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CULTIVATION, HARVEST AND POST-HARVEST IN THE CORIANDER PRODUCTION SYSTEM (*Coriandrum sativum* L.)

Lucero **Leyva-Abascal**[1], María Lorena **Luna-Guevara**[2*], Jesús Francisco **López-Olguín**[1,3], Dionicio **Juárez-Ramón**[1], Ynes **Ortega**[4]

[1]Centro de Agroecología, Instituto de Ciencias; Benemérita Universidad Autónoma de Puebla. Edificio VAL 1, Ecocampus Valsequillo, San Pedro Zacachimalpa, Puebla. 72960 México.
[2]Colegio de Ingeniería en Alimentos, Facultad de Ingeniería Química, Benemérita Universidad. Autónoma de Puebla. Av. San Claudio s/n, Ciudad Universitaria, Col. San Manuel. 7257.
[3]Herbario y Jardín Botánico, VIEP; Benemérita Universidad Autónoma de Puebla. Av. San Claudio s/n, Ciudad Universitaria, Col. San Manuel. 7257.
[4]College of Agricultural and Environmental Sciences, Center for Food Safety, University of Georgia Griffin Campus. 1109 Experimental Street Griffin, GA 302223.
*Corresponding author: maria.luna@correo.buap.mx

ABSTRACT

Coriander (*Coriandrum sativum L.*) is an aromatic plant with high culinary demand in Mexico and one of the agricultural products from Puebla that is exported to the United States. This product has been affected by FDA Import Alert 24-23 that prohibits its export, due to the detection of pathogens associated with disease outbreaks among consumers. The objective of this research was to carry out a diagnosis of the production, harvest and post-harvest process (in the packaging units of the producing region) to characterize the stages in the process and to assess capacities that require consolidation to achieve product safety. Through the application of surveys and interviews applied to producers, packers, operators and safety advisors, combined with an analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT), we carried out characterization of production, harvest and packaging processes. As a complementary activity, key stakeholders were trained in the Fresh Produce Safety course (endorsed by the Produce Safety Alliance) and their participation was evaluated. In conclusion, it appears that the system is disorganized and there are deficiencies concerning safe handling of the product. High productive capacity was observed in a region suffering from a high degree of marginalization, poverty, insecurity and environmental deterioration, suggesting that the problems have multifactorial origins and must be analyzed from a perspective that considers social, economic and environmental aspects.

Keywords: export, import alert, safety, SWOT, vegetable garden management**.**

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INTRODUCTION

Coriander (*Coriandrum sativum L.*) is an annual aromatic plant, classified as a green, leafy, edible vegetable, that pertains to the Apiaceae family, reaches between 30 and 70 cm in height, and has high culinary, demand due to its aromatic and flavor characteristics, that can stimulate appetite, besides being recognized as a naturopathic remedy (INTAGRI, 2021). Odor and taste properties are associated with polyphenolic compounds such as: ferulic, caffeic, gallic and chlorogenic acids, recognized for their bioactive, antibacterial and antifungal properties, as well as representing an important source of vitamins A, B12, C and folic acid (Rodríguez-Quintero *et al.*, 2021).

In addition to their nutritional and functional importance, Mexican agricultural products, including coriander, are in ample demand for their fresh consumption, in the United States of America (USA), promoting a commercial relationship between these two nations. Correspondingly, these foods must comply with quality and safety requirements for trade, factors which can determine their acceptance or rejection; in both cases, the economic impact for participants in the production system results in uncertainty and instability in terms of planning for production cycles. According to the Electronic Commerce Service in Mexico City (SMATTCOM, 2019), during 2019, 99,754 Megagrams (Mg) of coriander were produced in Mexico, corresponding to the annual planting of 1,704 ha, with a production value of $362,696.35 pesos. Puebla takes first place nationally for coriander production, with 29,355.98 Mg per year, of which approximately 22,000 Mg are destined for export to the United States market (SADER, 2017; Tibaduiza-Roa *et al*., 2018); therefore, this vegetable represents one of the nine most important Product Systems at the state level.

The Ministry of Agriculture and Rural Development (SADER, 2017) indicates that there are 48 municipalities in the entity that produce coriander, particularly the municipalities of Quecholac and Los Reyes de Juárez, which are located in Acatzingo, region 10, Tecamachalco in region 12, Palmar de Bravo in region 11, Ciudad Serdán and Tepeaca in region 32 in the State of Puebla (SPF, 2023).

