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Hazards, Risks and Control Measures in Productive Process of Fresh Asparagus

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Industrial activity is always exposed to events related to working risks that should be identified to seek suitable measures to tackle if necessary. The objective of the research was to identify the hazards and evaluate them to implement control measures to reduce the occupational accidents that may occur in the processes and activities of fresh asparagus agro-industrial companies. The industrial safety risk management methodology was used, starting by knowing the processes that are carried out in the production line, describing in detail the activities that are carried out, and then identifying the risk factors based on the probability and their frequency, as well as the dangers they pose. As a result, the risk was estimated as "Important" in all the processes of activities of the material collection and transport (all the activities), for the Hydrocooling process of raw material only in two activities out of a total of three and in two activities of the hydrocooling process and disinfection of the final product. On the other hand, a risk estimate of "Moderate" was obtained in the processes of raw material storage, selection and calibration, cutting and weighing, filling and coding of boxes, palletizing, storage in the chamber and dispatch, transporting the finished product. The importance of the results will allow them to make the best decisions in the risk management of this industry, allowing to reduce the negative impacts on the health of the operators and the environment.

1. Introduction

In Peru, one of the agro-industrial products with the highest production is asparagus, leading its export worldwide, from January to September 2021 there was a production of 101 788 tons of fresh asparagus, exporting 87 729 tons, being the eighth agricultural product most exported (Ministerio de Desarrollo Agrario y Riego - ROF-MIDAGRI, 2021). Industries in general require their activities to manage latent risk to reduce occupational accidents as in the case of asparagus production, generating risk management model systems such as in the auto parts manufacturing industry (Melendez, 2017), in companies with activities of a dangerous nature such as waste management where risks of a critical level are identified (due to noise, vibrations, particulate matter), of a significant level (handling of loads, repetitive movements, heat) that require the organization and work infrastructure to be improved and promoting a better culture of accident prevention (Ramos & Baldeón, 2017).

The prevention of occupational hazards is important, this should seek legislation before establishing reparations and compensation for accidents or occupational diseases, compliance with security measures, control and inspection and sanction must be supervised, all this could be improved with the incorporation in the legislation of the "crime of danger" with judges specialized in the subject, that is, not waiting for the harmful events such as accidents and deaths to occur (Gallo, 2019).

Research is important when identifying the activities and the risk that is generated, to propose actions or control measures to lower the level of risk of negative consequences on the health of workers, the results are generic for any company, within it, the fundamental is the preventive culture that must be adequately integrated into business management knowing the theory of causality (Frank Bird) thus, this planning improves productivity,

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there will be an economic improvement of the company and a better management of prevention of occupational risks (Fernández, 2019)

2. Methodology

2.1 Stages of the fresh asparagus process

The methodology of an industrial safety management system was established in a fresh asparagus processing plant where the set of operational activities observed in Figure 1 is followed.

