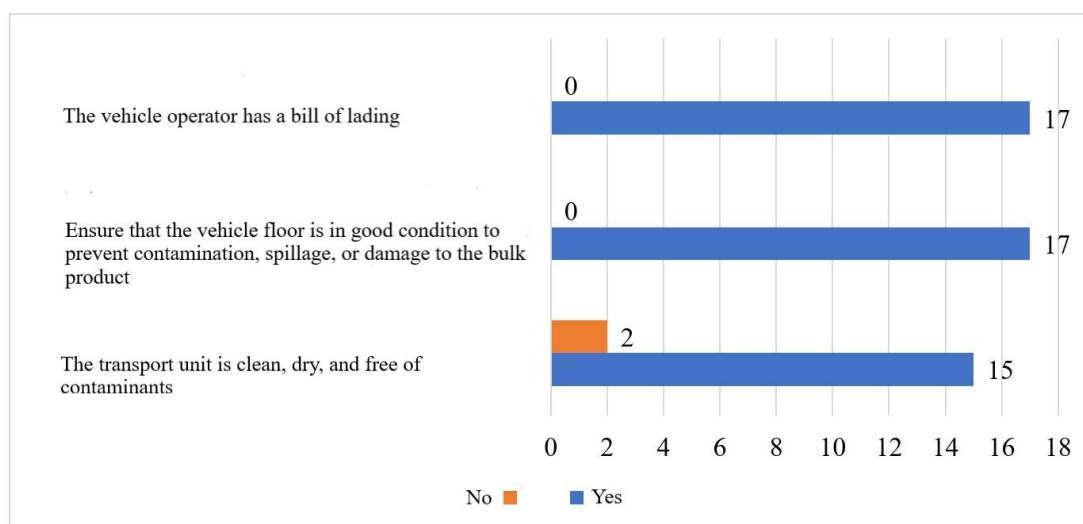


Figure 11. Verification of the initial conditions of transport units as a risk control factor.

An evaluation of the operational conditions of the loading system used during barley malt handling operations, considering components such as conveyors, elevators, dust extraction systems, and truck hoppers, is shown in Figure 12. The results show full compliance (100%) across the 17 evaluated units, as all system components were in optimal operating condition, with no cases of noncompliance recorded.

This performance reflects effective operational coordination between the client company and the service provider, where prior scheduling of activities allows for the preparation of equipment through cleaning, sanitization, and technical inspection processes. Maintaining the loading system under optimal conditions significantly reduces the likelihood of mechanical failure, dust generation, product contamination, and potential incidents during operations.

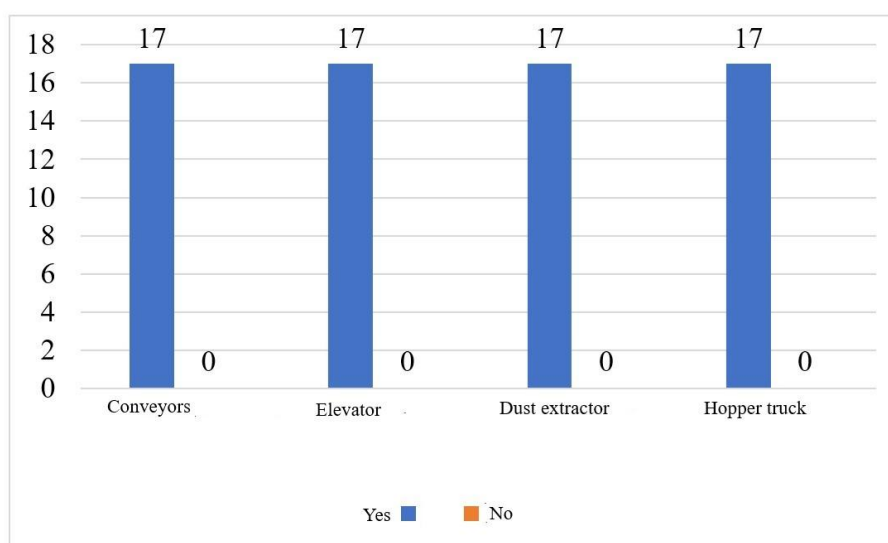


Figure 12. Verification of the loading system as an operational risk control factor.