The economic importance of coriander is directly related to the problem generated regarding trade with the United States since 2014, due to the fact that the Regulatory Agency of the United States of America, the FDA (Food and Drug Administration), discovered a relationship between consecutive outbreaks of gastrointestinal illnesses due to cyclosporiasis within the country, and inadequate handling and hygiene conditions related to coriander cultivation and packaging sites in the state of Puebla, which affected the safety of the product. Based on the above, the Import Alert 24-23 (2014) was implemented, curtailing the entry of coriander from Puebla to the US market, during the period from April-August of each year (FDA, 2021a), meaning that production in the State of Puebla is destined to national consumption.

The Import Alert affected the rural situation in Puebla, where limitations have been caused by environmental, political, social and economic factors. Specifically, it is important to identify the impact this has had on key players in the coriander production system (producers, harvesters, and packers), who participate in the production, packaging, and marketing of coriander for export, mainly to the United States. Ensuring the supply of safe and healthy food is important for reducing the effects of foodborne diseases (FBD), which besides affecting the health of consumers, have negative consequences on the economy of developing countries.

According to the new regulation for the export of fresh food to the USA (FSMA, 2019), when the safety of food destined for export is guaranteed, international trade is promoted, fostering economic growth for a number of countries (FAO/WHO, 2013). Taking into account this antecedent, our research intends to analyze the coriander production system in the agricultural region of the state of Puebla, by identifying the stages of crop management, harvesting and processing, as well as key participants in the system, how they interact, while also assessing which areas of competence need to be strengthened to improve product safety.

METHODOLOGY

The methodology of this research divides into six sections, outlined below: 1) regional diagnosis of production and packaging sites, 2) description of the coriander product, 3) analysis of the system and identification of participants, 4) operation of a packaging unit, (5) intervention activities and 6) analysis of information obtained.

Regional diagnosis of production and packaging sites

Study region

Research was carried out in the coriander-producing agricultural zone of San Bartolomé, Palmarito and Xaltepec in Puebla, between the coordinates 18º50’10” N, 97º33’40” W and 18º57’30” N, 97º37’50” W, lying at an altitude between 2050 and 2240 masl, and located within the temperate zone climates of Valle de Tepeaca and Puebla. The climate is semi-warm, sub-humid and temperate with thermal changes in the months of January and June, with an average annual temperature of 18 ºC, constituting a minimum of 15 ºC and a maximum of 21 ºC (CONAGUA, 2021).

This productive region includes the municipalities of Acatzingo, General Felipe Ángeles, Los Reyes de Juárez, Palmar de Bravo, Quecholac, Tecamachalco, San Nicolás Buenos Aires and San Salvador el Seco; and 16 ejido sites, including La Purísima, Jesús de Nazareno, San Bartolomé Tochapan, San Miguel Xaltepec, San Antonio Limones, La Cruz and Palmarito. The main economic activity at these sites is agriculture, which initially involved growing maize, beans, and broad beans but has now changed to mainly vegetable production, including coriander, onions, cabbages, broccoli, carrots, and lettuce (Barrientos -Gutierrez *et al*., 2013).

Field visits and features common to the coriander production system for export

Field visits were carried out and surveys applied to key informants in the coriander production system, including producers, packers, advisors and safety technicians from the State Committee for Plant Health in Puebla State (CESAVEP), instructors in the safety of Fresh Products (Produce Safety Rule) trained by the Produce Safety Alliance, private safety advisors from Coadyuvancia Units in Certification and verification and representatives from the Union of Coriander and Vegetable Exporters (UNACOMEX A. C.), pertaining to the study region. A questionnaire was used as a diagnostic tool, designed to include 25 topics in order to obtain general qualitative information about the coriander production system, including growing, harvesting and processing conditions for export; participants and their experience concerning the impact caused by implementation of the import alert 24-23.

Selection of production and packaging units

Based on information collected related to the previous issue, it was possible to establish contact with 50 production units, which were selected according to the criteria that they supply packaging units involved in exportation of coriander to the US, meaning their participation in this survey was requested. As a diagnostic tool, a questionnaire was designed consisting of 71 questions; closed, semi-open and open, to compile information about coriander production. The questionnaire was divided into ten sections: 1) Cultivated area and production history, 2) Production system, 3) Production inputs, 4) Agricultural work, 5) Safety, 6) Infrastructure, 7) Operators, 8) Soil improvers, 9) Wildlife and 10) Water for production. The questionnaire was designed based on the requirements stipulated in the Food Safety Modernization Act (FSMA) that must be considered by producers and packers, who export their fresh vegetables to the USA.

