International Journal of Lean Six Sigma

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Received 16 March 2016
Revised 28 July 2016
Accepted 21 November 2016

Abstract

Purpose – This paper aims to conduct case studies in companies of different branches of the agribusiness sector to analyze the degree of adherence to lean production system, considering the use of techniques and tools, and how the specificities of the agribusiness system work.

Design/methodology/approach – By contributing to the refinement of the theory, multiple type case studies were conducted in eight agribusiness units from different branches by applying structured interviews, on-site visits and document analysis. The comparative analysis of the cases occurred focusing on the degree of adherence to lean production system; use of techniques and tools; and influence of the specificities of agribusiness systems.

Findings – The adoption of lean production system occurs as an improvement mechanism of organizational performance. However, it is necessary to advance in the formalization of the actions, which need to encourage the creation of new leaders who spread the organizational philosophy. When comparing the degree of adherence to lean production with the use of techniques and tools, it was observed that there is no direct relationship, indicating that each organization should select only the techniques and tools that will improve their own organizational performance. At last, the specific characteristics of seasonality of consumption, quality and health surveillance and sociological aspects of the food have high influence on surveyed agribusiness systems, and its effects can be minimized by the techniques and tools associated with lean production system.

Research limitations/implications – The analysis is valid for the universe investigated due to the specific characteristic of the case study.

Originality/value – The literature regarding the lean production philosophy is vast; however, the agribusiness segment, one of the major sectors of the global economy, features a large gap in literature. This study is one of the first original papers to report this reality.

Keywords Lean manufacturing, Brazil, Agribusiness management system, Specificities, Techniques and tools

Paper type Case study

Introduction

In times of global economic crises, the survival and competitiveness of companies depend on their practices and adaptive capacities in external environments, which are attributed to shifts in customer preferences, government regulations, technology and competitors. This strategic alignment of internal resources and requirements of external market provides not only survival but also competitiveness (Soosay *et al.*, 2016).

This competitive intensification currently has achieved important and essential sectors of the global economy, such as agribusiness. The concept of agribusiness was initially created by Davis and Goldberg (1957, p. 2) to approach, in a systematic way, agriculture associated with all the actors involved in activities of production, processing, distribution and

International Journal of Lean Six Sigma
Vol. 8 No. 3, 2017
pp. 335-358

2040-4166
DOI 10.1108/IJLSS-03-2016-0012

consumption of food. They considered agricultural activities as part of an extensive network of economic actors and define the term as:

> […] the sum total of all operations involved in the manufacture and distribution of farm supplies; production operations of the farm; and the storage, processing, and distribution of farm commodities made from them.

Gunderson *et al.* (2014) claim that agribusiness competitive environment makes it unique by its distinct characteristics to other sectors and the specificities of production and trading. Furthermore, it is distinct from other sectors due to dealing directly with raw materials and processed products of high perishability and seasonalities that affect in demand and consumption and due to the constant monitoring and quality assurance, among others aspects.

Such characteristics allow designing a management model that differs in relation to other sectors. According to Ortega and Valencia (2015), the agribusiness organizations need to manage their systems performing an integration of its production processes to a horizontal level. This is done through a correct planning and control of production results, processing and distribution of products, to strengthen the chain and position themselves in the market.

In this direction, Dlamini *et al.* (2014) highlight that agribusiness needs to be competitive to fulfill the demand of not only the local market, but also global. However, the survival and competitiveness of an organization is mainly associated with the knowledge regarding the environment in which it is acting. Ortega and Valencia (2015) conclude that to remain competitive, agribusiness organizations need to improve their process management and means of production.

Such innovation in management and production processes in areas with competitive characteristics demonstrates the need for continuous improvement in its production processes. So, it seeks cost reduction and gain of economic advantage as a strategy for selling products or allowing access to international markets. It is within this scenario that companies compete against each other in search of excellence and high productivity, so as to be able to bypass the constant market shifts (Chiarini, 2014; Chay *et al.*, 2015).

Brown *et al.* (2007) disclose that to carry out such changes, management strategies are used (commonly named by researchers as an approach, systems, philosophies) which assist in selection of appropriate techniques and tools for achieving an improved industrial production, ensuring increased production performance.

The techniques and tools used are designed to make the efficient and effective organization in terms of quality, reliability, flexibility, innovation and cost. Such techniques and tools are selected through the study of available resources that satisfy and comply with the organization's objectives (Brown *et al.*, 2007).

In this sense, according to Chiarini and Vagnoni (2014), in the past decade, many organizations have adopted strategies for their development, such as approaches, systems and/or philosophies known as the Toyota production system (TPS), later called lean production, just-in-time (JIT) and total quality control (TQC), among others.

Among these management strategies, in the past decades, the use of lean production system stands out in manufacturing organizations, and became the subject of constant studies (Belekoukias *et al.*, 2014).

Its wide use is justified by authors such as Chiarini and Vagnoni (2014) because the lean production system helps approach a management that strives to make organizations more competitive in the market, increasing efficiency and reducing costs by eliminating activities that do not add value and also process inefficiencies.

In recent studies, Jasti and Kodali (2014) gathered, in a single material, 178 empirical articles published between 1993 and 2009. From this total, only 2.8 per cent of them carried

out studies in an agribusiness environment. In a similar study, Bhamu and Sangwan (2014) evaluated 209 publications from 1988 to 2013 and identified a set of publications, in which 3.8 per cent of these were related to researches in agribusiness environments. Finally, Marodin and Saurin (2013) evaluated 102 articles between 1996 and 2012, with 3.9 per cent of these addressed the lean practices in agribusiness.

Given this scenario, a shortage of research is identified, and therefore, a gap in literature related to studies that demonstrate the application of lean production concepts in the agribusiness segment. Thus, this paper aims to conduct case studies in companies acting in different branches of the agribusiness sector to analyze the level of adoption of the lean production concepts.

