Barriers and difficulties for the implementatios of HCC systems in food companies in Lima, Perú*

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ABSTRACT. In Peru, only 1 % of food processing companies located in Metropolitan Lima have obtained a technical validation for their HACCP plan. The low adherence to safety systems raises the goal of identifying the main barriers and difficulties for the implementation of the HACCP system. Data was collected by sending a questionnaire to 32 companies. In order to define the underlying structure of the barriers and difficulties identified we performed an exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) based on a selection of nineteen (19) items, identifying four new factors that account for 66,7 % of the overall variability. After assessing their relevance, it was found that barriers and difficulties at the organizational/managerial level (F1) and in adaptation (F4), such as infrastructure and employee's perception, were more relevant than attributes involving execution (F2), which comprises singular processes such as time, staff turnover, technology and others.

KEYWORDS: hazard analysis and critical control point / food security / food industry / safety regulations / Peru

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BARRERAS Y DIFICULTADES PARA LA IMPLEMENTACIÓN DEL SISTEMA HACCP EN EMPRESAS DE ALIMENTOS DE LIMA, PERÚ

RESUMEN. En Perú, solo el 1 % de empresas de alimentos y bebidas cuentan con validación técnica del plan HACCP. La baja adhesión a los sistemas de inocuidad plantea el objetivo de identificar las principales barreras y dificultades para la implementación del sistema HACCP. La recolección de datos se realizó por medio de un cuestionario a 32 empresas. Para definir la estructura subyacente entre las barreras y dificultades identificadas se realizó el análisis factorial exploratoria y confirmatoria a partir de 19 ítems seleccionados, identificándose cuatro factores que explicaron el 66,7 % de la variabilidad total. Al evaluar su importancia, las barreras y dificultades a nivel organizacional/gerencia (F1) y en la adaptación (F4), como infraestructura y percepción de los empleados se consideraron más relevantes que los atributos con respecto a la ejecución (F2), donde se ve instancias de procesos singulares como el tiempo, rotación del personal, tecnología, entre otros.

PALABRAS CLAVE: análisis de peligros y puntos de control crítico / seguridad alimentaria / Industria alimentaria / reglamentos de seguridad /Perú

1. INTRODUCTION

Hazard analysis and critical control points (HACCP) is a food safety management system recognized by the international community as a guideline for controlling foodborne safety hazards (Kafetzopoulos et al., 2013). HACCP uses a systematic approach to identify, assess, and control hazards in food production, distribution and storage in order to prevent foodborne illness (Kafetzopoulos et al., 2013; Farooq et al., 2021). The HACCP system has proven more effective at achieving safe, high-quality food than traditional quality control methods, in turn creating a positive image for the company (Shuvo et al., 2019). Taking the global COVID-19 pandemic into account and in spite of a lack of solid evidence on foodborne transmission of SARS-CoV-2, Silva-Jaimes (2020) points out that the pandemic has stressed the true importance of food safety, in particular the implementation of Good Manufacturing Practice (GMP) and HACCP at all stages of the food supply chain, emphasizing the need to establish and maintain such preventive measures from farm to table. According to Jubayer et al. (2022), the documentation and records generated by HACCP makes it undeniably easier to trace contamination sources, avoid the production of unsafe food and reduce the consumption of labor, materials and financial resources.

Government authorities worldwide have adopted food safety controls using the HACCP system as defined under the CAC General Principles of Food Hygiene (2020). According to Pop et al. (2018), these government regulations have helped set baseline quality and food safety standards to guarantee the population's access to safe food and combat fraudulent market practices. With MINSA's (Peruvian Ministry of Health) approval of the Sanitary Standard for the Application of the HACCP System in the Manufacture of Food and Beverages (2006), HACCP became a mandatory legal standard for the production and sale of food in Peru. The adoption of HACCP as a legal requirement is primarily aimed at the identifying, assessing and controlling hazards at critical control points, leading to higher product quality and safety as well as increased consumer protection and confidence (Birhanu et al., 2017), providing manufacturers with a scientific methodology that allows them to control production quality instead of inspecting finished products (Liu et al. 2021). While these regulations have evolved in complexity and rigor over the years (Pop et al., 2018), the HACCP system is far from perfect. Many of its shortcomings stem from inevitable variations that are inherent to the implementation process. It often proves difficult to identify the specific causes of such flaws (Kafetzopoulos et al., 2013), given that the responsibility of implementing the standards falls squarely on the organization without any involvement from the state, which limits itself to establishing the regulatory requirements (Albersmeier et al., 2009).

According to the Peruvian Institute of Statistics (INEI) (2018), 91 % of all companies in Metropolitan Lima engaged in the production of food and beverage products are

microenterprises (12,440 companies); 6 % are small enterprises (834); and 3 % (351) are medium to large enterprises, of which only 2 % (191) possess a certificate of compliance with the Codex Alimentarius Principles of General Hygiene (PGH) and 1 % (133) possess a technical validation for their HACCP plan (DIGESA-MINSA, 2018). There is data that illustrates the low adherence to preventive health standards to ensure food safety; Baş et al. (2007) state that potential barriers to effective HACCP implementation vary from country to country and sector to sector; Fotopoulos et al. (2011) and Barbancho-Maya & López-Toro (2022) recommend conducting more research in order to get a fuller picture with specific information on the main factors that influence the effectiveness of HACCP systems, given that the literature points the existence of several interrelated factors that interfere with the system's successful implementation and application. This situation sparked our interest in investigating to identify the main barriers and difficulties in the development and implementation of HACCP systems in Peruvian food processing companies located in Metropolitan Lima as a necessary first step toward understanding their nature for the development of any effective implementation strategy.