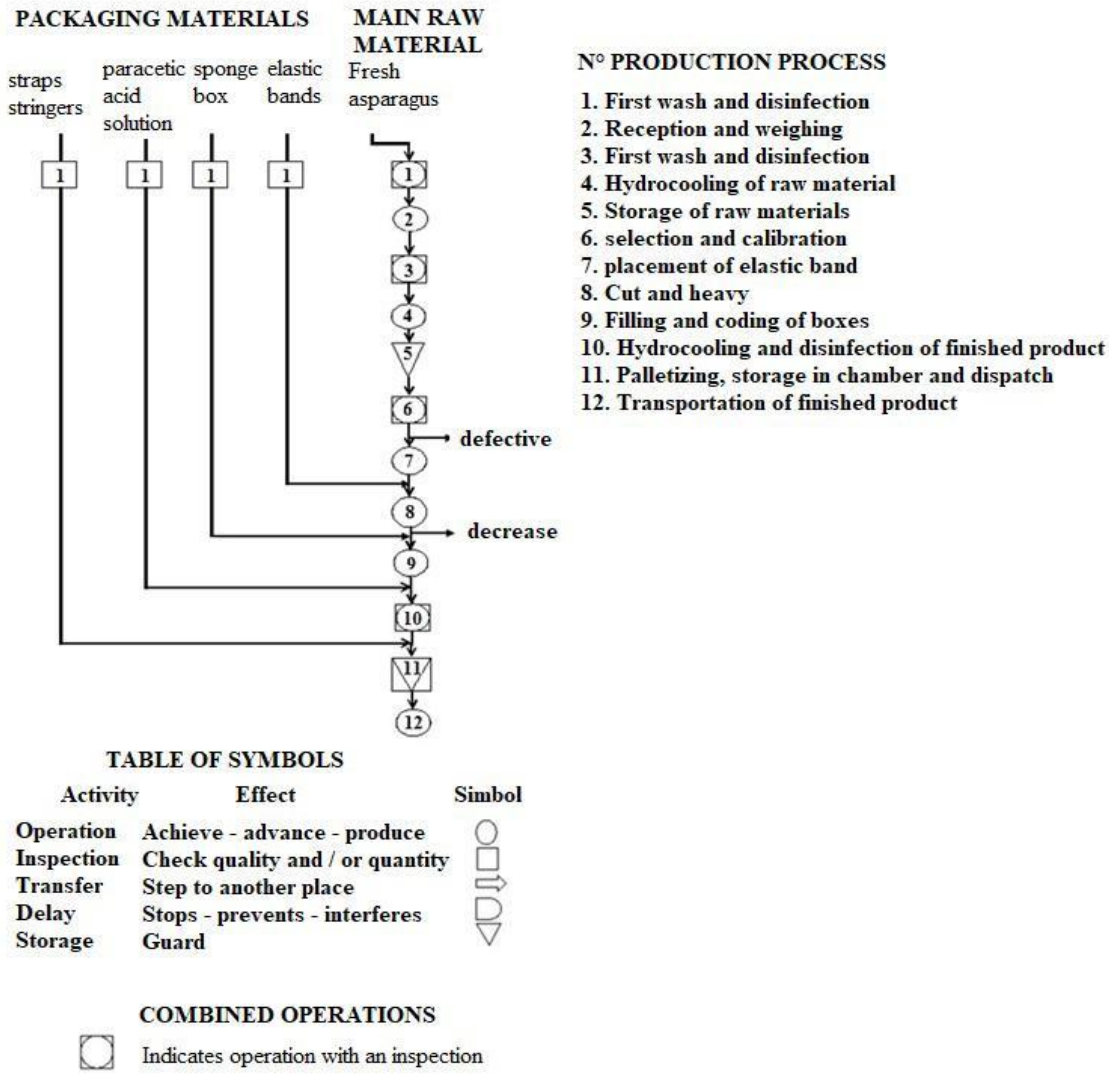

Figure 1 Process diagram of fresh asparagus processing.

2.2 Methodology for hazard identification, risk assessment and control measures

The risk identification was made using the risk matrix proposed by Ministerial Resolution No. 050-2013-TR through the formats that indicate the minimum mandatory registration information of the Occupational Health and Safety Management System, as well as the International Labour Organization (2020).

To determine the risk of the process activities in the asparagus production company, (taking account the aforementioned peruviana standard) the combination between the probability of occurrence of a dangerous event and the magnitude of its consequences (severity) was taken into account. See Eq (1)

$$Risk\ (R) = Probability\ (P)\ x\ Severity\ (S) \qquad \text{Eq (1)}$$

Where: $P = A + C + D$

A: Number of exposed people
B: Existing procedures
C: Training
D: Exposure frequency

The determination of the Probability and Severity in occupational accidents in the asparagus production company, took into account the considerations indicated by the standard, see Table 1.

Table 1: Indicators to determine Probability and Severity

Determination of Probability (P)				Determination Severity (S)
Index of exposed people (A)	Index of existing procedures (B)	Index of training (C)	Index of exposure to risk (D)	(consequences)
3	There are procedures, they are sufficient and satisfactory.	Trained personnel know the dangers and prevent them	At least once a year.	Injury without disability (S)
			Sporadically	Discomfort (SO)
12	There are partial procedures, they are not sufficient and satisfactory.	Partially trained personnel, know the danger, but do not take control actions.	At least once a month.	Injury with temporary disability (S)
			Eventually.	Irreversible damage to health.
More than 12	They do not exist	Untrained personnel do not take control actions.	At least once a day	Injury with permanent disability (S)
			Permanently	Irreversible damage to health

Source: RM N°050-2013-TR

For the assessment and estimation of the degree of risk, Table 2 was considered, which allows use colors to label the risk of the activities (green, yellow and red).