For a better presentation, this paper is organized into additional four sections besides this introduction. The second section presents a brief theoretical background about the concepts of lean production system and the use of techniques and tools applied during its implementation, besides the insertion of agribusiness in this scenario. The third section presents the research method detailing the data collection steps. The fourth section shows the results obtained from the comparison of multiple case studies, and finally the fifth section presents the final considerations of the study.

Literature review

Currently, the literature about lean production is dense and to approach the various study aspects about this thematic can be considered exhaustive.

This fact reflects the importance the issue represents for both the academic community and the industrial environment. This can be seen by the quantitative analysis of publications related to the theme. In a search through Emerald portal, 1,122 publications were identified in the last 10 years (2005-2015), which concentrated in the areas of operations management (33 per cent), quality management (7 per cent) and human resources management (7 per cent).

By part of researchers this aspect results in the systematization of literature published through the elaborate review articles that discuss the theme of lean production system. Authors such as Marodin and Saurin (2013), Bhamu and Sangwan (2014), Jasti and Kodali (2014) and Stone (2012) bring the theme under general approach by treating it as an area of concentration of the studies, the use of techniques and tools and types of employed scientific methodology. On the other hand, some authors have focused their reviews to specific themes such as lean six sigma (Pepper and Spedding, 2010), lean and the working environment (Hasle *et al.*, 2012), lean implementation (Moyano-Fuentes and Sacristán-Díaz, 2012), lean healthcare (Holden, 2011; Souza, 2009), lean supply chain (Jasti and Kodali, 2015), workplace ergonomics (Arezes *et al.*, 2015) and lean implementation within small and medium enterprises (Mason *et al.*, 2015).

According to Chiarini and Vagnoni (2014), the concept of TPS gained more notoriety with the use of the term lean production, which a lot of researchers and professionals define as synonyms. The TPS appeared at the end of the Second World War, when the Japanese industry had to rethink their production model (Ohno, 1988). But the term lean production was defined in the late 1980s in a research project at Massachusetts Institute of Technology (MIT), which studied the global automotive industry, with the main focus on the Japanese Toyota model, to map out the best industry practices, by interviewing employees, trade unionists and government officials. Only in 1990, the authors Womack *et al.* (2008), in the book *The Machine That Changed the World* spread more deeply this approach. According to Lewis and Slack (2003), this book served as a reference for the development of production management in various other types of organizations (Chay *et al.*, 2015).

The Lean business ideology (Bhasin and Bhasin, 2013) is associated with waste minimization or elimination (MUDA in Japanese) that affects the production system. For this, the organizations are based on five key principles (Calarge *et al.*, 2012; Lucato *et al.*, 2014):

(1) the definition of value from the customer view and their needs which determines the value chain;

(2) the value chain is required activities to offer the product to the customer with the lowest level of wastage;

(3) then the product is manufactured using a continuous flow, which is triggered only when the client performs the request;

(4) this is done using the logic of pull production; and

(5) on the basis of these above-mentioned principles and the use of continuous improvement (kaizen) or radical improvements (kaikaku), the fifth fundamental principle is reached, which is the system perfection.

Sharma *et al.* (2015) adds that a lean manufacturing philosophy requires respect from people, continuous improvement, a long-term view, a level of patience, a focus on process and ability to understand where the individual is in his or her development.

In this context, after 20 years of studying the TPS, Liker (2003) identified 14 management principles that drive the lean production techniques and tools. These principles, according to Liker (2003), can be grouped into four main categories for organizational assessment (see Table I), as follows: Philosophy category (Principle 1); Process category (Principles from

Categories	Principles	Description
Philosophy	Principle 1	To base management decisions on a long-term philosophy, even at the expense of short-term financial goals
Process	Principle 2	To create a continuous process flow to put problems in evidence
	Principle 3	To use pull systems to avoid overproduction
	Principle 4	To level the workload
	Principle 5	To build a culture of stopping and solving problems to obtain the desired quality on the first try
	Principle 6	Standardized tasks are the basis for continuous improvement and employee training
	Principle 7	To use visual control so that no problems are hidden
	Principle 8	To use only reliable and fully tested technology that meets the needs of employees and processes
People and partners	Principle 9	To develop leaders who completely understand the work, really live up the philosophy and teach others
	Principle 10	To develop exceptional people and teams who follow the company's philosophy
	Principle 11	To respect its partner and suppliers network by challenging them and helping them to improve
Problem solving	Principle 12	To see by yourself to fully understand the situation
	Principle 13	To take decisions slowly by consensus, thoroughly considering all options; implementing them quickly
	Principle 14	To become a learning organization through a tireless reflection and continuous improvement

Table I.
The 14 principles for the evaluation of lean production implementation

Source: Liker (2003)

2 to 8); People and Partners category (Principles from 9 to 11); and Problem-solving category (Principles from 12 to14).

The implementation of lean production system in organizations uses various techniques and tools, which should take place in a coordinated and structured way (Pettersen, 2009; Hunter, 2004). Al-Najem *et al.* (2012) point out that to correct losses in processes techniques and tools were created and are currently used in all large corporations, whether through specialized consulting or even by developing internal teams focused on improving.

Such techniques and tools can be classified, according to Feld (2001), in five major categories: manufacturing flow, organization and culture, process control, metrics and logistics, presented in Table II.

Savić *et al.* (2014) states that experience show that the concept can be successfully applied in all branches of production, including agribusiness environment.

Thus, agribusiness brings with it a need to accommodate the economic, social and environmental issues (Gunderson *et al.*, 2014). Management based on the waste elimination proposed by lean production system may play an important role, especially aiding to mitigate the inherent effects to the specificities of an agribusiness system. These specificities are handled by authors with different nomenclatures. Table III highlights these specificities for the agribusiness systems, on the basis of studies from Akridge *et al.* (2012) and Chandrasekaran and Raghuram (2014).