Description of coriander product for export

A general description of the product, potential consumers, form of use and consumption, expected shelf-life and storage conditions for coriander was elaborated in compliance with the Preventative Controls for Human Foods Rule of the FSMA law.

Analysis of the coriander system and identification of participants

This analysis was carried out using information obtained from key informants and referring to the main stages in the coriander production system: pre-harvest, harvest and post-harvest or product packaging. From these stages, the tasks and management operations undertaken by participants were investigated.

Description of a packaging unit

Among the production, a packaging unit, whose process was 'typical' in terms of other similar processors in the region, was chosen. A brief description of the packaging company is included, together with information about its consumer market, stages in the process and sources of post-harvest water at the plant, as suggested by the Regulation of Preventive Controls for Food for Human Consumption in the FSMA law.

Intervention activities

Assessment of strengthening needs

An evaluation of the capacities of the packaging unit was carried out to detect any strengthening needs, with respect to the handling of coriander during postharvest, applying the SWOT analysis technique (Strengths, Weaknesses, Opportunities and Threats) to address priorities and guarantee the safety of the product; complying with guidelines for the identification of needs and capacities provided by the FAO/WHO (2013).

Training activities with key stakeholders in compliance with the FSMA law requirements

Based on the SWOT analysis of the packaging unit and direct communication with producers in the region, common concerns among producers were detected; the most important being the need for training on the FSMA regulation, necessary to ensure compliance with the requirements for export of fresh products and in order to compare the current situation of the coriander product system with the desired future situation. For this reason, training was provided to producers who grow coriander and the operators involved in the packaging process, with an in-depth assessment of the characteristics of the audience such as: age, level of education and knowledge about the safe handling of coriander.

Information analysis

The information obtained in relation to these activities was recorded in an EXCEL Office (2010) database, for Mac® and later entered into the statistical program SPSS® version 18, for analysis.

RESULTS

In accordance with the methodology described, we present information, specifying its type, relating to each stage in the investigation, noting the tool used and the type of informant who was interviewed (Table 1).

General diagnosis of the agricultural zone of Puebla

According to SEMARNAT (2021), the productive region consists of a planted area of 70,795.41 hectares of agricultural production, of which 17,875 users, produce mainly maize, alfalfa, beans, sorghum and fresh leafy vegetables, such as coriander. In the 2016-2017 agricultural year, the total irrigated area was 54,829.08 ha, employing a total water volume of 264,498,700 m3 (CONAGUA, 2021; SADER, 2017).

According to SAGARPA (2018), in Puebla there are 348,736 production units in the rural sector dedicated to agriculture, of which 14% use an irrigation system and 86% constitute rainy season crops; in these production units, agricultural practices are implemented, distinguishing technical, semi-technical and traditional production systems.

During the semi-structured interviews with key informants, the impact of Health Alert 24-23 and its consequences was mentioned, which was perceived from different perspectives by producers and packers but is considered to have direct effect on the sale of the product. Notably, this Alert remains in force and is considered a highly relevant regulatory measure, as it involves safety as a requirement for the production, harvest and packaging stages of the fresh coriander product.

Table 1. Diagnostic tools and their application for the purpose of generating information about the coriander production system.

Stage	Tool	Interviewees	Type of information obtained
Diagnosis	Semi-structured interviews	Key informants from health regulation agencies: CE-SAVEP, Coadyuvancia Units and the president of UNACOMEX	Vegetable production region in Puebla Participants in the coriander system Production system, harvest and packaging Trade Effects of the implementation of Alert 24-23
Product description	Semi-structured interview	Workers in vegetable packing units	Characteristics of the coriander export product, US consumer demands, conservation system, raw materials and management.
Analysis of the coriander system and identification of participants	Surveys consisting of open and semi-open questions	Farmers, packers, safety advisers, health agencies	Characterization of coriander production, harvesting and packaging processes
Packaging unit description	Field visits and on-site verification	Packers	Work system, consumer types, market destination for the product, stages in the process, safety control measures
Intervention activities	SWOT analysis* and detection of capacities that require fortification	Packaging unit and producers	Training needs for safety controls regulated by the FSMA Law

*Strengths, opportunities, weaknesses and threats; †FSMA: Food Safety Modernization Act (U.S. FDA).