2. METHODOLOGY

The research was conducted participating companies from the food and beverage industry in Metropolitan Lima registered in the DIGESA–MINSA database. The data collection period ran from November 2018 to April 2019. The sample consisted of thirty-two companies selected at random from a list of 133 companies registered in the the DIGESA–MINSA database as of September 20, 2018 with an official, technically certified HACCP plan for at least one product line (Sotomayor, 2022).

The data was collected by means of a questionnaire, based on a review of studies on factors that affect the implementation of HACCP systems conducted by Fotopoulos et al. (2011), Baş et al. (2007), Toropilová & Bystrickýa (2015), Gutiérrez et al. (2011), Moreno (2012), Maldonado et al. (2005), Maldonado-Siman et al. (2009), and Oliveira and Costa (2017). The questionnaire included questions about the companies' demographics (education level of the respondents, company sector, number of employees), the companies' specific situation (level of implementation of BMP and HACCP) and respondents' perceptions of the critical factors that companies encounter in implementing the HACCP system. The questionnaire was sent by e-mail and filled out by a quality executive.

To measure the implementation level of GMP and HACCP, respondents were given twenty-four items on food safety practices to grade their degree of implementation according to a numerical rating scale (where 1 is "start of implementation" and 7 is "fully implemented"). In addition, twelve multiple-choice questions were included to collect data on the operations under the HACCP system at the different companies. The measurement of perceptions on the barriers and difficulties in HACCP implementation

applied a seven-point Likert scale to twenty-seven items, where the number indicates the frequency with which each item affects the implementation of a food safety/HACCP system (1 being "Never"; 2 "Rarely"; 3 "Sometimes"; 4 "normally"; 5 "frequently"; 6 "almost always"; and 7 "Always") (Hartley, 2014; Harpe, 2015).

The data analysis involved defining the descriptive statistics with Microsoft Excel (Microsoft, version 16, 2016) to calculate measures of central tendency (mean, median, mode) and dispersion (standard deviation). In addition to statistics on central tendency and dispersion for identifying barriers and difficulties in the implementation of HACCP systems, we also evaluated the distribution of responses (frequency table and normality test). To understand whether perceptions about barriers and difficulties in implementing HACCP systems could be "grouped" into a smaller set of latent variables, an exploratory factor analysis (EFA) was used based on statistics such as the Kaiser–Meyer–Olkin coefficient, Bartlett's test of sphericity, P-value, the measure of sampling adequacy (MSA), cumulative variance and Cronbach's alpha coefficients in accordance to the pre-established theory (Lloret et al., 2014; Hair et al., 2014; Aráuz, 2015). The SPSS 22 (IBM, version 22, 2014, Chicago, IL) statistical package for social sciences was applied for this purpose. The factors identified in the EFA were validated by confirmatory factor analysis (CFA) using Amos 22 software (IBM, version 22, 2014, Chicago, IL), by evaluating convergent validity (AVE >0,6; construct reliability >0,67), nomological validity (significant correlations between latent constructs in the measurement model) and discriminant validity (AVE >Corr2) in addition to the degree of fit of the model (Normed fit index (NFI) ≥ 0,90, Goodness-of-fit index (GFI) ≥ 0,90, Chi-square/degrees of freedom ($\chi 2$ /DF) < 3, Root mean square residual (RMR) ≤ 0,08, and Standardized root means square residual (SRMR) ≤ 0,08)) as suggested by Hair et al. (2014), Alcántara (2016) and Martínez and Fierro (2018).

3. RESULTS AND DISCUSSION

3.1 Profile of the Companies Surveyed

Of the thirty-two companies surveyed, 13 % are chocolate companies, 22 % produced beef and/or poultry, 16 % produced grain and/or legumes, 6 % produced foods prepared with and without heat treatment (industrialized sauces), 9 % produced candied fruit, jellies, marmalades and fruit pulp, 13 % produced powder mixes and 22 % fall under "other." According to their number of employees, 75 % of companies surveyed meet the "medium and large enterprises" category of the Peruvian Institute of Statistics (INEI) (2018), meaning they have 50 or more employees. According to Galstyan & Harutyunyan (2016), this means they have more institutional resources to address barriers in the implementation of HACCP systems, giving them an advantage over smaller organizations. Of those surveyed, 97 % answered that they had a HACCP system in place for at

least one product line as required by the General Directorate of Environmental Health (DIGESA) for official technical validation of the HACCP plan 34 % of respondents stated they had Codex Alimentarius GPFH certification, and 44 % also had other certifications, most notably ISO 9001 and British Retail Consortium (BRC).