Category	Description	Techniques and tools
Manufacturingflow	Covers techniques related to physical exchanges, product development procedures and definition of necessary standards	Value Stream Mapping (VSM); Customization Takt time concept Cellular layout organization, among others
Organization and culture	Adds up techniques and tools related to the definition of the individuals' roles, learning, communication and common values	Organization for multifunctional teams Empowerment Definition of mission and values of the organization, among others
Process control	Discuss techniques related to tracking, monitoring, control, stabilization and improvement of the production process	Statistical Process Control (SPC) Single Minute Exchange of Die (SMED); 5S Program Total Productive Maintenance (TPM) Poka Yoke, among others
Metrics	Techniques that measure the performance improvement goals and actions, recognition for work teams and employees	Cycle time. Inventory turns Value added per worker, among others
Logistics	Relates operating rules, planning and control methods of internal and external material flows	Just in Time (JIT) Kanban ABC classification, among others

Source: Prepared by the authors

Table II.
Five categories of lean production techniques and tools by feld (2001)

Specificities	Definition
Seasonal availability of raw materials	Large portion of raw materials in agribusiness are obtained directly from agricultural activities and are subject to harvest cycles, which configure the production control as well as the demand and supply relationship
Seasonality of consumption	Variations in demand (holidays) and climatic variations (seasons) are variables that determine consumer behavior, and at the same time impact the production control planning as well as the supply of products in distribution channels
Perishability of raw materials	Highly perishable products which can not be stored; must be manufactured quickly and distributed to consumers
Perishability of final products	Large part of processed products is perishable, in which its quality is linked to how quickly the product is available to the consumer
Quality and health surveillance	Agribusiness products are associated with the necessity of providing security to the final consumer, which are suitable for consumption. This aspect is ensured by safety criteria of food formalized by strict norms of sanitary legislation and food production
Sociological aspects of foods	Cultural and social changes of paradigms have been transforming society and, in parallel, changing ways of production and consumption of food, resulting in the creation of segmented markets, looking for differentiation in products, creating a need for adaptation by organizations
Biological and edaphoclimatic conditions of foods	It is important to know the biological cycles of plants and animals, inputs and their corresponding waste. These are subject to variations in climate and soil which directly affect in agricultural productivity

Table III.
Specificities of the agribusiness production systems

Source: Prepared by the authors based on Chandrasekaran and Raghuram (2014), Akridge *et al.* (2012) and Batalha and Silva (2008)

Batalha and Silva (2008) points out that much of the modern management tools have been developed for sectors other than the agribusiness.

This may be the reason there are difficulties to implant the techniques and tools, as well as a resistance on the researchers' side to adapt, implement and analyze the use of these in agribusiness environments.

Research method

The case study was used as a research method to conduct this work and reach the proposed goal (Yin, 2013). Due to the search for further development of a well-established theory, but little explored in this study theme (agribusiness), this article has a descriptive approach because it aims to provide subsidies for the refinement of the theory (Forza, 2002).

When trying to refine the theory, Voss *et al.* (2002) indicate that the use of multiple cases aids both the increased external validation, as it helps to protect against self-bias of the

researcher. To contribute to the reliability of collected data, the interaction between the various sources of evidence becomes important to support the propositions (Lewis, 1998). Thus, this research uses interviews, on-site observation and documental analysis.

The steps for conducting multiple case studies followed the roadmap proposed by Yin (2013). The first step refers to the theory development, presented in Section 2 of this paper. On the basis of this theory, the interview guideline was elaborated for data collection (Step 2), composed of 11 open questions that evaluated the categories presented by Liker (2003) for the implementation of lean production system, in combination with a framework for the usage analysis of techniques and tools.

The selection of cases (Step 3) to be investigated was based on the identification of active agribusiness organizations in different segments, to meet an initial exploration profile with a description of how the philosophy of lean production system is being used in different agribusiness environments.

Therefore, the region of Alta Paulista was selected. This region is located in the State of São Paulo (Brazil), whose economic base is centered on agriculture and livestock. A total of eight research units were selected from different branches and industrial size, highlighted in Table IV.

After conducting each case study, they were transcribed by an individual case report (Step 4) to identify the characteristics of each research unit. Finally, a comparative study of cases was prepared (Step 5), which is described in the results section of this study, seeking to compare and contrast with the literature, and propose modifications or additions theory.

Results

This section presents the inherent results to the multiple case studies conducted. To facilitate the presentation, these are divided into three blocks. The first block conducts to comparative analysis between research units on the degree of adherence to lean production system based on the principles described by Liker (2003). The second block highlights the use of techniques and tools employed by the research units during the implementation of lean production system, and finally, the third block analyzes the influence of agribusiness specificities on the research units.

	Characteristics				
Research unit	Agribusiness segment	No. of employees	Industrial size[a]	Governance structure	Job title of the interviewee
A	Poultry farming	20-99	Small	Family-run	Industrial manager
B	Poultry farming equipment	100-500	Midsize	Family-run	Industrial manager
C	Agricultural machines	> 500	Large	Family-run	Industrial engineer
D	Alimentary	100-500	Midsize	Family-run	Production coordinators
E	Rubber processing	20-99	Small	Cooperative management	Department manager
F	Pig farming	20-99	Small	Family-run	General Director
G	Sugarcane industry	> 500	Large	Professional management	Production Coordinator
H	Natural silk spinning	100-500	Midsize	Professional management	Production, maintenance and financial managers

Note: [a] According to Brazilian classification based on the number of employees
Source: Prepared by the authors

Table IV. Characterization of the research units participating in the case studies

The discussion of the results obtained was guided by the procedures of Voss *et al.* (2002), through the development of comparative scenarios between agribusiness units, to identify possible similarities and differences between the research units, thus enabling what is called the theory construction.

Comparative analysis between research units related to the degree of adherence to lean production system

The comparative analysis between research units took place after the construction of the individual panel for each case. In this panel, the description of the aspects of the organizational management was prepared on the basis of 14 principles of Liker (2003) for a lean company. Using the data obtained from the interviews, on-site visit and documental analysis, the principles were categorized into five levels: does not perform; has informal initiatives; performs in an informal manner; performs formally, but with pending; and performs formally.