Table 2: Risk estimation

Score	Degree of risk	Background color
0 - 4	Trivial (TR)	Green
5 - 8	Tolerable (TO)	Green
9 - 16	Moderate (M)	Yellow
17 - 21	Important (IM)	Yellow
25 - 36	Intolerable (IT)	Red

Source: RM N°050-2013-TR

To present the industrial safety risk management matrix of the processes of an industry in the production of asparagus and taking into account the estimation, level and risk classification of the activities, control measures were proposed, as detailed in the results.
The study was carried out involving 110 workers who worked 784 hours of work in total.

3. Results and discussion

Following the methodology for each process, the hazards were identified, the risks were evaluated and control measures were proposed, which are indicated in the corresponding Tables. The activities that were trivial, tolerable and moderate only indicate the global result; however, for the activities that resulted as an "IMPORTANT" risk, the evaluations and control measures for industrial safety risks are presented.

3.1 Process: First wash and disinfection

Four activities with risk of "Important" level were determined, see Table 3. In this stage there are activities of use of disinfectants, and if they do not have the protection and training measures, unfortunate work accidents can occur, also control measures must be implemented within the framework of the security legislation approaches of each country such as the SEVESO Directive and the implementation of the risk-based inspection (RBI) approach, (Bragatto, et al., 2020).

Table 3: Industrial safety risk management matrix for washing and disinfection

Activity	Identified Hazards	Risk	P	S	R	Risk classification	Control measures
Preparation of the disinfectant detergent	The cold, the water, the detergent	Mechanical, chemical, ergonomic, facilities. physicochemical	8	3	24	Important (IM)	Use of EPP, MSDS sheet, training
Place the crates in the disinfection tubs	The cold, the water, the crates, the weight, the detergent.	Mechanical, physical, chemical, ergonomic, physicochemical.	8	3	24	Important (IM)	Use of EPP, check list of equipment, training
Manual cleaning of shoots in the tub	The cold, the water, the crates, the weight, the detergent.	Mechanical, physical, chemical, ergonomic, physicochemical	8	3	24	Important (IM)	Use of EPP, MSDS sheet, check list of equipment, training
Remove the crates from the disinfection tub	The crates, the weight, the height, the hydraulic forklift, the floor.	Mechanical, physical, chemical, ergonomic, facilities, physicochemical	8	3	24	Important (IM)	Use of EPP, signaling

3.2 Process: Hydrocooling of raw material

For the Raw Material Hydrocooling Process, activities with 2 important risks and 1 moderate were found, See Table 4. In this stage, activities with electrical and physicochemical risks are carried out; so, in addition to the control measures indicated in Table 4, Automatic control equipment can be implemented to obtain information on dangerous levels of chemicals (Periolatto et al., 2020)

Table 4: Industrial safety risk management matrix for raw material hydrocooling

Activity	Identified hazards	Risk	P	S	R	Risk classification	Control measures
Preparation of Hydrocooler	Hydrocooler, electrical system.	Electric	8	3	24	Important (IM)	Check list of equipment, training. Fire protection system, use of EPP, training.
Preparation of the chlorine solution	The chlorine solution, the cold, the weight.	Physical, chemical, physico-chemical	8	3	24	Important (IM)	MSDS sheet, Use of EPP, training.
Stowage of loads on plastic stretchers	The crates, the weight, the height, the hydraulic forklift, the floor.	Physical, ergonomic, facilities	8	3	24	Moderate IM)	Use of EPP, signaling.

3.3 Process: Hydrocooling and disinfection of the finished product

For the process of hydrocooling and disinfection of the finished product, 2 important risks and 1 tolerable risk were identified (see Table 5). These risks could be reduced if it is possible to identify all of them, so it is possible to resort to the various ways of locating them and evaluating these occupational risks from the occupational, health and safety point of view, with methods of a single expert, but undoubtedly, the ones made by multiple attribute decision are the most efficient, such as the Bayesian Best-Worst Method (Bayesian BWM) and VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), (Ak et al., 2022).