3.2 Profile of Corporate Officers Who Responded to the Survey

Of the officers who answered the surveys, 47 % were between 31 and 50 years of age, 47 % were under 30, and only 6 % were over 50 years of age. In terms of their education, 94 % reported having obtained their undergraduate degree (university graduates) and 6 % had a postgraduate degree. As for additional training, "Safety" and "HACCP" were the most frequently mentioned topics. According to Oyarzabal & Roweb (2017), these are typically the most important topics, since they involve an understanding of new concepts and categories that should be required even the application of active methodologies. The lack of a clear understanding of the definitions of "hazard" and "risk," for example, is extremely common among HACCP training participants (Oyarzabal, 2015). To date, however, there are no papers examining the effectiveness of interactive modules for teaching key HACCP principles, meaning that people involved in system implementation and maintenance will continue to require this type of training over any other offered in the market.

The surveyed respondents had between 1 and 25 years of experience in the food sector, with a range of 24, a median of 7, and a mode of 3 years. There is no doubt that experience provides hands-on learning that, together with ongoing training, is essential for the effective implementation of HACCP. In regards to the time they had been working for their current employer, 50 % of respondents stated more than 2.75 years (range = 9,67; median = 2,75; and mode = 2).

Table 1

Implementation of food safety practices in Surveyed Companies (mean, median and standard deviation obtained according to numerical rating scale)

Food safety practices	Mean	Median	s
GMP Handbook	6,81	7	0,543
Program for Calibration and/or Verification of Instruments and/or Measurement Patterns	6,77	7	0,669
Control and recording of temperature in processes and equipment	6,71	7	0,588
Operational standards	6,55	7	0,675
Microbiological tests of your products	6,52	7	1,458
Identification and analysis of critical control points (CCP)	6,48	7	1,546
HACCP Handbook	6,45	7	1,524

Food safety practices	Mean	Median	s
Training programs	6,45	7	1,028
Mechanisms for verification and validation of the cleaning and disinfection program where its effectiveness is demonstrated	6,45	7	1,121
HACCP team	6,29	7	1,657
Programs to monitor and control food safety risks that detect any exceedance of Critical Control Point (CCP) limits	6,26	7	1,653
Identification of product characteristics that create food safety risks	6,23	7	1,407
Review and verification of the operational control system efficiency.	6,13	6	1,384
Establishment of corrective measures	6,13	7	1,803
Appropriate actions to monitor and control whenever a new food safety hazard is detected in the product or at any stage of food processing	5,97	7	1,798
There is evidence regarding the identification of food safety hazards	5,94	7	1,843
Evaluation and classification of each food safety hazard according to the probability of occurrence and its criticality	5,94	6	1,769
Establishment of a monitoring system	5,94	7	1,611
Documented procedures for evaluating food safety risks	5,87	7	1,803
Data collection to assess risk criticality	5,87	7	1,803
Adequacy of methods and devices used to control food safety risks	5,81	6	1,851
Brainstorm to identify food safety risks and their causes	5,77	6	1,746
Use of literature databases to identify hazards and/or food safety risks	5,68	6	1,887
Employees fully recognize the significance and criticality of any food safety hazard	5,55	6	1,748

3.3 The Food Safety Situation at the Surveyed Companies

The most common practice (by degree of implementation) among the food safety systems implemented at the surveyed companies is the GMP handbook (mean of 6,81 and standard deviation of 0,543) (Table 1). However, when asked if "employees fully recognize the significance and criticality of all food safety hazards," the mean was only 5,55 (median = 6 and standard deviation = 1,75) (Table 1). Regarding the time required to have authorities conduct a satisfactory official evaluation of a company's HACCP design and implementation, the most common responses were one year (9 respondents) and six months (6 respondents). As for the length of time the companies have had HACCP certification for, one has been certified since 1995 and other eight obtained certifications in 2017 or 2018.

Table 2

Summary of responses obtained from HACCP system operations

Why was the HACCP system established?	n	%	Do you believe you have enough technical requirements to ensure the functionality of the HACCP system?	n	%
To guarantee food safety	1	3			
To comply with legal and regulatory requirements	3	9	YES	30	97
Both	28	88	NO	1	3
Other	-	-			
Total	32	100			
Did the control authorities help you with the implementation?	n	%	Did control authorities have complaints regarding the functionality of HACCP?	n	%
YES	11	35	YES	3	10
NO	20	65	NO	28	90
Do you believe that the implementation of the HACCP system improved the health safety of the food produced?	n	%	Internal and/or external audit results confirm the adequacy of the methods used to monitor and control food safety risks	n	%
YES	31	0	YES	31	100
NO	0	0	NO	-	-
Since the implementation, have there been any changes?	n	%	he problems regarding the functionality of the HACCP system that arise in your company are:	n	%
YES	28	90	Financial resource attributes	12	35
NO	3	10			
Production conditions	17	63	Human resources attribute (availability, commitment, training and employee disposition)	14	41
Change in legislation	-	-	Company attributes (prerequisite programs, equipment, verification procedures, etc.)	3	9
Both	10	37			
Other	-	-			
Did you set the HACCP system in place yourself or through contracted experts?	n	%	Exogenous attributes –market	4	12
Yourself	13	42			
Contracted expert	2	6	Other (INFRASTRUCTURE)	1	3
Both	13	42			
OTHERS (safety team (2); HACCP team (1))	3	10			