Taking as reference the study of Lucato *et al.* (2014), two equations were created that allowed to establish the degree of adherence of the research units. Equation (1) determines the degree of adherence to each category set by Liker (2003), while equation (2) determines the final degree of adherence, i.e. taking into account the four categories of Liker (2003).

$$\textit{Category Degree of Adherence} = \frac{\Sigma \textit{Points obtained by the Research Unit for the category}}{\textit{Total maximum possible points for the category}} \times 100 \quad (1)$$

$$\textit{Degree of Adherence} = \frac{\Sigma \textit{Overall points obtained by Research Unit}}{\textit{Total maximum possible points}} \times 100 \quad (2)$$

Figure 1 portrays the comparison of the performance of research units related to the degree of adherence for Philosophy category. It was identified that, in general, the research units

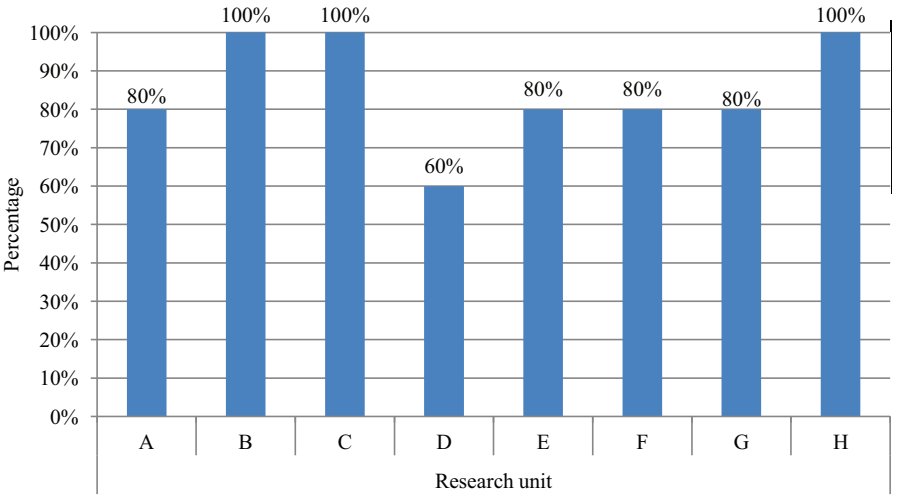


Figure 1.
Degree of adherence to the principles of lean production system for the philosophy category for research units

Source: Prepared by the authors

investigated have a good rate on this category, which include the long-term vision through the adoption of strategic planning.

It was noted that from eight units surveyed, three have this fully formalized process and in full action (B, C and H) and another four research units (A, E, F, G) need further improvement in the formalization process. Only one research unit (D) has an informal process. There was a good performance aspect for this category once the agribusiness organizations, as well as any other type of organization (producer of goods or services), must have established and outlined its short-, medium- and long-term goals.

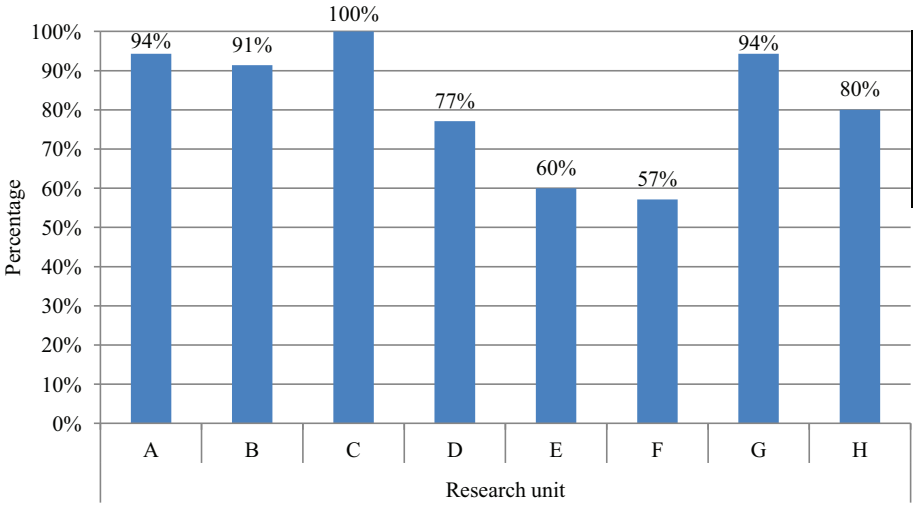
As described by Gunderson *et al.* (2014) and Dlamini *et al.* (2014), the agribusiness organizations are subject to actions related to political, economic and biological factors that influence sharply the operational and financial performance. Understanding, having pre-established organizational philosophy and knowing how to act through strategic plans over such adversity is essential for an organization to get a good performance.

Figure 2 shows a comparison among research units related to Process category, which includes in its assessment: organizational commitment to lean methods for the elimination of losses, the value stream perspective and the development of excellent processes that are supported by fully tested technologies.

It was observed that Research Units A, B, C and G have excellent performance in the Process category (over 90 per cent) by completing the category objectives formally in the organizational environment and in a constant manner. The Research Units D, E and F have a wide margin of organizational improvement that can be supported by the various techniques and tools associated with lean production system.

To think about this category, which includes the principles 2 to 8, Table V provides details of the performance of research units. For each research unit, items with lower performance were filled in gray.

It is noted that the Principle 7 (with 5 repetitions) and Principle 4 (4 repetitions) stand out with the lowest performance among the principles analyzed.



Source: Prepared by the authors

Figure 2.
Degree of adherence to the principles of lean production system for the process category for research units

Principle 7 refers to the use of visual management tools to prevent problems to be hidden on the shop floor. So the use of systems is indicated to achieve better organizational performance, such as Kanban, presentation of statistical process control (SPC) charts, quality performance charts and others. Principle 4 covers the use of uniform work load, which aims to avoid over-production and the occurrence of failures in manufacturing of products; allow for viewing process problems; generate the standardized work. The effort by the research units in improving these principles will assist in improving the lean production system.