The use of personal protective equipment (PPE) by personnel during barley malt loading operations is shown in Figure 13, considering a sample of 17 units. The results reveal significant differences in the level of compliance depending on the type of equipment.

In the case of safety helmets, total noncompliance (0% usage) was recorded, as none of the evaluated units had personnel equipped with this item, which is primarily associated with the lack of provision by the company. In contrast, full compliance (100%) was observed in the use of masks and safety boots.

With respect to safety goggles, partial compliance was identified, with 52.9% of units using this equipment and 47.1% not. Similarly, the use of gloves also resulted in partial compliance, with 47.1% of units using them compared to 52.9% that did not.

Noncompliance with the use of goggles and gloves is not related to a lack of provision but rather to behavioral factors, such as perceived discomfort or habitual practices of performing tasks without this type of protection. These findings highlight the presence of organizational and behavioral risk factors, where the absence of helmets and the inconsistent use of other protective equipment increase exposure to physical hazards such as impacts, airborne particles, and limb injuries.

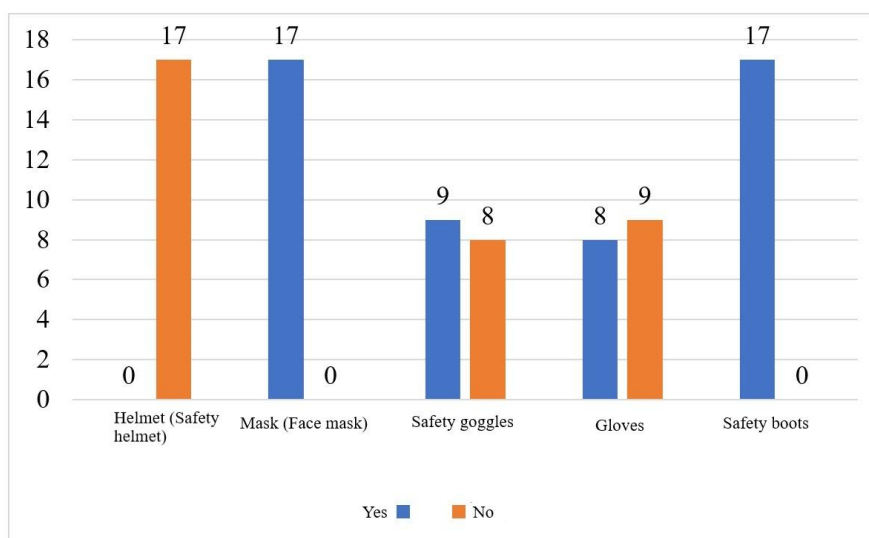


Figure 13. Level of compliance with the use of personal protective equipment (PPE) during loading operations.

The evaluation of compliance with operational procedures during the barley malt loading phase, which is based on a checklist applied to 17 units, is shown in Figure 14. The results show full compliance (100%) across all the evaluated variables, as in all the cases, constant communication was maintained with the unit operator, the loading process was continuously monitored to detect potential anomalies, and the established procedures were strictly followed to prevent damage to both the product and the equipment.

