MANAGING THE SAFETY OF THE MINIMALLY PROCESSED VEGETABLES PRODUCTION AND SUPPLY CHAINS: AN OVERVIEW OF THE SYSTEM

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Notified cases of food borne diseases do not appear to decrease, while they burden national health systems, causing negative social and economic impacts. The demand for fresh foods, which have transparency in production processes and are saafe for consumption is increasing, especially in developed countries. Given this scenario, this paper proposes a system for food safety management based on the conditions from food safety theory, minimally processed vegetables (MPV) technology, the fundamentals of quality and supply chain management, and by appropriate quality coordination among applicable agro-industrial production chains. Three plants of MPV were also visited in order to add to the proposed system. It is suggested that plant managers should consider adopting the system as one to support them assure the safety of such products through MPV chains.

Palavras-chaves: Food safety, management system, fresh cut

1. Introduction

The demand for fresh foods, which have transparency in production processes and are safe for consumption is increasing, especially in developed countries. Major distribution channels for fresh produce, such as large supermarket chains, pass on the demands of consumers forward the chain, requiring fruit and vegetable quality and safety attributes from their suppliers (Ribeiro, 2006).

Among the solutions for the development of new food products, minimally processed vegetables (MPV) is a technology established in the U.S. in the mid-70 seeking to meet the demands of consumers, and its main objective is to make them practical and suitable for consumption by the final consumer, with a maximum shelf-life and the freshness and nutritional values very close to the *in natura* product that it originates.

Inefficient exchange of information between agents in the production chain can cause irreversible damage to the final product because of the requirements for ensuring the safety of these products are not defined and communicated, and therefore not understood by the whole chain. Because of this, the final products may be unsafe for human consumption (Toledo et al., 2004; Franco; Langraf, 2006).

Although several authors show the importance of the food safety management issues in order to ensure food safety, there is not an approach that integrates the technological and legal requirements in MPV chain, from primary production to distribution of the final product, to methods of quality management commonly used in order to ensure its quality and safety for consumption. Moreover, Brazilian firms of MPV are mostly small companies with familiar administration and in general do not possess sufficient internal expertise to interpret the models of food safety and build an operational structure that meets the needs of the sector as a whole.

Based on the presenting problem, it can be assumed that the development of a customized system for food safety management that integrates the processes of primary production (Field), the processing plants, transporters and distributors of MPV (retail market and institutional) may result in a structure that is best understood by these actors, and thus facilitating the smooth operation of a system of food safety management. This assumption leads to the research question of this work: "How could be a system of safety management of minimally processed vegetables?"

The objective of this paper is to define the overview of the MPV safety management system to the MPV chains

The result of this study is the overview of the proposed system for food safety management of MPV products Additional studies to detail this proposed system and its subsequent evaluation by potential users will be later conducted.

Literature review

1.1 Food quality and safety management

For Toledo (2001) a quality food is one that, consistently, meets the needs of consumers in terms of convenience, organoleptic, functional, nutritional, hygiene and safety characteristics, complies with relevant legislation and informs consumer about care procedures and the methods of conservation, preparation and eating. Peri (2006) supports this definition with a