Figure 3 highlights the comparison among research units for the People and Partners category, which includes into its assessment the organizational commitment to generate leaders who experience the philosophy and establish a commitment to develop people and long-term partners.

In this category, Research Unit C stands out against the others, with 87 per cent. Research Units A and G performed well, both with 73 per cent, while other units showed a lower margin performance, especially Research Unit F, with 33 per cent.

Table V.
Comparison among research units in relation to the degree of adherence to the principles of process category

	Research unit							
Principle	A	B	C	D	E	F	G	H
Principle 2	100	100	100	40	80	100	100	100
Principle 3	100	100	100	80	100	100	100	100
Principle 4	100	80	100	40	60	20	100	60
Principle 5	100	80	100	100	20	20	100	80
Principle 6	80	100	100	100	60	40	80	60
Principle 7	80	80	100	80	20	20	80	80
Principle 8	100	100	100	100	80	100	100	80

Source: Prepared by the authors

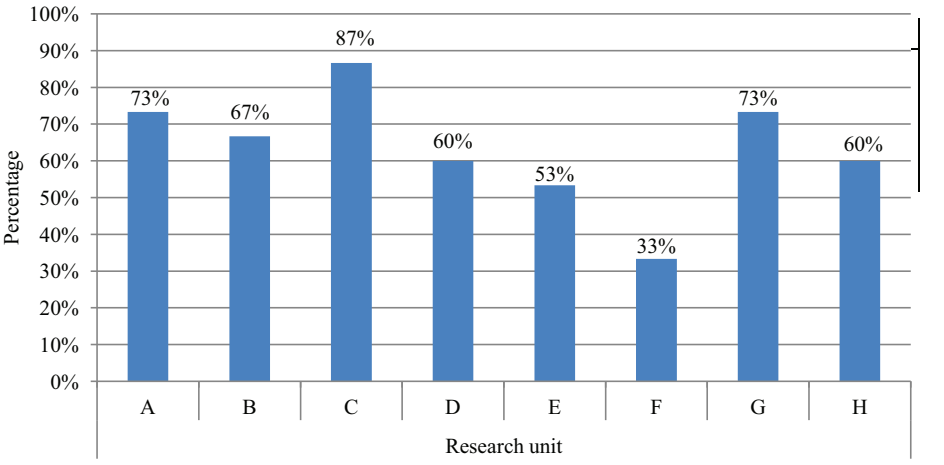


Figure 3.
Degree of adherence to the principles of lean production system for the people and partners category for research units

Source: Prepared by the authors

Similarly to Table V, Table VI details the performance of the research units for principles 9 to 11, which are part of this category. For each research unit, items with lower performance were filled in gray.

It was noted in Table VI that with the exception of Research Unit E, Principle 10 had the worst performance. This principle involves an important factor within the organization that is the development of exceptional people and teams who follow the company philosophy. In this aspect, the surveyed units presented themselves with failures (except Research Unit C). Such a reason can be given by the management model adopted by companies, which mostly showed up as decentralized and informal, a fact that is largely due to governance structure model, which is a family-run structure.

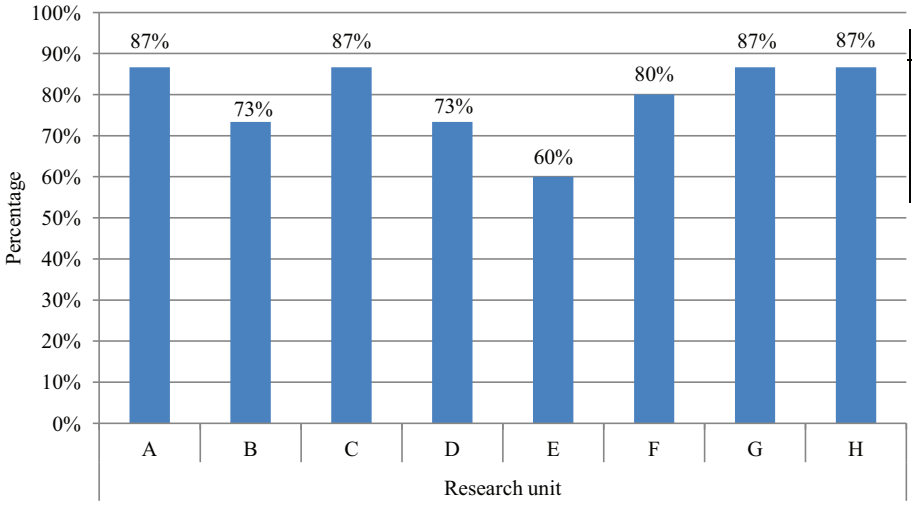
Figure 4 portrays comparison among research units for the Problem-Solving category, which evaluates the organization and the commitment to build a learning organization, which understands the processes in detail and take these factors into full consideration when making decisions.

In this category, there has been a variation performance of research units from good to great, except for Research Unit E, which had a rate of 60 per cent, demonstrating in a lower organizational commitment than others for continuous improvement of processes.

Principle	Research unit A	B	C	D	E	F	G	H
Principle 9	80	60	80	80	20	20	80	60
Principle 10	40	40	80	20	40	20	40	20
Principle 11	100	100	100	80	100	60	100	100

Source: Prepared by the authors

Table VI. Comparison among research units in relation to the degree of adherence to the principles of people and partners category



Source: Prepared by the authors

Figure 4. Degree of adherence to the principles of lean production system for the problem-solving category for research units

Table VII details the performance of research units to the Principles 12 to 14, which are part of this category. For each research unit, items with lower performance were filled in gray.

In this category, it was observed that there is an equality of points to be improved in all of the principles, so it is not possible to highlight an item with lower force. This demonstrates that the research units are genuinely acting and reacting on the identified problems but often leaving the full formalization of process improvement to be desired, needing a little attention to meet completely the principles.