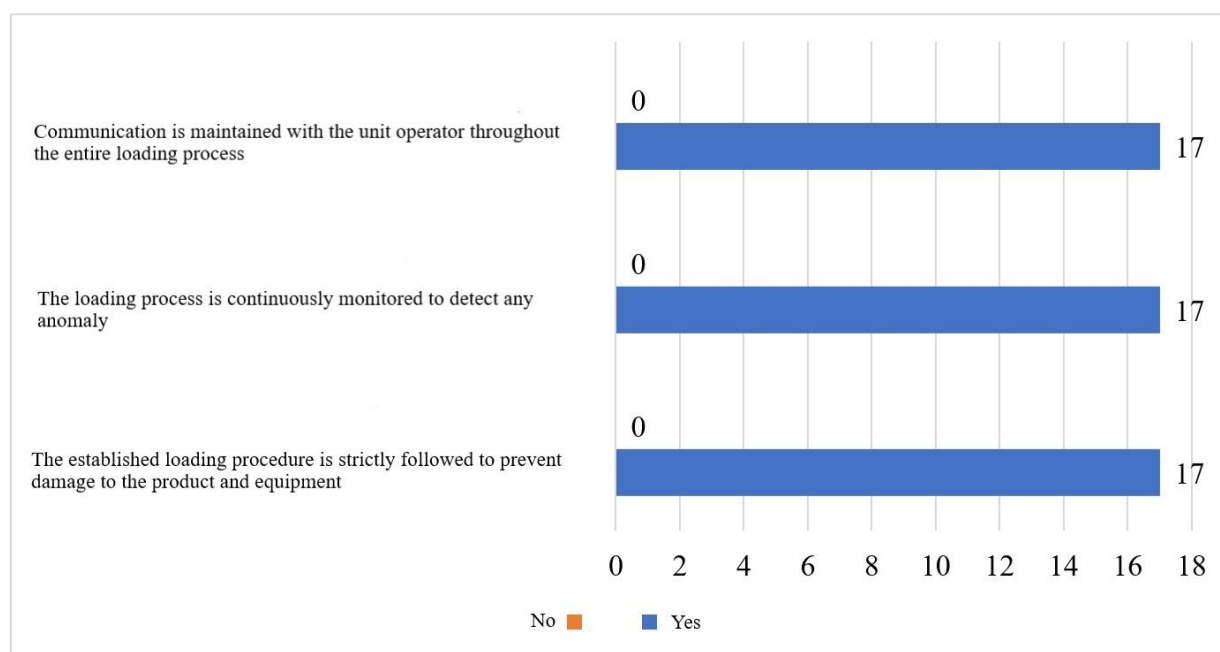


Figure 14. Verification of operational controls during loading as a risk mitigation factor.

With respect to the placement of security seals on vehicle doors and gates, 82.4% of the units complied with this requirement, whereas 17.6% did not place them properly (Figure 15). This noncompliance represents a critical issue, as it compromises product integrity and traceability during transport.

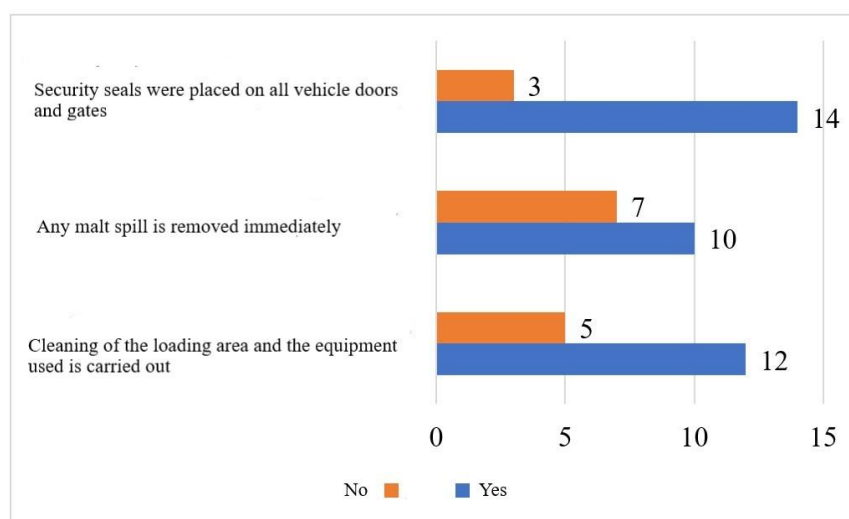


Figure 15. Verification of critical end-of-loading activities as operational risk factors.