Description of coriander product for export

At the packaging unit facilities, coriander can be collected from different production sites and selected by operators according to customer requirements. The quality parameters for coriander are mostly organoleptic and are checked visually for: apparent freshness, uniformity in size, shape, color, and absence of defects such as yellowed or damaged leaves, rot, presence of insects, or wilting (Cantwell and Reid, 2014). Coriander for export is sold in wooden boxes, which contain bunches of approximately 25 g of the product that are rolled up with plastic strips; the rolls are wrapped in plastic paper and covered with crushed ice to maintain product freshness. The wooden boxes must be kept at refrigerated temperatures during transit, so “Thermo King” type trucks are used to ensure the product maintains its quality conditions when it reaches its destination market. The characteristic aroma and flavor are essential for consumer approval, although these properties may deteriorate during storage (Jemni *et al.*, 2019).

Various sources indicate that the optimal storage temperature and humidity levels to preserve herbs are 0 ºC and 95%, respectively, to achieve a shelf-life of up to three weeks (Cruz-Álvarez *et al*., 2013; Cantwell and Reid, 2014; López-Blancas *et al*., 2014; Jemni *et al*., 2019). Coriander is frequently chilled and transported with ice, even though its presentation in the direct market is refrigerated, and it is not possible to avoid the loss of water from the product, which in turn will cause loss of quality. At the same time, refrigeration temperatures help avert the growth of bacteria such as *Salmonella* and *Escherichia coli* (FDA, 2021b).

Analysis of the coriander system and identification of participants

Coriander system analysis

Figure 1 was elaborated with information collected during the diagnosis, which shows the different stages for the cultivation, harvest and post-harvest handling of coriander. Coriander production in Puebla implies the same agricultural tasks that are undertaken in the principal states where this vegetable is produced: Baja California, Tlaxcala, Yucatán,

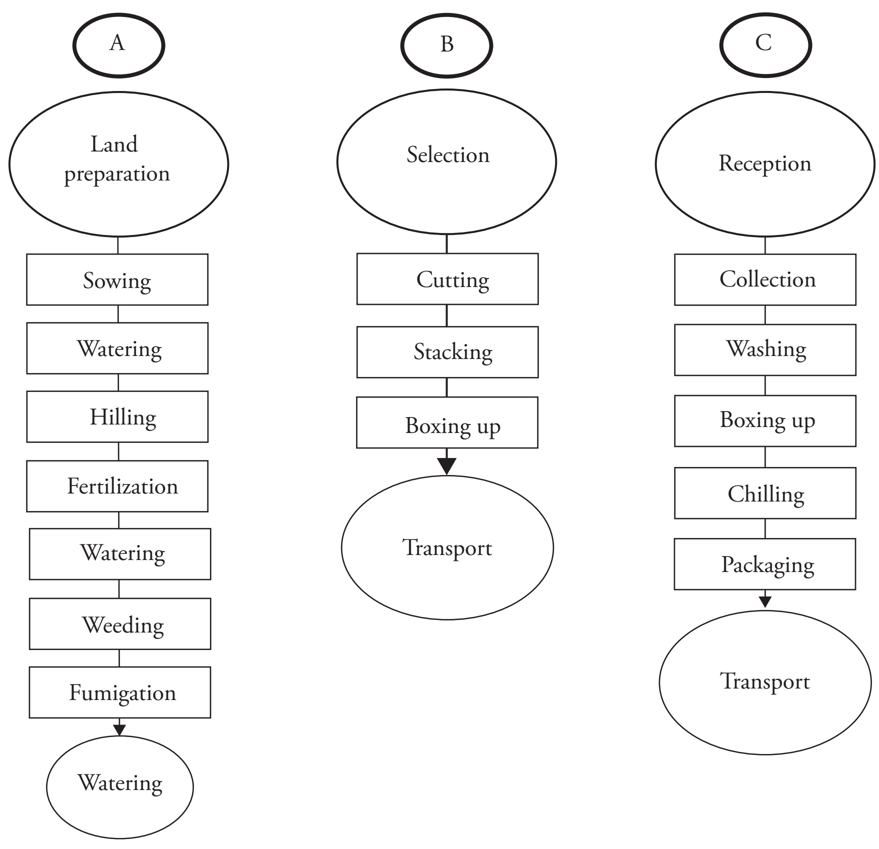

Figure 1. Stages in the Coriander Production System. (A) Coriander production farm work (B), Coriander harvesting operations and (C) Coriander processing operations.