When asked about authorities' involvement, 65 % responded that the authorities did not help with implementation, while 10 % had received objections from the authorities regarding the functionality of their HACCP systems (Table 2). The objections mentioned include authorities' pronouncement on the product or infrastructure conditions, as well as nonconformity with implementation according to inspectors' criteria. Commenting on the subject, Toropilová and Bystrický (2015) argue that it is imperative to understand the open nature of HACCP and enforce legal requirements without a bureaucratic rejection of creativity. Discussions over the legality of the HACCP system have been long-standing, considering that it was initially designed as a tool for self-control. Only 3 % of companies surveyed believe that the implementation of the HACCP system is intended to guarantee food safety and 9 % believe that it is only implemented for the purposes of complying with legal and regulatory requirements, and 88 % responded that it serves both purposes (Table 2).

Živkovic et al. (2022) see more problematic policy frameworks such as national and current European Commission (EU) regulations as obstacles to the development of food supply chains, especially for small food producers. There is a widespread notion, especially in this sector, that food safety regulations are an obstacle to development.

3.4 Functioning of the HACCP System at the Surveyed Companies

Of the respondents, 97 % said they met the technical requirements to guarantee the functioning of the HACCP system, while 90 % reported having made changes since implementing the system due to production conditions (63 %) and changes in legislation (37 %) (Table 2). These results support Kafetzopoulos et al.'s (2013) findings that HACCP is a dynamic system and its continuous and effective implementation can help a company produce safe food in the long term. If companies were to disregard the constantly evolving nature of HACCP, they would eventually lose control over it and jeopardize its functionality, as studies by Kafetzopoulos et al. (2013) and Toropilová and Bystrický (2015) have shown. According to Panghal et al. (2018), all members of an organization are responsible for assisting in this task by reporting system issues to the appointed team leader for system maintenance and improvement.

According to Allata et al. (2017), a committed senior management is critical to the system's success, as their their power to appoint a head of food safety with sound knowledge and proven experience in food safety in this field grants them special influence on implementation and continuous improvement (Soman & Raman, 2016). Issues with HACCP system functioning experienced by surveyed companies include human resources (availability, commitment, training and employee disposition), as mentioned by 41 % of respondents; financial resources (35 %); exogenous/market factors (12 %); and internal factors (prerequisite programs, equipment, verification procedures, etc.),

noted by 9 %. According to Moza et al. (2017), seafood processors identified cost-related barriers as their top concern. However, they also highlighted barriers related to a lack of staff experience, skills, and commitment.

In general, gaps in attitudes, a correct understanding of HACCP, prerequisite programs, awareness, training and consulting, as well as authority overreach in applying the law and overlapping duties among national regulatory authorities are among the factors that most profoundly impact effectiveness and success of the system's implementation. These observations coincide with Toropilová and Bystrický (2015), who posit that a lack of motivation is the main cause for a failure of the system. In practice, proper HACCP functioning depends the personnel that develops and operates it, as well as the prerequisite programs that support it (Mortimore, 2001). It is also worth noting that respondents' most common answers regarding how food safety could be improved at the company point to staff commitment and training. Indeed, according to Thimoteo da Cunha (2021) most foodborne disease outbreaks occur due to avoidable failures by food handlers that are generally due to poor handling practices, poor use of temperature and exposure time and personal and environmental hygiene problems (Hull-Jackson & Adesiyun, 2019; Wu et al., 2018). All of these factors reflect the personnel's training and their commitment to the system.

3.3 Identification of Barriers and Difficulties in HACCP Implementation

Barriers and difficulties regarded as less important in the implementation of the HACCP system (mean < 3,5) include the unreliability of certification bodies, complicated terminology, a need for simple guidelines, excessive paperwork and documentation and difficulties tied to the product type (Table 3).

Table 3

Average and dispersion of the 27 items indicated by the companies as barriers and difficulties in HACCP implementation

Item	Mean	Mode	s
8. [Inadequate infrastructure conditions at the company]	4,94	6	1,46
4. [Increased financial resources (Cost)]	4,78	5	1,48
1. [Lack of prerequisite programs]	4,75	7	1,8
3. [Employee perception of the value of HACCP]	4,72	5	1,61
7. [Lack of management]	4,5	3	1,5
17. [Lack of managerial commitment to food safety]	4,5	5	1,93
2. [Lack of knowledge about HACCP]	4,47	3	1,65
13. [Lack of staff training]	4,44	3	1,41

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(*continuación*)

Item	Mean	Mode	s
21. [Inadequate organizational infrastructure]	4,34	4	1,52
18. [Resistance to change and employee attitudes]	4,31	3	1,42
20. [Low availability of human resources]	4,28	3	1,51
14. [Limited knowledge and skills for HACCP implementation]	4,25	3	1,63
16. [Lack of employee commitment to food safety]	4,19	3	1,49
26. [Inappropriate suppliers]	4,00	3	1,41
6. [Staff turnover]	3,97	3	1,62
5. [HACCP development and implementation time]	3,94	3	1,44
19. [Lack of technical expertise and support]	3,91	3	1,4
22. [Difficulties related to technology and production design]	3,84	3	1,3
25. [Insufficient planning]	3,84	5	1,32
9. [Lack of employee motivation]	3,72	3	1,35
24. [Difficulties in HACCP plan verification and validation]	3,66	3	1,56
15. [Insufficient support from authorities]	3,59	3	1,54
23. [Difficulties related to product type]	3,47	2	1,52
12. [Amount of paperwork, excessive documentation]	3,44	3	1,41
11. [Need for simple guidelines]	3,34	3	1,18
10. [Complicated terminology]	2,78	2	1,24
27. [Unreliability of certification bodies]	2,69	2	1,47