With respect to the immediate removal of malt spills, compliance was recorded in 58.8% of the cases, whereas in 41.2%, this action was not carried out in a timely manner.

Similarly, 70.6% of the units were subjected to loading area cleaning, whereas 29.4% of the units were not adequately filled (Figure 15). These deficiencies are associated mainly with operational dynamics,

as when loading units arrive continuously, personnel tend to postpone cleaning activities until the end of the workday or until all scheduled units have been processed. However, this practice increases residue accumulation and makes it more difficult to maintain adequate working conditions in the operational area.

The results shown in Figure 16 indicate full compliance (100%) across all the evaluated variables, as in all the cases, the copy of the weighbridge ticket, the three delivery notes, the original bill of lading, and the loading inspection form were correctly provided.

These results indicate that the documentation closing process is fully standardized and controlled, ensuring that transport units can continue their journeys without administrative or legal issues. Furthermore, the proper delivery of documentation ensures product traceability, verification of transported weights, and consistency of the information recorded during the operation.

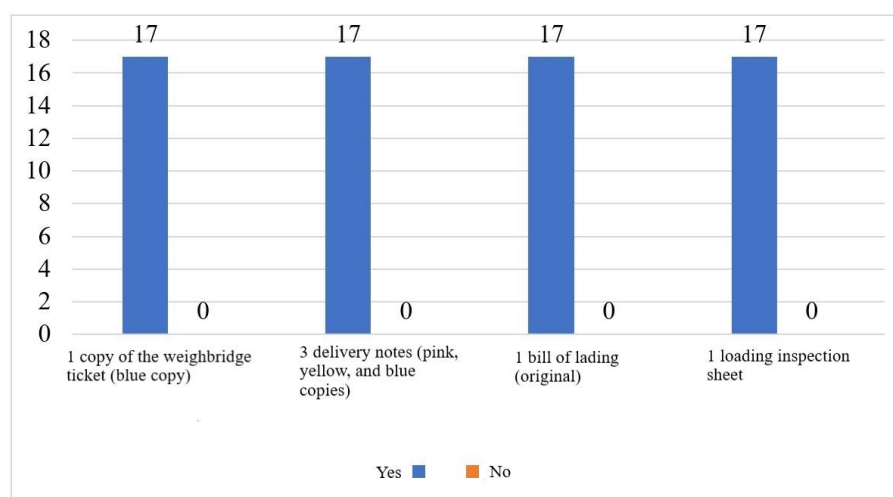


Figure 16. Verification of documentation closure as an organizational control factor in loading operations.

The evaluation of preoperational preparation conditions in units assigned for corn semolina loading, which is based on a checklist applied to 5 units, is shown in Figure 17. The results show 100% compliance for most of the evaluated variables, as in all the cases, the operator was in optimal condition, the units had valid insurance, no oil leaks were present, appropriate hoses for the operation were available, lighting and signaling systems were in good condition, and the tires met the required quality standards.

However, partial noncompliance was identified in the verification of the structural integrity of the hopper, where 80% of the units met this criterion, whereas 20% of possible deficiencies associated with cracks or signs of corrosion were detected. This finding represents a relevant issue from an operational

safety perspective, as the structural integrity of the hopper is essential for preventing material leakage, spills, or failures during the loading process.

These findings indicate that although preoperational controls are adequately implemented, an operational risk factor related to the physical condition of the hoppers persists, which may compromise both worker safety and product quality. Strengthening preoperational technical inspections and establishing stricter unit acceptance criteria are recommended to ensure full compliance with requirements and minimize risks associated with structural failure.