State of Mexico, Hidalgo, Coahuila and Guanajuato, comprising 88% of total national production (Gordillo, 2000).

Production (pre-harvest management)

According to the responses received from the questionnaires applied to coriander producers and with that reported by Tibaduiza-Roa (2018), coriander cultivation is carried out in the open air and is defined in terms of seven principal agricultural operations that are necessary for coriander cultivation, including land preparation and its fertilization and irrigation (Figure 1-A). Depending on the conditions of the productive unit, the irrigation system used can consist of either sprinkler or drip, with the latter resulting in more efficient use of water (Gordillo, 2000); simultaneously, a fertilization/irrigation system is used to apply fertilizer. Once the coriander seed has been sown and irrigated, the germination process begins (2-3 days), the shoots are visible in the soil and the development of roots and stems initiates (14-20 days). According to Gordillo (2000), the stem develops a height from 26 to 40 cm, supporting upper leaves that develop from 4 to 7 points and several lobes from 2.5 to 10 cm long and 2 to 7.5 cm wide; foliar development implies periods of 30 to 40 days and the plant is cut prior to flowering (60-72 days); during periods of drought, the harvest can take up to 90 days (Mejía *et al.*, 2014; INTAGRI, 2021).

Harvest operations

The diagram in Figure 1-B lists each stage of the harvesting operations. Once the coriander plant reaches a height of 30-45 cm, after a period of 60 to 72 days in the field, it is ready to be cut. The main objective of the coriander harvest stage is to preserve the fresh or intact appearance of the plant (Cantwell and Reid, 2014). The cutting is done by harvest teams, made up of groups of people hired by the packing unit, whose job is to select the coriander plants according to the requirements demanded by the production unit. It must be ensured that coriander is not cut at the "tender" or immature stage to avoid "smoothing", a term used by producers which refers to rapid deterioration in the color and texture of the leaf. Knives are used for cutting and this is undertaken at ground level, and bunches are formed to later be placed in boxes. Gordillo (2000) suggests that coriander cutting be undertaken during the early morning or at sunset, as it is less susceptible to dehydration and then the product must be placed immediately in a cool and dry place in plastic boxes. However, harvesting processes are quite long (4-8 hours), and in the Tecamachalco region, the boxes of harvested coriander spend long periods of time exposed to the sun, reaching temperatures above 35 °C. The coriander bunches are placed in plastic boxes and transported to the packaging at room temperature (25-33 °C).

Packaging (postharvest handling)

In the study region, there are 12 formal packaging units that sell coriander and other vegetables to the United States of America, which are supplied with raw material from production units in the region; this was mentioned by key informants in the coriander production system. Within the packaging plant, the coriander collected from production units in the region and from five operations is processed from selection to packaging for trade purposes (Figure 1-C).

Participants in Coriander Systems

According to the information collected in questionnaires 1 and 2, six main participants can be identified in the system: farmer (producer), collector or harvester, packer, operador, safety technician and regulatory agency. The former depend on agricultural work in the territories they inhabit, that is, on the demand for raw material by the packaging units, and these in turn depend on demand from the foreign market; producers and packers in the coriander production system indicate that most of the coriander exported from Puebla goes to the state of Texas, United States of America, where it is distributed to self-service stores and restaurants.

Table 2 describes the activities of participants in the coriander production system, and the way in which producers (64) and coriander harvest teams (3 with 120 operators) have been interacting during the last three years, and whom together have an agreement with a packaging unit that processes and markets coriander in the US. Within the packaging unit, 38 process operators work on the same shift for up to 20 hours a day, carrying out post-harvest operations. Producers, harvest teams, and packaging operators receive safety advice or recommendations from 3 food safety regulatory agencies: local private, national, government, and international. Each function and participant is important and must be considered within the safety plans that are designed for pre-harvest, harvest and post-harvest handling processes (FAO, 2017; FSMA, 2019).