Of the most important items (mean > 3,5), the five highest scores corresponded to inadequate infrastructure conditions at the company, increased financial resources, lack of prerequisite programs, employee perception of the value of HACCP and lack of managerial commitment to food safety, with mean values ranging from 4,5 to 4,94, the standouts being inadequate infrastructure conditions at the company and increased financial resources (cost) with higher means and lower standard deviations (Table 3). In a study by Baş et al. (2007), time and money were identified as the primary barriers to improving food safety. Barbancho-Maya & López-Toro (2022) argue that the high cost of adopting safety management systems in agricultural food companies is the most significant barrier. Similarly, Moreno (2012) notes that one of the main limitations to implementation of the HACCP system is the high cost of infrastructure, while Maldonado et al. (2005) found that investing in new equipment and microbiological tests of the products make for the majority of implementation and operation costs. Welsh manufacturers and

stakeholders also identified time, cost and resources, knowledge, skills, communication and information accessibility barriers for obtaining certification (Evans and Taylor, 2019). However, recent research by Liu et al. (2021) suggests that HACCP certification has both short- and long-term positive impacts on a company's profitability, manufacturing productivity and asset turnover, which leads to higher profits for the company, higher sales growth, increased asset turnover and reduced production costs immediately following certification. Regarding companies' inadequate infrastructure conditions, regulations require that food plant designs be oriented toward achieving a functional operation flow while demanding the least possible amount of food handling (CAC, 2020).

Before applying HACCP, Law N.° 449-2006/MINSA (MINSA, 2006) requires that manufacturers and professionals in charge of food safety quality control verify compliance with requirements and conditions such as physical structure and facilities, environment layout and equipment location, operational aspects and others. However, it is common to find food plants with overcrowded preparation rooms and unhygienic designs, especially small businesses that have increased productivity without expanding their facilities, or companies that have maximized staff and machinery to meet seasonal or temporary peaks in workload, leading them to operate in poorly designed plants (Fotopoulos et al., 2011; Panisello & Quantick, 2001). HACCP implementation is made much more complicated in these situations due to the difficulty of ensuring basic food safety standards, which in turn results in a higher number of CCPs to prevent or reduce the risks of cross-contamination and recontamination of food (Panisello & Quantick, 2001). Jubayer et al. (2022) acknowledge that numerous factors may act as potential barriers at all stages of the HACCP implementation process, placing particular emphasis on the incorrect design of plants and equipment.

One of the significant barriers to HACCP implementation is the lack of prerequisite programs. (Table 3). In DIGESA records (as of September 2018), 191 companies carry a Codex Alimentarius Principles of General Hygiene certification, which represents just 2 % of all registered companies. According to CAC (2003), the low number of companies that have completed HACCP implementation is due to poorly established and even more poorly applied prerequisite programs. The development and implementation of written standard operating procedures in food businesses is one of the first steps in building an effective HACCP system as well as other food safety systems (Baş et al., 2007).

Perceptions about barriers and difficulties in HACCP system implementation were grouped into a smaller set of latent variables (factors) by means of an exploratory factor analysis (EFA), shown in Table 4, based on the following statistics: Kaiser-Meyer-Olkin = 0,777; Bartlett's test of sphericity = 442,378; p = 0,000; MSA > 0,55; cumulative variance = 66,7 %; and Cronbach's α > 0,812. We worked with 19 selected items (barriers and difficulties) and singled out four factors that may lead to failed HACCP implementation,

labeled as follows: F1 (Barriers and difficulties at the organizational/managerial level); F2 (Barriers and difficulties in execution/implementation); F3 (Barriers and difficulties in system management); and F4 (Barriers and difficulties in adapting the new design/ redesign).

Table 4

Estimation of the measurement model for the 19 items grouped into four factors of barriers and difficulties in HACCP implementation