systemic focus, defining the quality of food as a set of performance product developed in accordance with the requirements of the consumer, and are determined by a set of product characteristics obtained by means of processes that run across the production chain
Food safety is not negotiable, and its differentiation between food quality has implications for public health policy and influence the nature of the control system in which food is subjected in each country (ICMSF, 2006).
The primary means of ensuring food safety is to minimize the occurrence of hazards in food, through a food safety management system, based on the controls performed in each step of the production chain. These controls are the technological food processing procedures that aim to prevent the quantitative evolution of pathogens, chemicals and physical impurities at levels which become a health hazard to the consumer, and/or procedures to eliminate existing hazards in the food to be processed or that the decrease in levels safe for human consumption (CAC / RCP, 2003; Cruz et al., 2006).
The adoption of pre-requisites programs (PRP) is essential for ensuring the safety of these foods. The PRP are defined as a set of steps and formalized and essential operational procedures to control the hygienic conditions of food processing in the production chain, which promote favorable conditions in the food processing environment for the production of safe food, and are prerequisites for the implementation of any program of food safety (Pierson; Corlett, 1992; Mortimore; Wallace, 1998, Wallace, Williams, 2001; CAC / RCP, 2003). PRP includes Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP).
Mortimore (2001) and Sperber (2005) relate that Hazard Analisys and Critical Control Points (HACCP) is a tool for food safety management and its practice should be related to other management systems and be associated with PRP to guarantee food safety. Tajkarimi (2007) relates that this tool promotes conformity of products and services to international standards providing guarantees in relation to its quality, safety and reliability.
Some models of food safety management are proposed in the literature and include a proposal for the quality of process in supply chains based on defined, controlled, monitored and continuously improved procedures (Beamon; Tonja, 1998), another approach in which technology and managerial issues are integrated (Luning; Marcelis, 2007) and the other establishing the relationship between traceability, transparency, testability, time, trust and training that should be involved all over the food production chain in order to achieve a food with positive quality (Roth et al., 2008). Worldwide recognized systems to manage food safety, such as Hazard Analysis and Critical Control Points (HACCP), ISO 22000, Safe Quality Food (SQF), are the basis to develop such models.
All models for food safety and quality management are characterized by an intensive exchange of information between the actors of the production chain. In general, this flow of information is the object of study of supply chain management (SCM) theory.

1.2 Supply chain management

Supply chain (SC) is a cycle of activities that began with the extraction of raw material from natural resources that are processed in several stages to produce a final product, meeting the requirements of consumers (Batten, 2008).
Lambert and Cooper (2000) adds to this concept the integration of key business processes, defining the agents as stakeholders defined between the end user to the first provider of a particular chain.

Zokaei and Hines (2007) consider the Supply Chain Management (SCM) focused on continuous range of consumers needs through efficiency and effectiveness of SC that are maesured, respectively, in terms of customer satisfaction and performance of individual processes in this chain. This focus aligns the definitions of product quality.
Lambert et al. (1998) and Lambert and Cooper (2000) identified and defined eight key business processes for the SCM and that, according to Ballou (2007), are to be coordinated through collaboration and the management of all stakeholders, from suppliers to customers.
Integration between the actors for efficient SCM is achieved through transparency in their transactions (flow of effective and efficient information), which leads to build such relations of mutual collaboration and long-term partnerships.
Batten (2008) relates that the main peculiarity of the SCM for the food industry is the existence of additional requirements for ensuring food safety that are made up of several issues of quality and safety related to the transport of food products from suppliers to processing plants, for these retailers and ultimately to consumers. This author states that the practice of SCM should consider methods for food safety management to eliminate risks to food supply chain.
Du et al. (2009) reported that due to the highly perishable agricultural products, their prices decrease as they reach the shelf-life, and on the other hand, a lack of foresight in demand may lead to a shortage of these products during storage which meeting may result in significant loss of revenue for companies with a need for effective management of these chains.
Zylbersztajn and Farina (1999) corroborate showing the need to develop a tightly coordinated system of information and commitment from key actors in the production chain to achieve the required quality attributes in terms of food safety or other aspects demanded by the consumer.

1.3 Minimally processed vegetables

Minimally processed vegetables (MPV) can be defined as read-to-eat products, which are pre-selected, washed, and may or may not be pre-cut, disinfected, packaged in modified atmosphere and kept under refrigeration. These processes are designed to ensure the nutritional and sensory qualities very similar to *in nature* raw materials with greater shelf-life and safety. It, thus, meets practicity and convenience for consumers who increasingly demands healthy foods and has less time available (Darezzo, 2004; Chitarra; Chitarra, 2005; Pinto, 2007).
Compared to canned and frozen foods, which lose about 20% of its nutritional value as a result of processing operations, MPV have been enjoying a large market share of fresh produce because it maintains the sensory and nutitional characteristics (Wiley , 1996).
These products come from a need to add value to vegetables by the producers, since, according to Pimenta and Vilas Boas (2007), the market for fresh vegetables does not achieve the adoption of strategies of differentiation, because a focus on environment as a whole features a large wholesale market, many Sellers and no power to influence the selling price. In addition, the vegetables are highly perishable products, and need special care for transportation and storage and therefore can not stay in storage without a proper cooling technology.
In the U.S., sales grow 8% or $ 1 billion per year since 2001, with current values around U.S. $ 12 billion (Christie, 2008). The minimally processing technology promotes the best use of raw material, which would be discarded in the selection process, helping to reduce losses, and provide higher value-added products. This value in the MPV can reach 240% on the *in natura* one (Mittmann, 2001), which is extremely attractive to the farmer.