In the coriander production system of the study region, participants were identified at each stage of the system, similar to other vegetable production systems in Mexico. As the packers point out, they share similarities with other food processing systems known as "supply chains" in which sourcing, production, storage, transportation and distribution activities are usual (FAO, 2007); specifically for fresh foods with a short shelf-life, such as coriander, temperature control is required from harvest to packaging. Traditionally,

Table 2. Functions performed by participants in the coriander production system**.**

Participants	Activity	Interviewed participants	Place
Farmer	Agricultural labors	64	Production unit
Harvester	Selection and cutting of coriander	3	Production unit
Packer	Coriander processing and packaging	1	Packaging unit
Operator	Processing operations	38	Packaging unit
Safety technician	Supervision and advice on safety	6	Production unit/packaging unit
Regulatory agency	Regulates compliance with standards and implementation of safety systems	3	Local, national and international

participants in the coriander production system are not well organized, generating deficiencies in the system such as: lack of production control, lag in scheduled harvest and processing times, or economic disagreements related to the costs of buying and selling the product; this makes the productive system vulnerable and problems can result during handling of the product, as well as increasing the risk of loss of product safety (Gutiérrez, 2021).

Figure 2 shows the coriander production system, consisting of the pre-harvest, harvest and post-harvest management stages; as well as interaction between participants. The boxes indicate the main operations and tasks and the arrows indicate the direction of the process. The cultivation and packing processes are delimited by the dotted line.

Vegetable production systems or fresh vegetable supply chains mainly involve two complex processes: handling and distribution (Shin *et al.*, 2019), which in the case of various vegetables such as chives, parsley, cauliflower, lettuce, broccoli, carrot and zucchini, originating in Mexico, are implemented by producers and packers, who can sometimes undertake both functions; they face complications due to the perishable nature of the products and the need for their conservation, as well as complications at a productive, operational, economic and environmental level (Rubio *et al.*, 2009). Likewise, when fresh agricultural products are destined for export, they must comply with current regulation requirements, specific to the type of product in the market, which generally involves selection, cleaning and washing, packaging and storage at low temperature (FAO, 2002; Shin *et al.*, 2019).

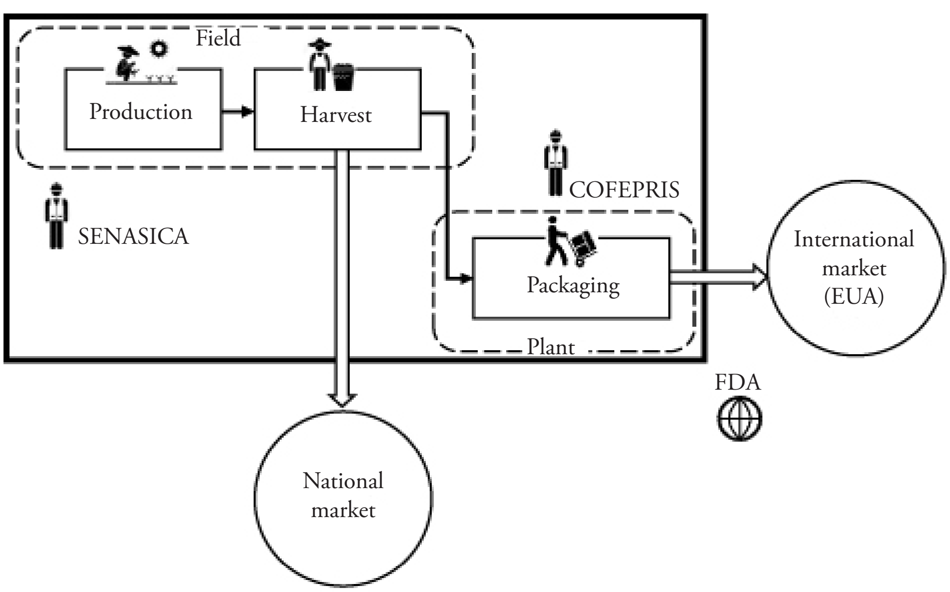

Figure 2. Dynamics between stages and participants in the coriander production system.

Common traits of coriander producers in Puebla

In the state of Puebla, producers mostly fall within an age range of 35 to 75 years old, and there is a significant lack of young people in these activities. At the same time, evidently educational level is deficient, with an average of 6 years of basic academic training, that is, up to sixth year of primary education, compared to 9 years (third year of secondary education) for average schooling in the State of Puebla; this is coupled with a high percentage of illiteracy (19%) (INEGI, 2022). However, most producers generate jobs for people with less knowledge of these tasks (auxiliaries).

Regarding gender equality, a high proportion of inequality was observed, as only one of the interviewed producers was a woman and only one of the 17 vegetable packing units located in the region is directed and represented by a woman. This may be due to the fact that in rural areas of Mexico, customs persist that permit physical and financial access to agricultural land mainly to people of male gender, even though a large number of women were observed in agricultural work. The INEGI (2016) ranked the state of Puebla as the second entity with the highest percentage of women producers (9.6%), with 20% participation in agricultural work; the time that rural women dedicate to this work represents 19% of production value in rural Puebla.