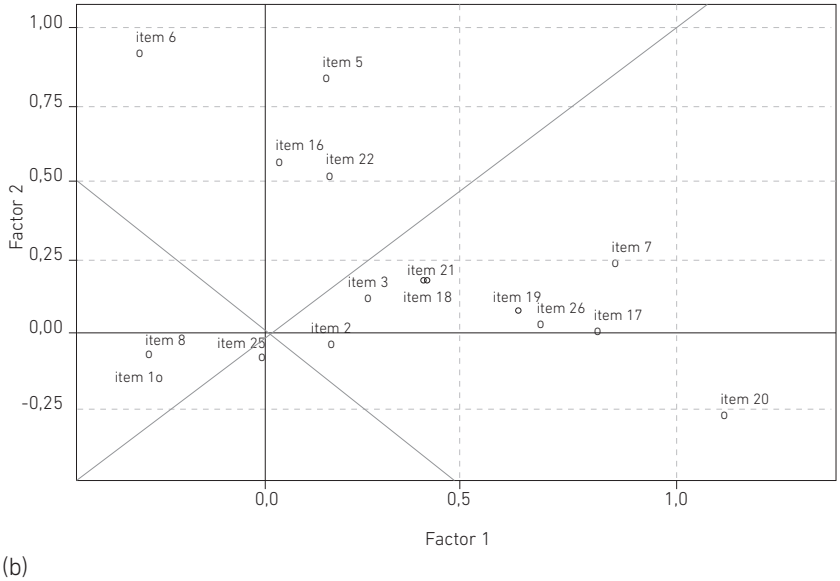
Critical factors in the effective implementation of the HACCP system	Variables	Standardized regression weights	Squared multiple correlations
F1: Barriers and difficulties at the organizational/ managerial level (Importance 1)	20. [Low human resources availability]	0,779	0,607
	14. [Limited knowledge and skills for HACCP implementation]	0,858	0,736
	13. [Lack of staff training]	0,823	0,678
	19. [Lack of technical expertise and support]	0,894	0,799
	7. [Lack of management]	0,76	0,577
	21. [Inadequate organizational infrastructure]	0,836	0,699
	17. [Lack of managerial commitment to food safety]	0,713	0,509
	18. [Resistance to change and employee attitudes]	0,801	0,642
	26. [Inappropriate suppliers]	0,685	0,469
	4. [Increased financial resources (Cost)]	0,576	0,332
F2: Barriers and difficulties in execution/ implementation (Importance 4)	5. [HACCP development and implementation time]	0,852	0,727
	16. [Lack of employee commitment to food safety]	0,918	0,844
	6. [Staff turnover]	0,442	0,195
	22. [Difficulties related to technology and production design]	0,822	0,675
F3: Barriers and difficulties in system management (Importance 3)	25. [Insufficient planning]	0,81	0,656
	1. [Lack of prerequisite programs]	0,884	0,782
F4: Barriers and difficulties in adapting the new design/redesign (Importance 2)	8. [Improper infrastructure conditions at the company]	0,697	0,486
	2. [Lack of knowledge about HACCP]	0,855	0,731
	3. [Employee perception of the value of HACCP]	0,811	0,658

Figure 1 shows the dispersion reflecting the location of the variables in a space defined by the factors using a saturation graph in factor spaces rotated via the Promax method in two-dimensional space (F1–F2; F1–F3; and F1–F4), offering a visualization of each variable's (item) correlation.

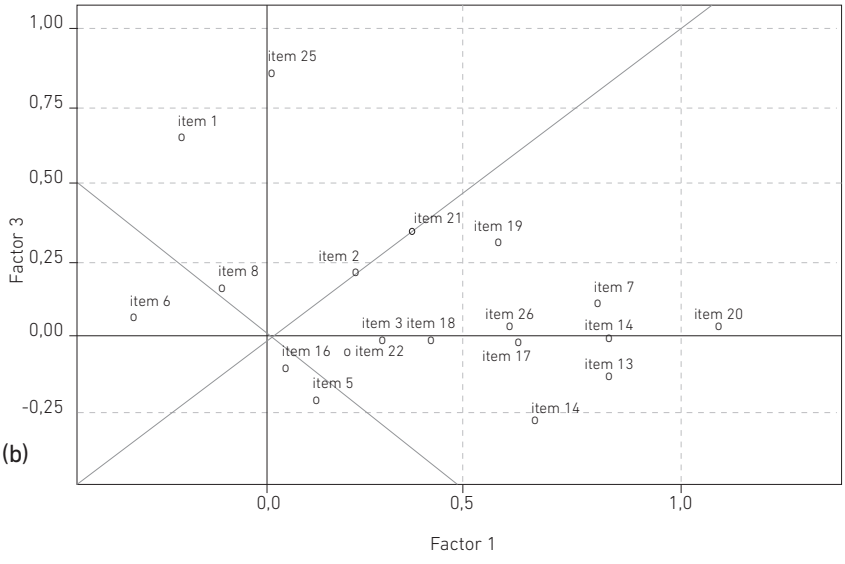
Figure 1

Factor saturation graph for the 19 selected items on barriers and difficulties for HACCP implementation in factor spaces rotated using the Promax method in a two-dimensional space; (a) factor 1 (F1) and factor (F2); (b) factor 1 (F1) and factor (F3); and (c) factor 1 (F1) and factor (F4).