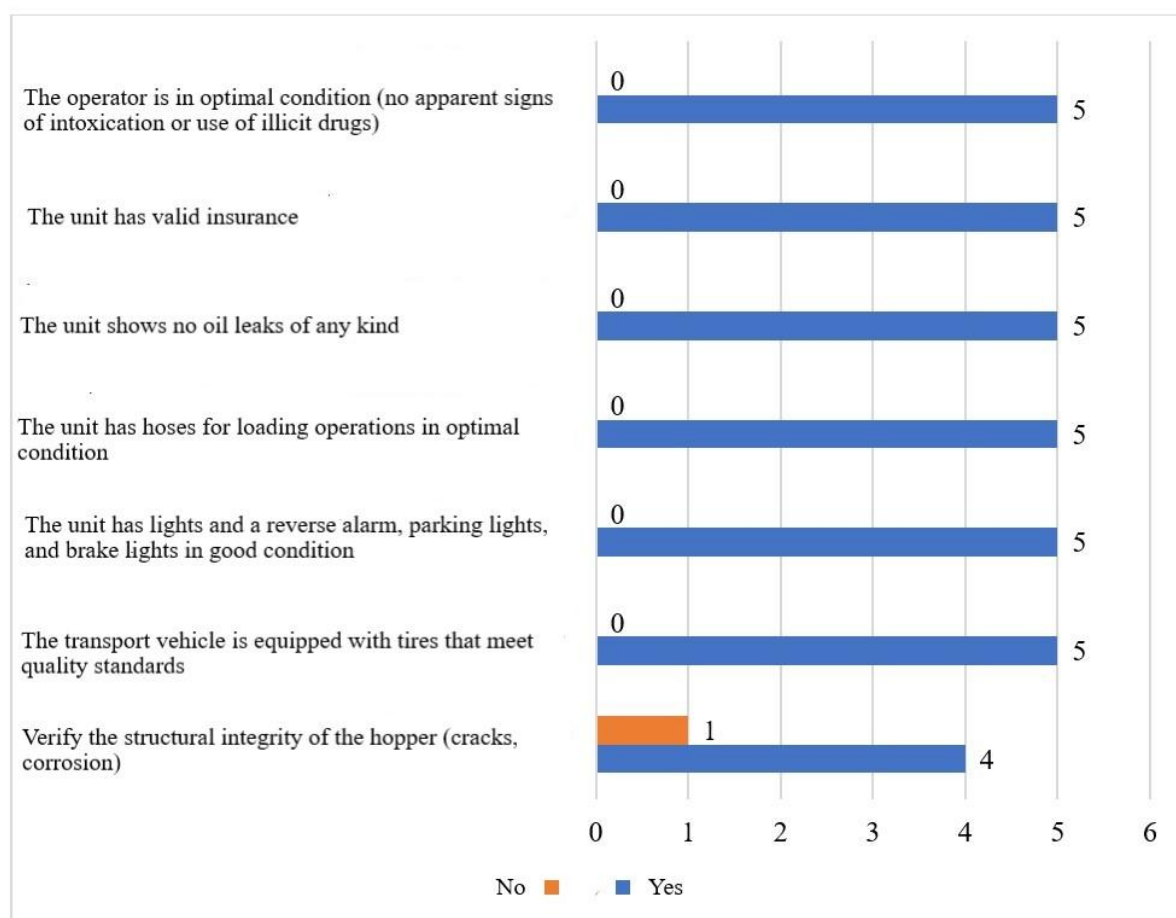


Figure 17. Verification of preoperational conditions as a risk control factor in corn semolina loading.

The evaluation of personal protective equipment (PPE) use during corn semolina loading operations is shown in Figure 18. The results show full compliance (100%) in the use of safety helmets, gloves, safety boots, and safety goggles, as personnel in all evaluated units were equipped with these protective items.

However, deficiencies were identified in other PPE components. In the case of masks, total noncompliance was recorded, as none of the evaluated units (0%) used this equipment. With respect to

hearing protection, partial compliance was observed, with only 40% of units using earplugs and 60% not using them.

The use of earplugs and masks by operators is primarily associated with specific workplace conditions, such as exposure to noise and dust; however, their use is not fully standardized among personnel. These results suggest the presence of occupational and behavioral risk factors, where the lack of mask use and the partial adoption of hearing protection increase exposure to risks associated with airborne particles and elevated noise levels.