After completion of the analysis of individual categories and principles, they were grouped, allowing the visualization of the maturity level of the concepts of lean production system in each research unit. As closer to 100 per cent, higher is the adherence to the concepts previously discussed in each research unit. Figure 5 portrays the general degree of adherence of the principles of lean production system for research units.

It was noted through Figure 5 that the overall performance of organizations varied between good and great for the principles of lean production system. Research Unit C stands out with the highest degree of adherence to lean principles, with a 93 per cent rate. The units A, B, G and H present degrees of close adherence to each other, between 82 and 84 per cent. Finally, Research Units D, E and F have the most scope for improvement to be carried.

At this point, it is worth drawing a parallel to the study of Lucato *et al.* (2014), which carried out an evaluation study of the degree of adherence to lean production system through the application of the standard SAE J4000 in Brazilian companies predominantly from

Table VII.
Comparison among research units in relation to the degree of adherence to the principles of problem solving category

	Research unit							
Principle	A	B	C	D	E	F	G	H
Principle 12	100	60	80	80	20	100	100	80
Principle 13	80	100	80	60	80	100	80	80
Principle 14	80	60	100	80	80	40	80	100

Source: Prepared by the authors

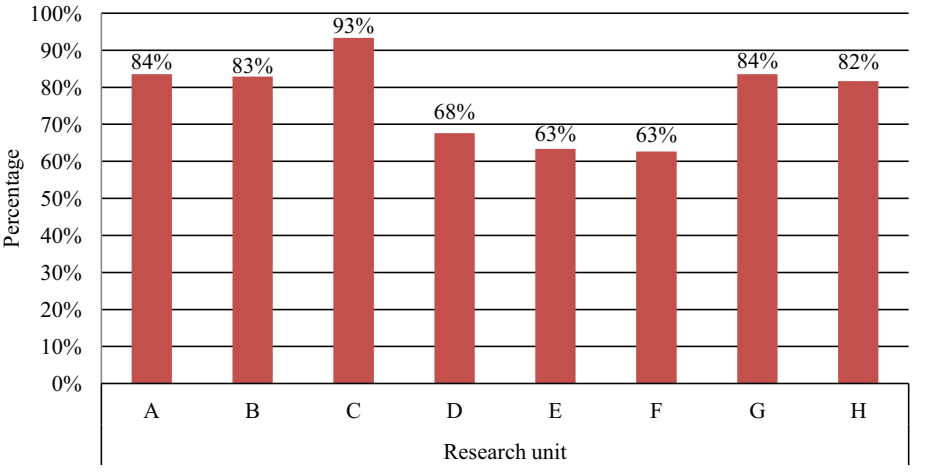


Figure 5.
General degree of adherence to the principles of lean production system for research units

Source: Prepared by the authors

metal-mechanical and automotive sectors. In such a study, it was evaluated that the best units surveyed had a degree of adherence between 94 and 84 per cent, which are similar indicators to the agribusiness units participating in this research.

Table VIII shows a comparison between the categories proposed by Liker (2003) to detail the performance of the research units. The best performances of the category for each research unit were highlighted in green, while the worst performances are in red.

It is noted that the research units have a strong degree of adherence to the Philosophy category, demonstrating commitment with society in a long-term thinking, while glimpsing at economic performance and thus the actual organizational performance. The insertion into an agribusiness sector, in which the degree of uncertainty is high and is placed in a competitive market, it is extremely important to reach excellence and quality over the entire the process. Therefore, investments in quality technology, employee empowerment, market monitoring and other aspects are essential to keep the project activity. However, this only occurs if the organization has hereby established long-term culture vision, and, regarding this, Research Unit D needs improvement because it has an inferior performance as compared to others.

The process category stands out among four of the eight research units. In this category, there is a strong emphasis on the possibility of using a variety of lean production techniques and tools. These results demonstrate the concern over organizational commitment for continuous improvement, reduction of waste and the development of production processes.

The focus on process improvement can be seen in the Problem-Solving category, which performed well among the research units as all of them act on problems for the construction of organizational learning.

Generally, the People and Partners category showed the worst performance among research units, needing further attention by managers. In this category, as aforesaid, the maximum scope for improvement is the development of internal leaders who experience and spread the philosophy.

Comparative analysis between research units related to the use of techniques and tools of lean production system

Table IX summarizes the identification and incidence of use of each technique and tool of lean production system for units surveyed.

The analysis of Table IX shows that the research units employ the techniques and tools associated with lean production system in a diverse level. Research Unit C uses all the techniques and tools presented in survey questionnaire and Research Unit G also features a high level of utilization in 75 per cent. However, Research Units A, B, D, E, F and H use techniques and tools of lean production system less often.

	Research unit							
Category	A	B	C	D	E	F	G	H
Philosophy	80	100	100	60	80	80	80	100
Process	94	91	100	77	60	57	94	80
People and partners	73	67	87	60	53	33	73	60
Problem solving	87	73	87	73	60	80	87	87
Degree of adherence	84	83	93	68	63	63	84	82

Source: Prepared by the authors

Table VIII. Category-wise and general comparison to the degree of adherence to the principles of lean production system among research units

Techniques and tools	Research Unit A	B	C	D	E	F	G	H	(%)
Value Stream Mapping (VSM)			x						12.5
Lean Suppliers (JIT)			x				x		25.0
Total Productive Maintenance (TPM)			x				x		25.0
Lead time			x						12.5
Six Sigma/DMAIC			x				x		25.0
5S/8S			x				x	x	37.5
Standardization of operations		x	x	x			x	x	62.5
Single Minute Exchange of Die (SMED)		x	x						25.0
Economic order quantity	x	x	x						37.5
Cellular manufacturing (Continuous flow)			x				x		25.0
Takt-time			x				x	x	37.5
Kanban			x	x		x		x	50.0
Continuous improvement-Kaizen			x	x	x		x	x	62.5
Poka-Yoke (Error proofing)	x	x	x	x				x	62.5
Pull production and continuous flow	x		x	x	x	x	x	x	87.5
Supply chain integration	x		x		x	x	x	x	75.0
Multifunctional workforce			x		x		x		37.5
Visual management		x	x				x		37.5
Problem solving teams	x		x				x		37.5
Group Technology (GT)/Cellular manufacturing			x				x		25.0
Production leveling	x	x	x	x	x		x	x	87.5
Statistical Process Control (SPC)			x		x	x	x	x	62.5
Autonomation/Jidoka	x	x	x	x	x		x	x	87.5
Concurrent engineering			x				x		25.0
Frequency of use (%)	29	29	100	29	29	17	75	46	