(a)

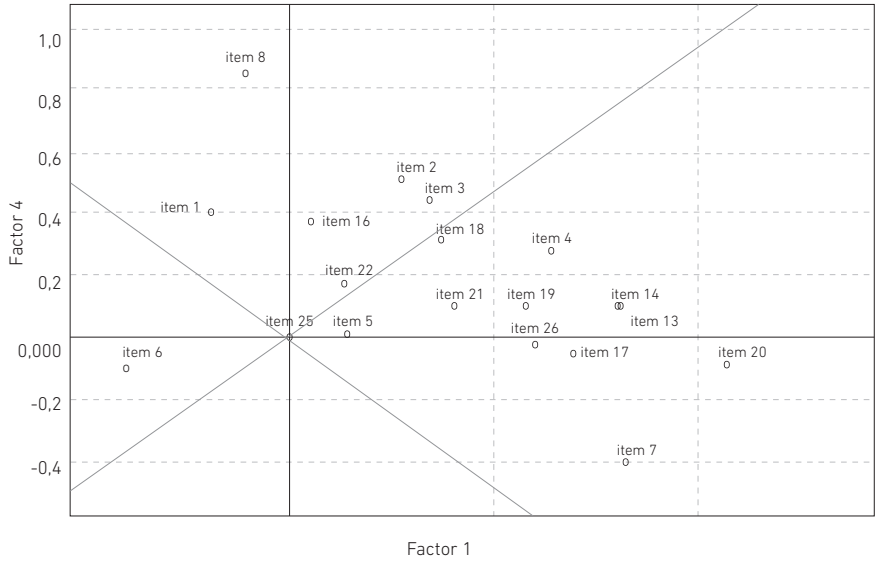


(b)



(b)

(c)



For the first factor (F1), the most correlated variables are Items 20, 13, 14, 7, 26, 17, 19 and 4, while Items 8, 25, and 1 had almost no correlation due to their proximity to origin (Figure 1.a). For the second factor (F2), a clear grouping of variables closely related to the factor can be observed (Items 6, 5, 16, and 22). The variables less correlated to this factor are located nearly at origin (Items 20, 13, 14, 7, 26, 17,19, 4, 8, 25, 1, 2, 21, 18, and 3). As for the third factor (F3), Items 1 and 25 are positively correlated (Figure 1.b) while for the fourth factor (F4), the same holds true for variables (items) 8, 2, and 3 (Figure 1.c).

The model obtained in the AFE was confirmed using a confirmatory factor analysis (CFA), adjusting the model fit using the unweighted least squares (ULS) method. Table 5 presents the goodness of fit indices for the measurement model, where three of the four parameters (χ2/gl, NFI, GFI) meet the criteria, corroborating the fit by calculating the standardized root mean square residual (SRMR ≤ 0,08) (Martínez & Fierro, 2018).

The evaluation of convergent validity (AVE > 0,6; construct reliability > 0,67), nomological validity (significant correlations between the latent constructs in the measurement model), and discriminant validity (AVE > Corr2)—except for F1 with F4 (AVE < Corr2), which is consistent because they are conceptually correlated—confirm the validity of the measurement model (Table 6).

Table 5

Goodness of fit measures for the measurement model consisting of four factors on the barriers and difficulties of HACCP implementation

Goodness-of-Fit Measures	Measurement Model
CMIN ()	172 213
Degrees of freedom (DF)	146
Normed fit index (NFI)	0,973
Goodness-of-fit index (GFI)	0,978
Chi-square/degrees of freedom (χ2/DF)	1 180
Root mean square residual (RMR)	0,171
Standardized root means square residual (SRMR)	0,077

Note. Indicative of good fit: NFI ≥ 0,90, GFI ≥ 0,90, χ2/gl < 3, RMR ≤ 0,08, SRMR ≤ 0,08.

Table 6

Evaluation of the reliability and validity of the measurement model consisting of four factors on the barriers and difficulties for HACCP implementation using confirmatory factor analysis (CFA)

Reliability statistics: Cronbach's alpha, average variance extracted (AVE), and construct reliability (CR) by factor

Factor	Cronbach'salpha	(AVE)	(CR)
F1	0,934	0,605	0,908
F2	0,843	0,610	0,790
F3	0,812	0,719	0,666
F4	0,832	0,625	0,748

Comparison of AVE estimates with the squared correlations (AVE > corr2) for each factor

Factor	F1	F2	F3	F4
F1	0,605*	0,432**	0,212**	0,634**
F2		0,610*	0,109**	0,454**
F3			0,719*	0,524**
F4				0,625*

*AVE = (number of items = 1... , = standardized factor loading);
**corr2 (the highest quadratic correlation between the construct of interest and the remaining constructs)

Finally, when assessing the importance of these factors by using their mean values or those of their respective observed variables (Table 4), Factors F1 (Barriers and difficulties at the organizational/managerial level), F4 (Barriers and difficulties in adapting to the new design/redesign) and F3 (Barriers and difficulties in system management) are considered more relevant than F2 (Barriers and difficulties in execution/implementation), which includes variables such as time, staff turnover, and technology, among others.

The review conducted by Fotopoulos et al. (2011) of a series of published papers (1995–2008) shows critical factors for effective implementation where employee attributes, the requirements of the HACCP system and certain important attributes of the company all play a vital role. Jevšnik et al. (2006) described the lack of financial and human resources as fundamental barriers to the implementation of HACCP in small food businesses. However, even when senior management expresses a commitment to allocate financial resources, human resources and training, there is still a series of different barriers to overcome during the implementation process (Panisello & Quantick, 2001).