Table 5: Industrial safety risk management matrix for hydrocooling and disinfection of finished product

Activity	Identified hazards	Risk	P	S	R	Risk classification	Control measures
Placing boxes in the Hydrocooler	The cold, the weight, the floor, the hydraulic truck.	Electric.	8	3	24	Important (IM)	Check list of equipment, use of EPP, training. Order and cleanliness.
Equipment monitoring	The cold, the weight, the floor, the hydraulic truck.	Physical, chemical, physico-chemical.	8	1	8	Tolerable (TO)	Check list of equipment, use of EPP, training. Order and cleanliness.
Hydrocooler Water Change	The cold, the weight, the floor, the hydraulic truck.	Physical, ergonomic, facilities.	8	3	24	Important (IM)	Check list of equipment, use of EPP, training. Order and cleanliness.

3.4 Overall results of trivial, tolerable and moderate processes

- Collection and transportation of raw material: 4 moderate risks
- Reception and weigh-in: 3 moderate risk activities
- Raw material storage: 1 tolerable risk and 2 moderates.
- Selection and calibration: 1 tolerable risk and 2 moderate
- Linked: 1 tolerable risk and 2 moderates
- Filling and coding of boxes: 1 tolerable risk and 1 moderate.
- Palletizing, cold room storage and dispatch: 7 moderate risks.
- Transportation of finished product: 1 tolerable and 1 moderate.

3.5 Average risk of production processes

In summary, Table 6 shows the average risks for each production process in an asparagus production plant. The results statistically show a mean of 15.33, corresponding to a "Moderate" risk, a maximum of 24 for an "Important" risk and a minimum of 8 for a "Tolerable" risk with a standard deviation of 4.4586.

Table 6: Average, percentage and risk classification of production processes

N°	Production process	Risk Average	% of risk	Risk classification
1	Collect and transport of raw materials	18	50.00%	Important (IM)
2	Reception and weighing	13	36.11%	Moderate (M)
3	First wash and disinfection	24	66.67%	Important (IM)
4	Hydrocooling of raw material	21	58.33%	Important (IM)
5	Raw material storage	13	36.11%	Moderate (M)
6	Selection and calibration	14	38.89%	Moderate (M)
7	Bound	8	22.22%	Tolerable (to)
8	Cut and weigh	16	44.44%	Moderate (M)
9	Box filling and coding.	12	33.33%	Moderate (M)
10	Hydrocooling and disinfection of finished product	19	52.78%	Important (IM)
11	Palletizing, chamber storage, dispatch	14	38.89%	Moderate (M)
12	Finished product transportation	12	33.33%	Moderate (M)

Risk management in work centers is important and there is a deficiency in their identification to improve working conditions in asparagus production centers, this coincides with the investigation of the economically active urban population of Peru that found that they are exposed to many occupational risks and occupational health is not managed, affecting the health of workers and quality of work (Sabastizagal-Vela et al., 2020). Therefore, implementing risk management must be imperative in order to comply with existing regulations, as in the case of a fishing company that implemented an occupational health and safety system based on Peruvian Law No. 29783 and managed to reduce the risk from an initial mean of 18 to a mean value of 6 (Miñan-Olivos S et al., 2020). In the same way, the method used in the investigation compared with the Bayesian method, similarity is found when prioritizing the risks and proposing control measures, the latter applied in a textile industry managed to evaluate the risks with six different criteria that were: probability of an event dangerous (P), frequency (F), severity (S), detectability (D), cost (C), and the sensitivity for not wearing personal protective equipment (SNP); therefore, the results achieved in the research can help the risk managers and analysts of the companies to formulate proposals for improvement and thus increase safety in the work environment (Ak et al., 2022).

4. Conclusion

The risk activities in the processing of a fresh asparagus industry were identified through a matrix of industrial risks, then it was assessed and suggested control measures for the activities with risk classified as "Important" that corresponded to the washing and disinfection processes, hydrocooling of raw materials and hydrocooling of finished products and disinfection. With this information, the company in this area would be able to handle an efficient risk management of its operations in order to safeguard the business image, comply with labor and environmental legislation, improve the safety and health at work of its collaborators, and, at the same time, obtain economic returns. This will be corroborated in the future with an evaluation made after a period of implementation of the control measures suggested for each activity.

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