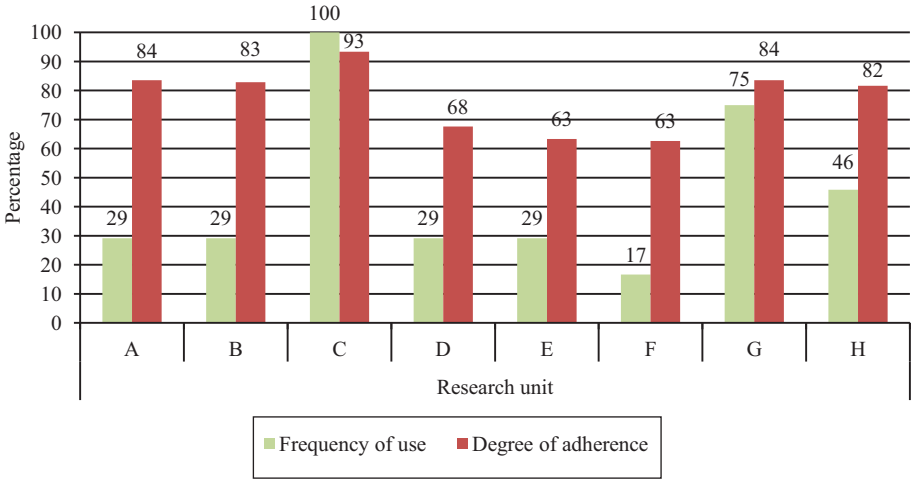
Table IX. Techniques and tools of lean production system employed by the research units and their utilization percentage

Source: Prepared by the authors

This frequency of use of techniques and tools is presented in Figure 6 in conjunction with the degree of adherence obtained by each of Research Units. It is interesting to note that for Research Unit C, which has the best degree of adherence there is also the highest degree of use of the techniques and tools. This fact is not confirmed when observed this relationship to other research units, in other words, when analyzing Research Units A, B, D and E, which have a frequency of use in 29 per cent for the techniques and tools. It is noted that the degree of adherence does not appear close among them. It may be mentioned that Research Units A and B have a degree of adherence between 83 and 84 per cent, and Research Units D and E lower performance, between 68 and 63 per cent.

Such aspect can be an indication that to obtain a good degree of adherence to the lean practices, techniques and tools of lean production system do not need to be applied in their totality. These should be chosen and used in the agribusiness environment as organizational needs of each company. Such characteristic is in line with studies as Karim and Arif-Uz-Zaman (2013), which emphasize that the selection of the technique or tool depends on the particular manufacturing process to each organization and not all of those serve to be applied in their organizational environments.

Also regarding Table IX, it is noted that the most used techniques and tools are: Autonomation/Jidoka, Production Leveling, Pull Production and Continuous Flow (87.5 per cent); supply chain integration (75 per cent) and statistical process control (SPC),



Source: Prepared by the authors

Figure 6.
Comparative analysis among research units related to the frequency of use of techniques and tools regarding the degree of adherence of lean production system

continuous improvement-Kaizen, Poka-Yoke (error proofing), Standardization of operations (62.5 per cent).

The fact that such techniques and tools were those that had a higher frequency of use among the research units is consistent with a predisposition to the organizations to maintain and increase their productive efficiency with a focus on satisfying customers and maximally reduce production costs. Regarding the supply chain integration, an explanation is given by the profile of family-run and cooperative management by most of the research units, in which there is the adoption of a flexible and informal management policy, combined with a culture to remain faithful to their suppliers due to established proximity links.

Confirming the analyzes, it generated a comparison of techniques and tools used by the research units with the five categories listed in Feld (2001) classification, shown in Table X.

It is noted from Table X that the Process Control and Manufacturing Flow categories have the highest number of techniques and tools applied in agribusiness segment, 10 and 7, respectively. As the number of techniques and tools is not presented equal among categories, equation (3) was established to calculate the relative weight of the techniques and tools by category depending on their frequency of use by the research units.

$$\text{Relative weight catagory}_i = \left(\frac{\text{Quantity of application of techniques or tools in the category}}{\text{Quantity of total possible applications of techniques or tools in the category}} \right) \times \left(\text{Number of techniques and tools in the category} \right) \times 100 \quad (3)$$

Results of the calculation in the relative weight are shown in Table XI.

Table XI corroborates the observations made in Table IX, showing that the application of techniques and tools of Process control (45 per cent), followed by

Categories by Feld (2001)	Techniques and tools	Research units A	B	C	D	E	F	G	H	%
Process control	Total productive maintenance (TPM)			X				X		25.0
	Single minute exchange of die (SMED)		X	X						25.0
	Statistical process control (SPC)			X		X	X	X	X	62.5
	Continuous improvement-Kaizen			X	X	X		X	X	62.5
	Visual management		X	X				X		37.5
	Poka-Yoke (Error Proofing)	X	X	X	X				X	62.5
	5S/8S			X				X	X	37.5
	Concurrent engineering			X				X		25.0
	Six Sigma/DMAIC			X				X		25.0
	Autonomation/Jidoka	X	X	X	X	X		X	X	87.5
Manufacturing flow	Value Stream Mapping (VSM)			X						12.5
	Kanban			X	X		X		X	50.0
	Takt time			X				X	X	37.5
	Production leveling	X	X	X	X	X		X	X	75.0
	Group Technology (GT)/Cellular manufacturing			X				X		25.0
	JIT - Just in time			X				X		25.0
	Standardization of operations		X	X	X			X	X	50.0
Logistics	Pull production and continuous flow	X		X	X	X	X	X	X	87.5
	Economic order quantity	X	X	X						37.5
	Supply chain integration	X		X		X	X	X	X	75.0
Organization	Multifunctional workforce			X		X		X		37.5
	Problem solving teams	X		X				X		37.5
Metrics	Lead time			X						12.5