Staff engagement needs to be paired with a full recognition of the importance and criticality of any food safety hazard (Kafetzopoulos et al., 2013). In food companies, criteria for correct risk identification and prioritization include the quality/safety manager's skill level, knowledge of production processes and "sensitivity" (Rosak-Szyrocka and Abbasi, 2020). However, convincing managers of the importance of food safety is no easy task (Arpanutud et al., 2009). While some argue that the costs exceed the benefits, or that it is a prohibitive expense, others—who are fortunately increasing in number—believe that adopting a food safety management system improves competitive advantage and reduces costs. For Chen et al. (2021), leadership is essential to a good food safety culture. Therefore, owners and managers must demonstrate a full commitment to the proper functioning of safety systems. According to López-Santiago et al. (2022), this makes it easier for all workers to align themselves with senior management in achieving HACCP effectiveness. Organizations should consequently invest in training managers on food safety. Once this has been met, system requirements will no longer be regarded as an unreasonable and unnecessary burden, but rather as an effort to ensure continuous improvement, where senior management is highly motivated to develop and maintain a culture of food safety in their businesses (Jevšnik et al., 2008). It does not suffice to allocate the necessary financial resources and time to develop and implement the HACCP system. This investment needs to go hand in hand with a high level of commitment to food safety on the part of all personnel involved (employees, managers, and executives) (Fotopoulos et al., 2011).

López-Santiago et al. (2022) found that significant barriers to HACCP performance in warehouses include lack of staff training on food safety, low participation of all staff

members in food safety tasks, the application of deficient chemical and microbiological control methods for CCPs and limitations in budget allocation. In general, so-called "technical barriers" that include staff attitude, education, experience and training, among other things, are immense obstacles to overcome since they encompass the entirety of practices and perceptions that negatively affect the proper understanding, implementation and effectiveness of HACCP principles. Behavioral studies on this matter carried out in the United Kingdom, Italy, the United States, Poland and the Philippines confirmed that such barriers are universal in nature (Evans et al., 2020; Tomašević et al., 2016).

Finally, note that only 1 % of the companies located in Metropolitan Lima carry a technical validation of their HACCP plan (DIGESA-MINSA, 2018) and 88 % of those surveyed implemented the HACCP system not only to guarantee safety but also to comply with legal and regulatory requirements. According to Toropilová & Bystrický (2015), when HACCP implementation is made mandatory under a regulatory framework, this centers the focus of compliance on satisfying authorities, hindering its opportunities as a meaningful exercise in achieving safety. It is instead perceived as a bureaucratic obstacle, with the attendant risk that all personnel involved in its implementation and maintenance may consider it a burden. This is no minor detail, as it directly affects the necessary creation of a culture of safety within the organization.

According to Frankish et al. (2021), although the main factors that contribute to foodborne illnesses are contaminated inputs, poor personal hygiene, contaminated equipment and failures in the process, all of these factors are directly or indirectly influenced by individuals' behavior. Thus, the system's successful implementation and maintenance will depend on an organization's overall culture (Jespersen et al., 2019). An attitude of authority obedience that lacks any safety-focused perspective, can lead to a poor implementation of the system and a deterioration in the routine maintenance of measures already in place and the preventive control system. Under such circumstances, the implemented system will slowly become a set of repressive, failure-prone operating practices that lead to an increasing mass of paperwork that exists as mere formality, unless the organization is completely surrounded by business partners with full-fledged, robust HACCP (Toropilová & Bystrickýa, 2015).

4. CONCLUSIONS

Infrastructure conditions, increased financial resources, lack of prerequisite programs, employee perception on the value of HACCP and lack of managerial commitment to food safety were the barriers and difficulties with the highest degree of approval (mean values between 4,5 and 4,94). The most important items (m≥3,5) were in turn grouped into a smaller set of variables, allowing us to see broader dimensions, where the organizational/

management level (F1); adaptation (F4): as infrastructure – employee perception; and management (F3): planning and prerequisite programs, stand out compared to execution (F2), where instances of unique processes such as time, staff turnover and technology are observed. Both results visualize which managerial and operational factors regarding employees and infrastructure/financial cost are interconnected as main barriers and difficulties for HACCP implementation. It is worth mentioning that these companies had an official technical HACCP plan validation for at least 1 product line. Consequently, the result was based on experience, where 97 % of those surveyed believe they meet the sufficient technical requirements to guarantee functionality of the HACCP system, not to mention that that 90 % had made changes to the HACCP system since its implementation due to production conditions (63 %) and changes in legislation (37 %).

Knowing the most impactful barriers and difficulties allows companies to foresee and strengthen not only economic aspects (infrastructure) but also the human factor, which starts at the managerial level, where an understanding and commitment to safety principles can foster a culture of safety across the company. Organization is crucial for a successful HACCP implementation and more so for successful food safety management (Sotomayor, 2022).

The low percentage of food and beverage processing companies in Metropolitan Lima that carry official technical HACCP validation of their HACCP plan leads us to reflect on authority involvement (Sotomayor, 2022). The implementation of safety systems must be promoted as part a culture of safety, which will prevent it from being perceived as a bureaucratic obstacle. Because our study has its limitations, however, we suggest that future research collect data be conducted by examining documents, records and interviews as well as direct observation of the activities carried out in the food industry, which will allow to determine the level of implementation of prerequisites and HACCP with homogeneous criteria. All the while, we advise the use of more simplified questionnaires. The questionnaire designed for this study spanned nine pages or five sections in its online version, which could account for the low response rate (54 %).

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