The consumer of MPV is distinguished and extremely demanding on the quality and safety of products consumed. Given this fact, the MPV industry is constantly seeking mechanisms to improve the quality of its products to meet consumer expectations and lower costs for failures and losses (Toledo et al., 2004).

Nantes and Fares (2001) observed that the raw materials are common problems like irregular supply and price changes that impact directly in MPV processing. Nantes and Lionelli (2003) found that although the market of MPV is significant in volume and sales, the segment as a whole appears to be inefficient due to the unstructured way in which its stakeholders are organized.

Recent discussions on techniques of food preservation have focused on processes that are safe, but also preserve the intrinsic attributes of nutritional and sensory quality in the raw material used for food processing by minimizing the severity and quantity of subsequent processing operations. This explains why the MPV have gained so much popularity, but new risks are emerging along with them. An example is the need to effectively maintain the refrigeration temperatures throughout the production chain, including during warehousing and distribution, to prevent microbial growth (Zeuthen; Soresen, 2003).

The high water activity (aW), the values of acidity (pH) near the neutrality range and the presence of intrinsic nutrients (carbon and nitrogen) to fruits and vegetables meets a prerequisite for microbial development, classifying them as highly perishable, mainly due to bacterial contamination (Franco; Landgraf, 2003; Frazier; Westhoff, 2003). In this sense, Forsythe (2000) lists a large number of bacterial and fungal contaminants surveyed in fresh vegetables that can lead consumer to death, if consumed them with an unacceptable level of these contaminants.

Taylor (2001) reported that there are barriers in the implementation of food safety systems in MPV processing plants, since most are small to medium businesses with few employees who accumulate various activities without any knowledge of practices for ensure food safety.

2. Research method

In order to propose the system, theory and processes through MPV chain should be understood and compared. In this way, the object of study are minimally processed vegetables productions and supply chains. Three MPV chains were identified to conduct this research, and they are located at Sao Paulo and Rio de Janeiro States. Each chain has been defined and focused in this research on four players, namely: farmers (suppliers); processing plants (processors), transporters, and distributors which are related to retail and institutional market (hospitals and restaurants). Two visits were performed in each of the plants in order to make direct observations of incoming raw materials (unloaded from trucks and packaging of raw materials), production of minimally processed vegetables and loading of final products on trucks for transport to the distribution centers. The purpose of these visits was to know each of the actors in the MPV chain, its key processes and the integration of them through the chain. Visits were guided by the leaders of the processing plants and were performed in the period from April to August 2009. Visits were also conducted to three small farmers, to two professionals responsible for transport and to three distributors for each of the chains studied. This strategy allowed the acquisition of multiple sources of evidences. Based on this information and the theory found, it was built the food safety management system for MPV.

3. Results

The observation of the studied chains led the structuring of a system containing four basic modules, which are achieved with the continued integration of actors in the chain of MPV.
The first module concerns the identification of food safety requirements of the clients and from the legal framework. Food safety requirements are intrinsic to consumers and unlikely to be explained by them. The definition of these variables provide a set of requirements for MPV safety that should be interpreted by the agents in the supply chain to be transformed into operations and properly controlled as shown in Figure 1. This is the first step towards the goal of safety management of MPV production and supply chain: defining what must be controlled.