It is also important to stress that 94% of producers indicated that they had not received technical advice or training, regarding the regulatory standards necessary to be considered as a reliable supplier of coriander and to be included in the official list of SENASICA (2022). Here only 12 production units are listed, compared to the 348,736 production units reported by SAGARPA (2018). Generally, it seems that producers with technical systems have greater capacity to implement the required changes and comply with current export legislation. In contrast, small-scale producers face a greater number of difficulties, in terms of investment in infrastructure, as well as a number of unexpected bureaucratic obstacles. Among the concerns and aspirations mentioned, coriander producers emphasize the need to construct toilets and hand washing facilities in the production units, the drilling and maintenance of wells, and construction of perimeter fencing around production units; conditions that are required of the packaging units for their products to be purchased; some of these have been sued by importers who adhere to the requirements established in the FSMA law (2019). Evidently financial access to resources for investment is the main limitation for producers to promote or encourage the use of technologies in their production systems; these limitations impact the ability to modify and update their infrastructure and conditions related to the management of water, soil and cultivation resources.

In the municipalities visited, great productive capacity was evident and at the same time a high degree of marginalization, poverty, insecurity and environmental deterioration, indicating that the rural problems of this agricultural region may have multifactorial origin and which require multidimensional analysis; covering economic, social and environmental aspects.

Description of a typical regional packaging unit

The packaging unit selected as the work site is a company dedicated to the packaging and marketing of vegetables produced and transported from the State of Puebla to the State of Texas in the United States of America, with coriander representing the product in greatest demand. Bunches of coriander are received and stored in the packaging unit throughout the year. The product is selected manually according to criteria of color and acceptable quality conditions (apparent freshness, uniformity in size, shape, color and absence of physical defects). During the rainy season (May to September), the coriander is washed to remove external agents such as earth. The water used in the plant comes from a deep well and is stored in a concrete cistern without any treatment. Subsequently, coriander bunches are wrapped in a plastic sheet of PolyPaper, placed inside a wooden box and covered with crushed ice to preserve the freshness of the product. The wooden boxes are stacked, wrapped in self-adhesive plastic on pallets and placed inside a refrigerated thermos for transportation to their market destination.

Intervention activities

Once the capacities of participants in the coriander production system have been identified during the directed Diagnosis, and their concerns and needs have been detected, it is essential that they provide mutual technical training in order for adequate agricultural and manufacturing practices to be adopted, and improve safety based on the current regulation that imposes the content of the FSMA Law regulated by the FDA on products imported into the United States. This in turn, will generate security for producers, packers and traders of fresh vegetables, strengthened by carrying out follow-up or progressive studies in stages, to promote the safety of the product by identifying possible sources of contamination to which the production system is exposed, as indicated in the training course for PSA producers (2019).

Assessment of needs to fortify the system based on SWOT analysis

A SWOT analysis was undertaken, where the internal weaknesses and strengths of an organization are organized in a table, together with the external opportunities and threats, which affect the coriander production system from the perspective of product safety. This is designed to present the system from the participants' point of view, in terms of the reality lived by producers, packers, operators and coriander harvesters, in order to obtain an overall interpretative framework (FAO, 2007; IICA, 2013), within the difficult context that they face daily in the State of Puebla. This means that the packaging units that process and market coriander abroad are not isolated; instead, they are involved in a dynamic that includes interactions between rural, economic, technological and social contexts (Ojeda-Barrios *et al.*, 2010).

Capacities requiring strengthening and external opportunities were identified in order to improve packaging conditions and product safety. These are facilitated if the unit contemplates the implementation of a safety system internally and generates control measures that form part of the requirements of the FSMA law for the export of coriander to the United States. Table 3 presents the analysis of the strengths, opportunities, weaknesses and threats related to the packaging operation. Within the company, task rotation is very common and there is no consistent training plan for personnel. The facilities are not completely finished and the hydraulic installation is not sufficient for the sanitary use or hand washing requirements on the part of personnel. There is no delimitation of processing areas and uniforms and protective equipment for operators are inadequate.