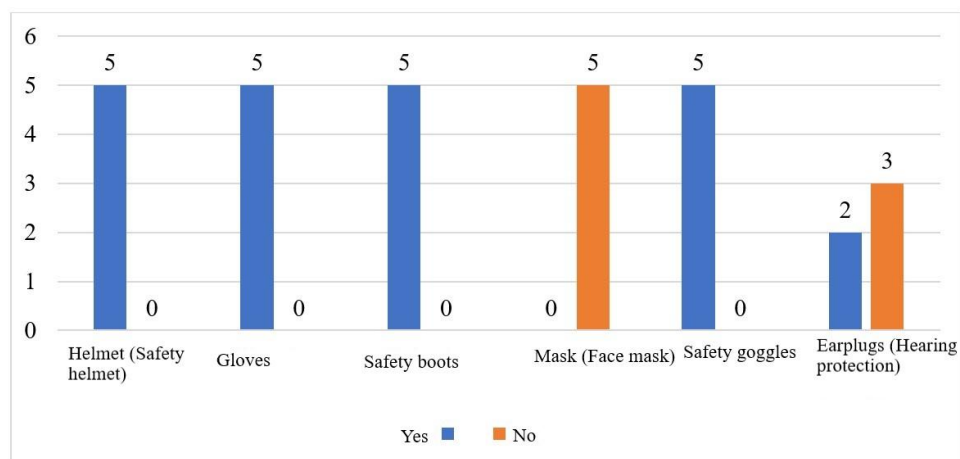


Figure 18. Verification of PPE use as an occupational risk factor in maize semolina loading.