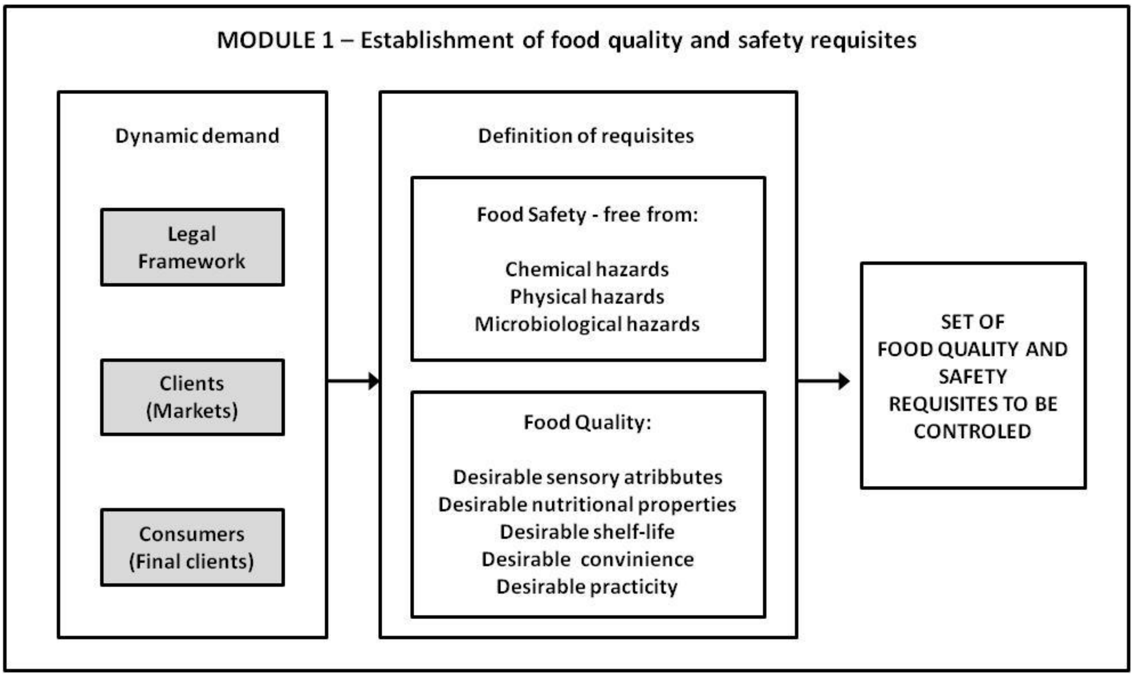

Figure 1- Definition of food quality and safety requisites for MPV

Module 2 provides a strategy to develop the PRP. According to the literature, the PRP is the key step in establishing any program to assure food safety. This module is the interpretation of the requirements of quality and safety as defined in the previous module into operations in each of the agents in the MPV supply chain, as shown in Figure 2. To ensure that these operations will be performed in a standardized way, it is necessary to structure the Standard Operating Procedures (SOP) so as to instruct the correct execution of operations in order meet the defined requirements. Other issues that concern PRP program are facility under conditions that do not cause any interference in the outcome of planned operations, such as cross-contamination, and a committed team who knows and is trained about their responsibility for the operations in the supply chain. This module sets out how it runs each operation needed to ensure a final safe product and who is responsible for them.