Training activities with key stakeholders on the FSMA course

Besides the diagnosis activity, a training course was provided, dealing with the Fresh Produce Safety Law (PSR) of the Fresh Produce Safety Alliance (PSA). This lasted three days in order to establish a foundation in Good Agricultural Practices and information concerning the management and requirements for Safety Standard for fresh produce in the Food Safety Modernization Act (FSMA) and provide tools and knowledge for the development of a safety plan for production of fresh products and for packaging units.

Issues relating to production, harvesting, packaging and product storage were considered, as these are relevant to the safety of vegetables that are consumed fresh, and modules included: health, hygiene and worker training, soil improvement, wildlife and domestic animals, water for agricultural use (for production and post-harvest use), post-harvest handling and sanitation, as well as a development of a food safety plan.

Participation of key stakeholders during training

The course was designed for producers, administrators and/or owners of productive units; people directly or indirectly involved in the production, harvest and handling of fruits and vegetables destined for export to the United States. This also included participation on the

Table 3. Analysis of strengths, opportunities, weaknesses and threats related to the safety of coriander in the packaging unit.

	Positive aspects	Negative aspects
Internal factors	Strengths • Proficiency in the coriander production system • Ideal agro-productive conditions for coriander production • The Packaging Unit employs food safety professionals	Weaknesses • Productive system not divided into 3 stages: production, harvest and post-harvest • Decisions not based on safety, but on demand • Insufficient capacity to generate control measures
External factors	Opportunities • Ample and guaranteed market • FDA green list • Safety improvements in the coriander production system	Threats • Rejection of new labor measures as a result of resistance to change by growers and packers. • Low confidence on the part of foreign consumers concerning Mexican fresh agricultural products (health alerts)

part of technical safety advisory staff, merchants-exporters and participants in coriander production.

Interested packaging units were requested to provide the course for their operators and suppliers, as well as use of facilities for the training process, which had a high percentage of participation on the part of coriander producers who were invited (98%), likewise 26 producers and representatives from coriander production units in the region attended and operating personnel from the packaging unit (4), and advisors and safety technicians (3). Participation in the course by key participants in the coriander production system is evident in Figure 3.

Course participants acquired and understood some topics about microorganisms that threaten the safety of fresh agricultural products and how to identify the main sources of contamination, and their relevance was indicated by the FPS (2016), so that each participant became clear about the importance of their role in the production system in terms of ensuring safety. Likewise, threats were identified and information shared on how to implement practices that reduce exposure of products to safety threats. Finally, the categories necessary for a safety plan in production units were identified, including monitoring operations of possible sources of contamination.

CONCLUSIONS

Handling and processing conditions for coriander in some production units of the coriander-producing agricultural zone in the State of Puebla require the implementation of safety systems to ensure a safe product for fresh consumption, in both the national and international market; however, social factors were detected that limit reinforcing the

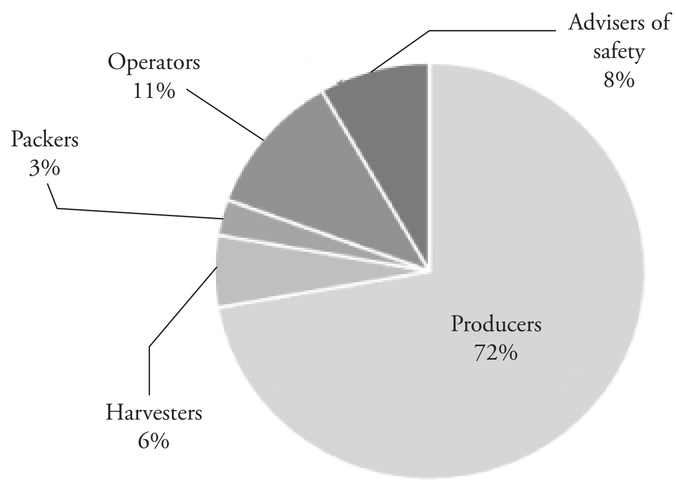

Figure 3. Percentage participation by participants in the coriander production system in the Fresh Product Safety (FPS) course.

productive capacities of the system and the improvements in infrastructure required for coriander producers and packers in charge of agricultural work and processing operations. This is reflected in the concerns expressed by the producers during the diagnosis. Similarly, we recommend identifying the activities and strategic stages in pre-harvest, harvest and post-harvest handling processes of coriander to improve safety, evidencing the collective commitment of participants in the system to deal with the demands that caused the origin of the alert of import 24-23. Finally, it is necessary to consider the concerns and needs expressed by participants in the product system, as well as to design and supervise required safety procedures in the coriander production and packaging units of the State of Puebla.

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