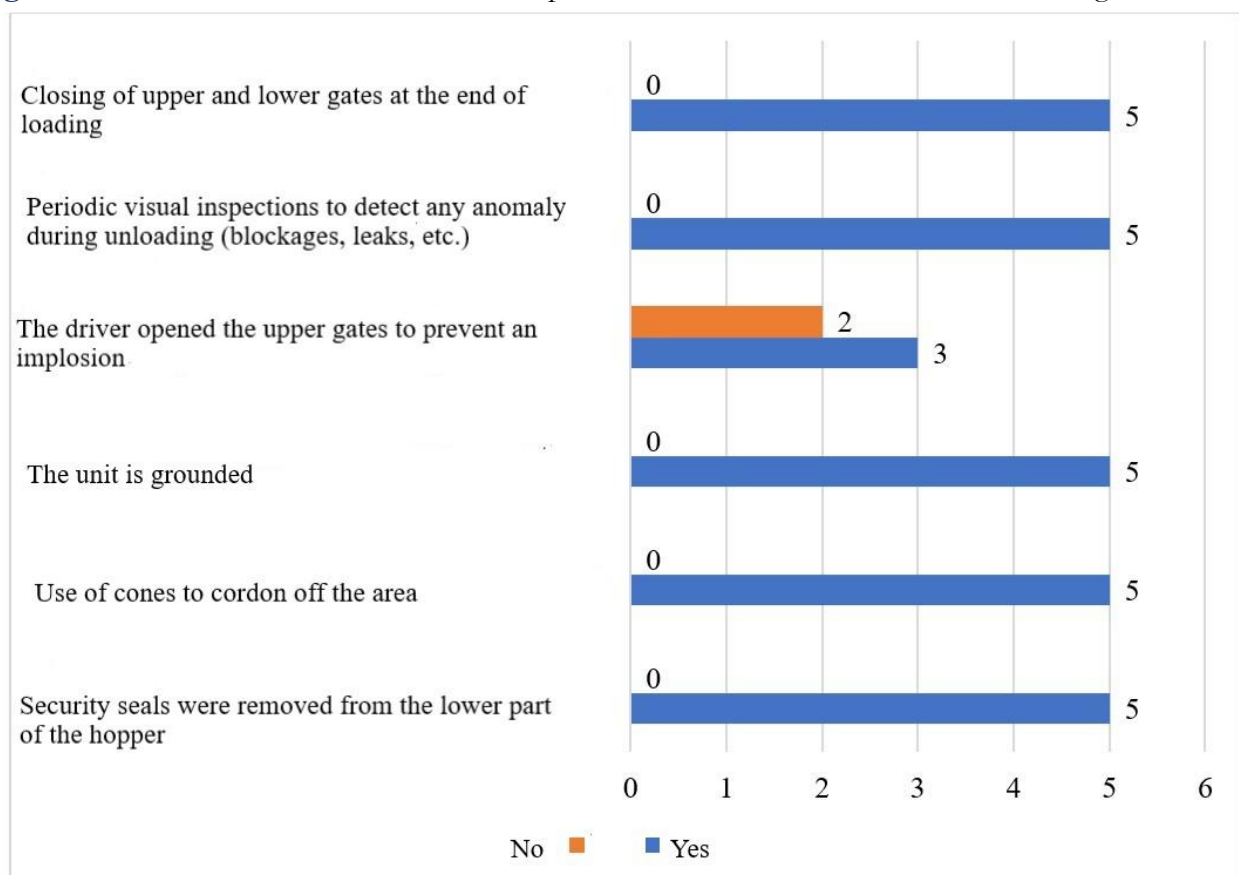


Figure 19. Verification of operational conditions during maize semolina loading as a risk control factor.

The evaluation of compliance with operational conditions during the corn semolina loading phase is shown in Figure 19. The results show a high level of compliance across most of the evaluated variables, as in 100% of the cases, periodic visual inspections were conducted to detect anomalies, gate closure was performed at the end of loading, the unit was properly grounded, safety cones were used to cordon off the area, and security seals were removed from the lower part of the hopper prior to the operation.

Partial compliance was identified in the variable related to the opening of upper hatches by the operator to prevent possible implosion during the process. In this case, 60% of the participants performed this action properly, whereas 40% did not, indicating relevant noncompliance.

The evaluation of compliance with the activities required for the release of units upon completion of the corn semolina loading process is shown in Figure 20. In 100% of the cases analyzed in this study, valve sealing was carried out using preassigned seals, as well as the final inspection of the hopper truck for corn semolina sampling.

This behavior reflects adequate standardization of closing procedures, where the involvement of responsible personnel, such as supervisors, ensures compliance with critical activities before unit departure. Proper valve sealing helps maintain the integrity of the corn semolina during transport, while final inspection and sampling allow verification of its quality and traceability.

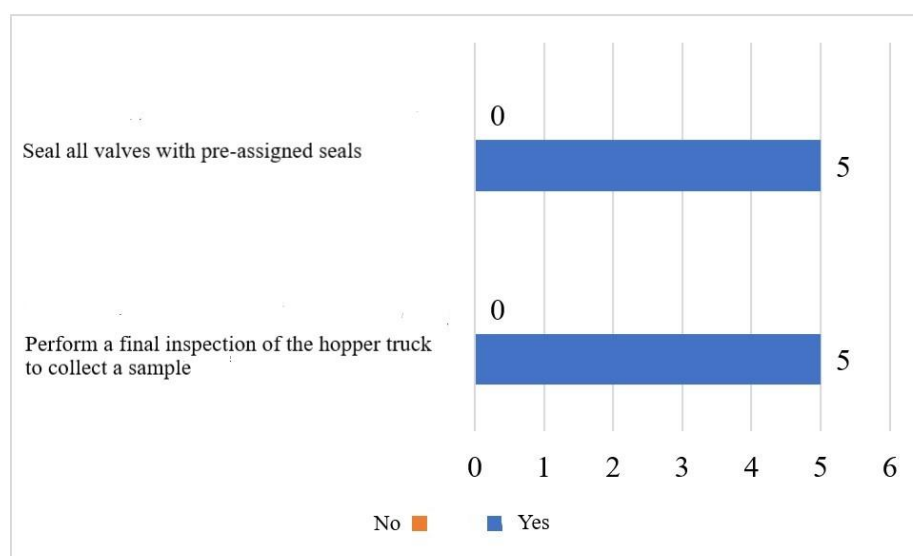


Figure 20. Verification of critical activities for unit release as a risk control factor.