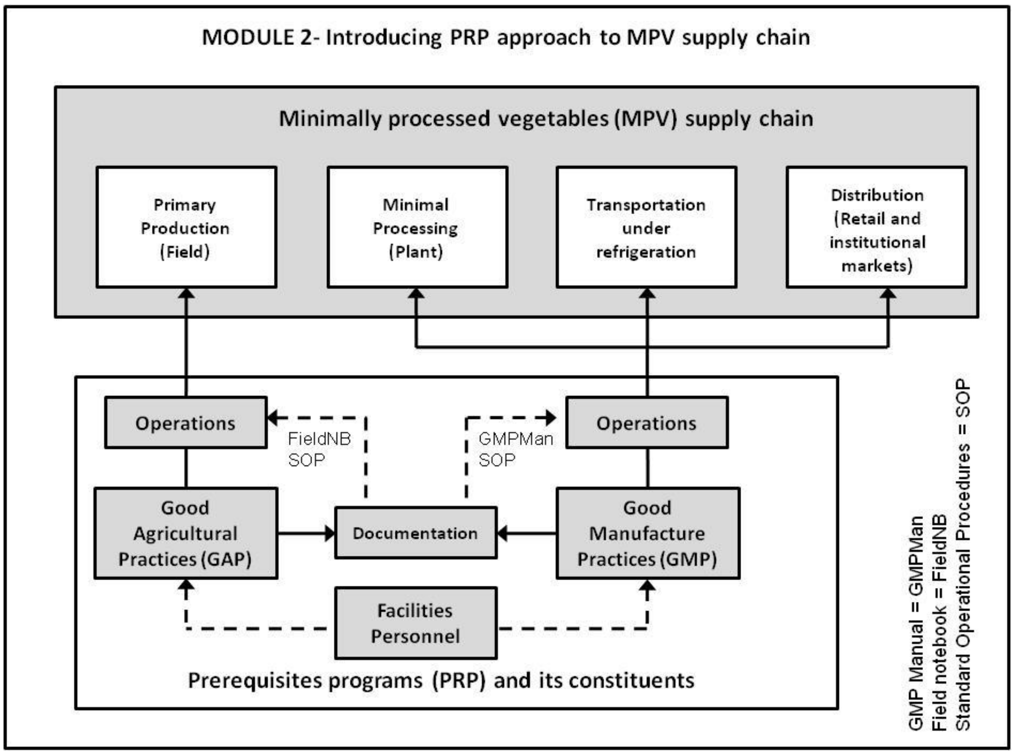

Figure 2 - Overview of the strategy to introducing PRP

Module 3 starts the strategy of ensuring the safety of MPV through the introduction of the principles of HACCP as shown in Figure 3. In this sense, the passage from the prior module to this one can only occur if the routine activities and responsibilities of all actors in the chain are well understood by themselves, or if the pre-requisites are properly implemented and properly running . Some control points that exist in the previous module, become critical control points, whose monitoring is essential to ensuring safe food to MPV. By moving to this module, the activities of the previous module are not extinguished, but are added to these. The operations under PRP are constantly evolving, because of the dynamics of demand for different requirements by consumers, clients and by updates of the legal framework. The development of activities in this module is much easier if the team is well familiar with the activities of the previous module. One can say that the previous module is a learning exercise to start this module.

The fourth and final module aims to ensure that the established requirements for MPV quality and safety are being achieved without any deviations, which can lead to the production of final products potentially unsafe. This conformity is evaluated by means of internal audits by verification of records and the operations performed. In case of deviations immediate corrective actions should be taken and be communicated to all actors in the chain. However, it is necessary to investigate the causes of deviations that they no longer occur. High integration levels in a supply chain leads to the identification of the causes of this deviation and the found solution. These solutions may lead to adjustments in one or more operations, in one or more agents in this chain. For this reason, the search of this solution should be performed in an integrated way. Communication for integration between agents in this chain is represented by dashed lines in the figures. The agent responsible for managing the MPV supply chain and production is the MPV processing plant. This is because this agent is under pressure from consumer or customer for quality products. The basic condition for MPV with assured quality starts with raw material quality. According to the observations in the case studies, minimal processing of vegetables does not correct problems of low quality raw material. Thus, the processor is tightly coupled to the farmer and this means that they have almost hierarchical relationships, with long-term partnerships with a low selected number of them. This makes the processing plant to coordinate relations with farmers, as well as transporters and distributors.

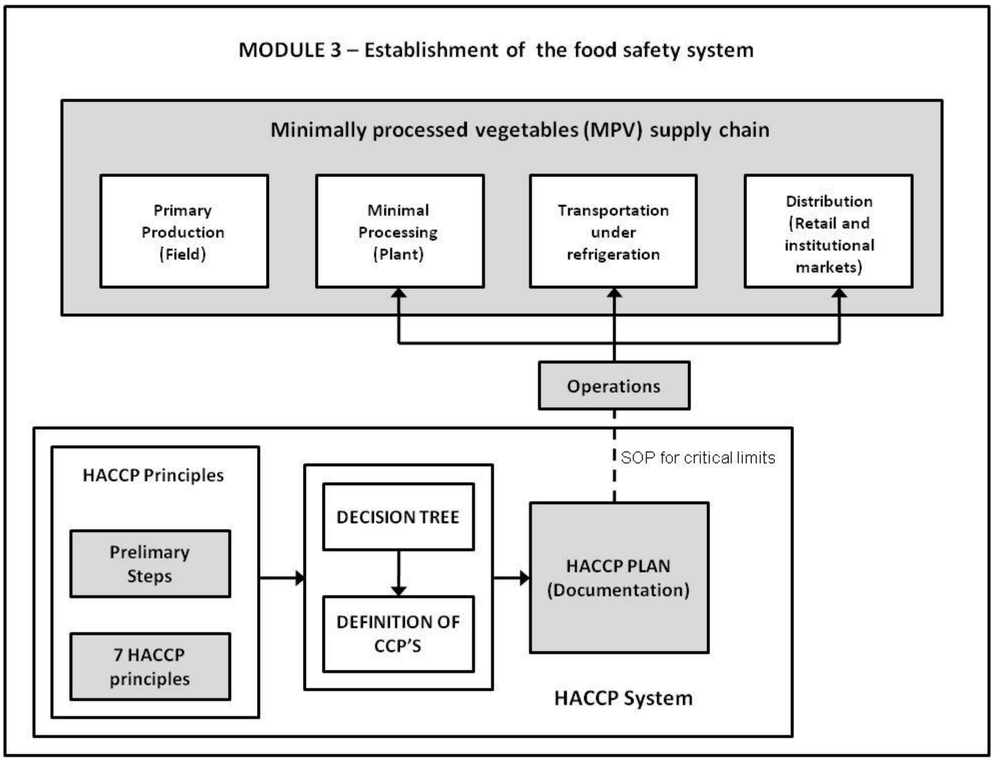

Figure 3 - Food safety system for MPV

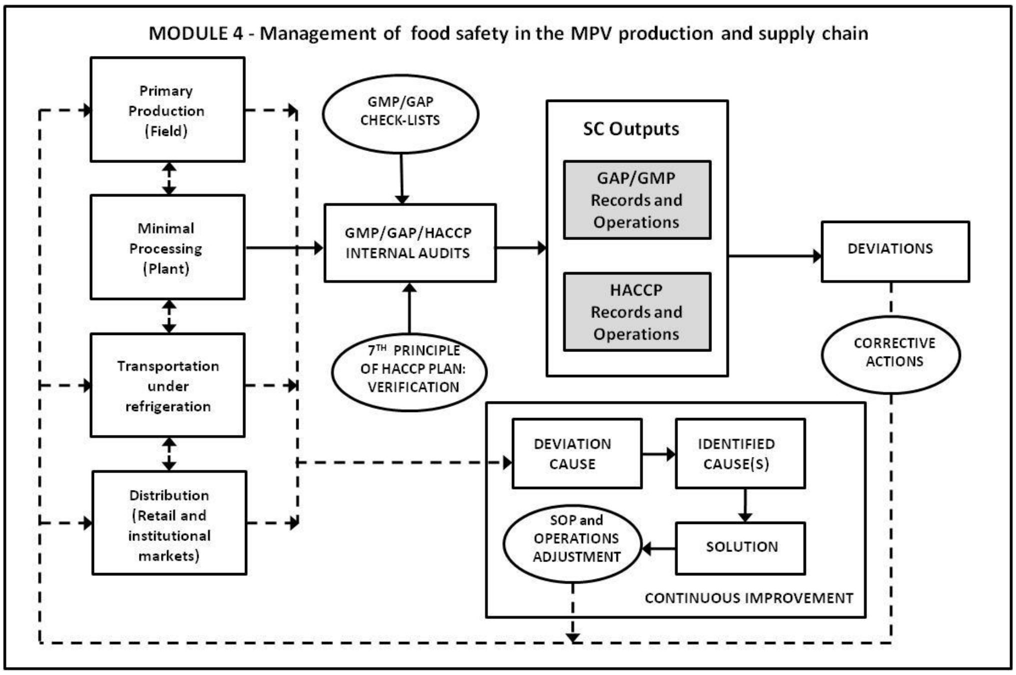

Figure 4 - Food safety management system approach for MPV supply chain

Figure 5 shows that the modules must be implemented sequentially and gradually so as the agents can exercise the integration in the MPV supply chain. There is no doubt that the main bottleneck for achieving the target level is the module 2. All activities to formalize the documentation of quality, resulting from operations, staff training and optimization of communication in the chain occur in this module. It was observed in the study that the chains that have rural producers (suppliers) away from the processing plant or a weak commitment to the quality of raw materials have difficulties to formalize long-term partnerships, resulting in communication difficulties, which leads to difficulties in settlement and communicate the policy of quality and safety of MPV through supply chain. Another factor that complicates these issues is lack of partnership with distributors, particularly the large retail chains charge for quality, but do not pay for it. On the other hand, processing plants that select farmers who are committed and distributors that charge for quality, but pay a fair price for it, are more likely to achieve the module 4 of the system, since it is easy to share goals and information along the chain.