The evaluation of compliance with the delivery of the documentation required for unit release upon completion of the corn semolina loading process is shown in Figure 21. A 100% compliance rate was observed across all the evaluated variables, as in all the cases, the three copies of the bill of lading, the weighbridge ticket copy, dispatch orders, the certificate of analysis (COA), and the unit cleaning certificate were correctly provided.

This behavior indicates that the documentation closing process is adequately standardized and controlled, ensuring the proper release of units without administrative or regulatory issues. Furthermore, the complete delivery of documentation guarantees product traceability, verification of transported volumes, and compliance with established quality and food safety requirements.

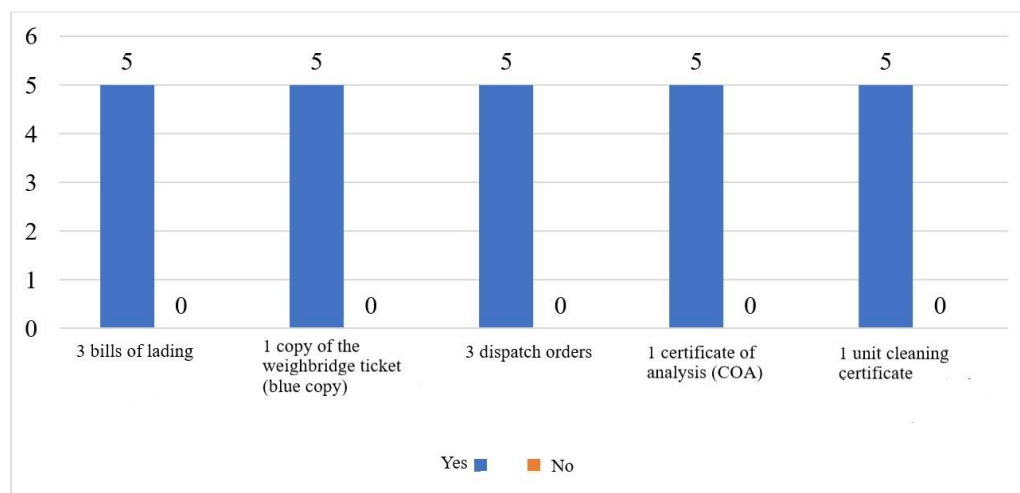


Figure 21. Verification of documentation closure as an organizational control factor in unit release.

CONCLUSIONS

Loading and unloading operations of agricultural products in land transport units represent a critical component of the agro-industrial supply chain, as they involve multiple operational, organizational, and occupational risk factors. The findings of this study indicate that although there is a high level of compliance in aspects related to documentation, equipment conditions, and operational procedures, significant deficiencies persist that may compromise worker safety and product quality.

In particular, deficiencies were identified in the use and provision of personal protective equipment (PPE), highlighting the complete absence of safety helmets and the inconsistent use of goggles and gloves, which reflects the presence of both behavioral and organizational factors. Additionally, noncompliance was detected in critical post operational activities, such as area cleaning, spill control, and the placement of security seals, increasing the likelihood of incidents and product contamination.

On the other hand, external factors, such as disruptions in railway infrastructure and limitations in raw material supply, demonstrate the vulnerability of the logistics system to uncontrollable conditions, emphasizing the need for more robust risk management strategies.

The implementation of comprehensive occupational health and safety management systems, the strengthening of personnel training, and continuous process supervision are recommended as key elements for mitigating risks, improving operational efficiency, and ensuring the sustainability of agro-industrial operations.

ACKNOWLEDGEMENTS

To the BioSecuraNet International Network—International Network for Biotechnology and Innovative Strategies for Global Food Security.

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9786585756792



BioSecuraNet

**Red Internacional de Biotecnología y
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Pantanal Editora

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