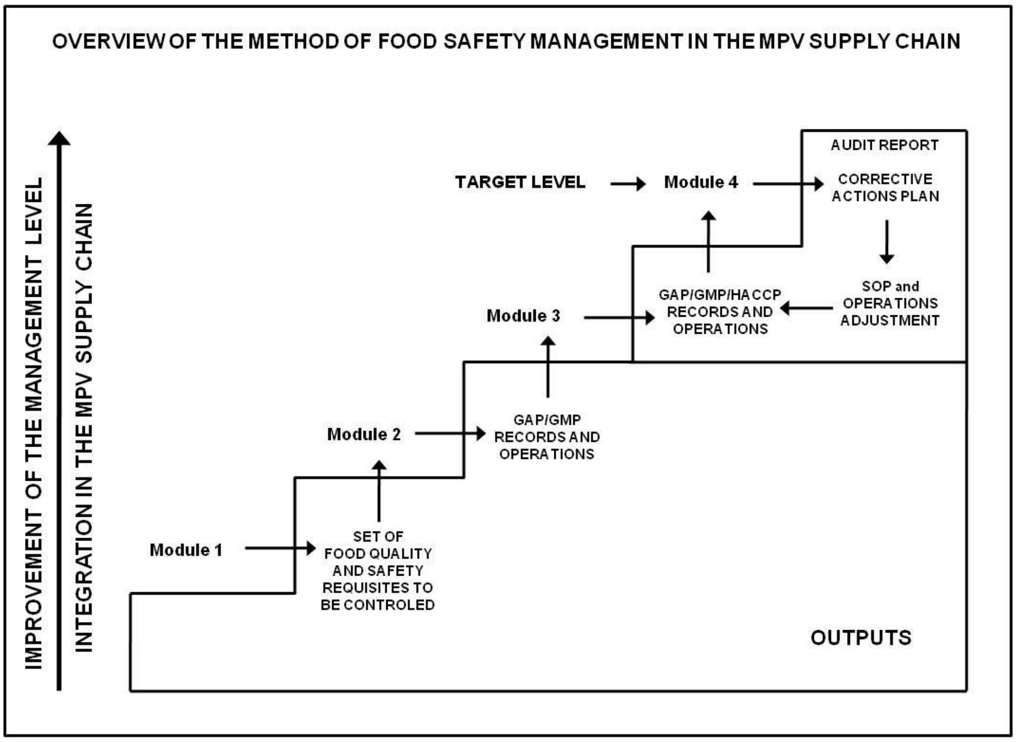

Figure 5 - Management operations along the MPV production and supply chain

4. Conclusions

The system for MPV safety management demonstrates the importance of integration between the actors in this chain to achieve the module 4 of the system that is the main goal of the chain of MPV. Several studies report the difficulty of ensuring the safety of food, since the communication between agents in a chain, and share common goals is the basis for achieving these objectives, while it is challenging for most food chains even large ones, and even the MPV.

According to observations during the visits, the main bottleneck for obtaining final products with assured quality and safety is the use of raw materials with guaranteed quality. In general, as the number of farmers willing to have well-structured partnerships and mutual trust with the processing plants for the supply of raw materials with the required quality is less than the demand of these for processing, the processing plants have been providing in-house production of raw materials with the quality they need. Complementing this, these companies select the smaller distributors, but in larger quantities. Transactions and communication with these agents become more direct and transparent, increasing the bargaining power, the decrease in information asymmetry in transactions, which consequently impacts in a more effective communication. According to observations, these features in transactions between the two sides get together the ideal conditions to assure safety of product.

Although the module 4 to be the last step of the proposed approach, it can be used early after the structure of the module 2. Undoubtedly, this will facilitate the stakeholders of a crossing to the module 3 and ensure a great facility to care for the following modules. These issues will be addressed further through the details of this proposed overview of the system in question and studies are being conducted in these chains. Additionally, Table 1 addresses the main differences between the proposed custom system for MPV and the others of worldwide recognition.

Items	HACCP Plan	ISO 22.000	SQF 1000/2000	Proposed System
1. General Characteristics				
Type	method	Management system	Management system	Management system
System scope	Method for Food safety	Food Safety Management	Food Quality and Safety Management	MPV Quality and Safety Management
Comprehensiveness of the system	Processors	Whole chain	Producers/Processors	Producers/Processors
Existence of system requirements	n.a.	Yes	Yes	Yes
Existence of management policy for the system	No	Yes	Yes	No
Existence of claim management	No	Yes	Yes	No
Sets the system responsabilities	No	Yes	Yes	No
Sets operational responsabilities	Yes	No	No	Yes
Sets the minimum organizational structure	No	No	No	Yes
Revision of the policy management	No	Yes	Yes	No
Sets a business plan	No	No	Yes	No
System evolution by maturity levels	No	No	Yes (in three levels)	No
Certification required	No	Yes	Yes (in three levels)	No
Sets certification scope	n.a	Yes	Yes (in three levels)	n.a.
Enables certification	No	n.a	n.a	Yes

Cont.

Items	HACCP Plan	ISO 22.000	SQF 1000/2000	Proposed System
2. Prerequisites Programs (PRP) Management				
GAP	Prerequisites	Prerequisites	Defined in SQF 1000	Prerequisites
GMP/SSOP	Prerequisites	Prerequisites	Prerequisites	Prerequisites
Issues on GMP/SSOP	Not specified	Not specified	Detailed requisites	Implicit
Sets SOP/SSOP	No	No	No	Yes
Sets GMP Manual	No	No	No	Yes
Incorporates practices for sensory quality aasurance of the product	No	No	Yes	Yes
Sets internal auditing sheets for PRP	No	No	Yes	Yes
Sets monitoring procedures for PRP	No	Yes	Yes	Yes
Sets validation procedures for PRP	No	Yes	Yes	No
3. Food Safety Management				
Incorporates HACCP plan	n.a	Yes	Yes	Yes
Sets Food Safety Manual	No	Yes	Yes	No
Based on the Sanitary Code	Yes	Yes	Yes	Yes
Sets shelf-inspection sheets for critical limits (CL) to food safety	No	No	Yes	Yes
Sets monitoring procedures for CL	Yes	Yes	Yes	Yes
Sets validation procedures for CL	No	Yes	Yes	No
Sets a single system for PRP and CL monitorirng	No	No	No	Yes
4. Management of Coninuous Improvemnet				
Sets internal audits for the system	Yes	Yes	Yes	Yes
Sets corrective actions for non-conformities identified by auditing the system	Yes	Yes	Yes	Yes
Identifies causes of non-conformities	No	Yes	Yes, in the last 2 levels	Yes
Enables third-party audits	No	Yes	Yes	Yes

Cont.

Items	HACCP Plan	ISO 22.000	SQF 1000/2000	Proposed System
5. Human Resource Management				
Needs a multidisciplinary team to manage the system	Yes	Yes	Yes	No
Knowledge area team to manage the system	Field/Crop Technology, Food Procesing, Food Safety, Operations Management.	Field/Crop Technology, Food Procesing, Food Safety, Operations Management.	Field/Crop Technology, Food Procesing, Food Safety, Operations Management.	Food Procesing and Operations Management.
Demanded level expertise to manage the system	Intermediate	Advanced	Advanced	Basic
Time to adopt the system with thee defined level of internal expertise	Medium term	Medium to long-term	Medium to long-term	Short term

Source: Compiled by the authors from Pierson, Corlett (1992), ABNT (2006), IMF (2008) and IMF (2010)

Legend**:** n.a. = not apply; SOP = Standard Operational Procedures; SSOP = Standard Sanitizing Operational Procedures; GAP= Good Agricultural Practices; GMP = Good Manufacture Practices.

Table 1- Comparison between classical systems of food safety assurance and the proposed system

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