Source: Prepared by the authors

Table X. Relationship of techniques and tools conducted against Feld (2001) classification

Categories	Quantity of application in the category	Quantity of total possible applications	No. of techniques and tools in the category	Relative weight	Relative (%)
Process control	36	80	10	450	45.0
Manufacturing flow	24	64	7	262.5	26.3
Logistics	16	24	3	200	20.0
Organization	6	16	2	75	7.5
Metrics	1	8	1	12.5	1.3
			Total	1,025	100

Source: Prepared by the authors

Table XI. Relative weight to the use of techniques and tools for each category by Feld (2001)

manufacturing flow (26.3 per cent) and logistics (20 per cent) have higher incidence in conducted studies.

It can be seen, however, that as the relative percentage there is a concentration in process control and manufacturing flow categories, with 71.3 per cent of techniques and tools used in research units. Such results collaborate with previous discussions, demonstrating that the

techniques and tools of lean production system, when applied in the agribusiness segment, assist in production management through its monitoring, stabilization, improvement and standards definitions.

It is noted that even though only three techniques and tools are classified in Logistics category, this presents a high incidence of use by the research units, strongly emphasizing two: pull production and continuous flow, and supply chain integration.

It is also noted that there is a low use of techniques and tools for the organization category, and the non-application of metrics category. It is noteworthy that in this diagnosis, the studies identified in the agribusiness sector guide the implementation of lean production system in the productive performance of the organization, aiming mostly at results and gains in the productive sector.

Thus, regarding the organization and metrics categories, both include people involved with lean production system and the results of frequencies are negligible as compared with other categories.

Figure 7 shows how the percentage distribution of techniques and tools does from the Feld classification (2001).

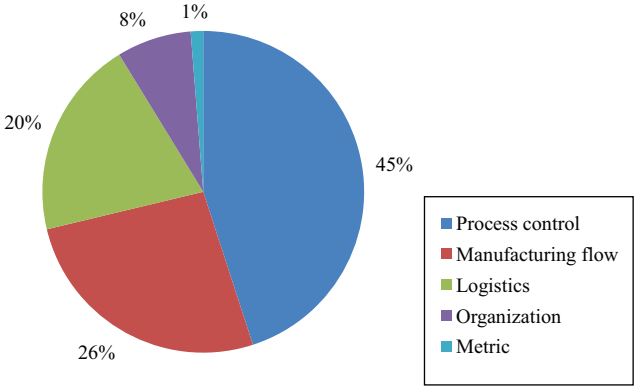
Comparative analysis among research units regarding the specificities of the agribusiness sector

The agribusiness production system, according to Batalha and Silva (2008), is under the influence of specificities, as previously shown in Table III.

To elaborate, the evaluation matrix was carried out a variant "house of quality" used in QFD matrices (Miguel, 2001), by correlating the research units and the specificities due their degree of influence.

The degree of influence was set at three levels: strong influence (symbol - ▲, weight = 9); average influence (symbol - ⊗, weight = 3); and low influence (symbol - ○, weight = 1). As it occurs in the application of QFD, as the correlations are adopted empirically, you should always question their reliability (Miguel, 2001).

To obtain the level of influence of the specificities in the research units it was applied to an adaptation of the calculation of importance degree and the relative weight carried in QFD.



Source: Prepared by the authors

Figure 7.
Representativity of the use of techniques and tools of lean production system through the calculation of the relative weight in terms of Feld (2001) classification

Such equations were named specificities influence degree and specificity relative weight, shown in equations (4) and (5), respectively.

$$\text{Specificities Influence Degree} = \sum \begin{matrix}\text{Weights assigned to each specificity} \\ \text{to the Research Unit under analysis}\end{matrix} \tag{4}$$

$$\text{Speicificity Relative Weight}(\%)_i = \frac{\sum \begin{pmatrix}\text{Weights assigned to the} \\ \text{specificity}_i \text{ to each} \\ \text{Research Unit}\end{pmatrix}}{\begin{pmatrix}\text{Total number of} \\ \text{Research Units}\end{pmatrix} \times \begin{pmatrix}\text{Strength of} \\ \text{influence weight}\end{pmatrix}} \times 100 \tag{5}$$

The Specificities Influence Degree indicates how much each research unit is being affected by all the specificities, while the Specificity Relative Weight shows how a particular specificity affects all research units under analysis.

Thus, Table XII performs the construction of the correlation matrix between research units and the specificities as well as the Specificities Influence Degree and Specificity Relative Weight.

The first analysis to be performed, from Table XII, refers to the specificities and their relative weight. Unlike some productive sectors, agribusiness has its specificities intrinsically related to natural resources, as this type of industry search in agricultural and livestock production its raw materials.

It is noted that, for the research units studied, the Seasonality of Consumption appears as the specificity of major influence, with a relative weight of 100 per cent. Such fact can be justified by market instability and fluctuations that occur in product demand resulting in a strong impact on the organization. According to Akridge *et al.* (2012) in planning and control

Specificity	Research unit A	B	C	D	E	F	G	H	Sum of the weights	Specificity relative weight (%)
Seasonal availability of raw materials	▲	▲	⊗	⊗	▲	▲	▲	▲	60	83.3
Seasonality of consumption	▲	▲	▲	▲	▲	▲	▲	▲	72	100.0
Perishability of raw materials	▲	⊗			○	▲	⊗	○	20	27.8
Perishability of final products	▲	▲			○	▲	▲	○	38	52.7
Quality and health surveillance	▲	▲	⊗	⊗	▲	▲	▲	▲	60	83.3
Sociological aspects of foods	▲	▲				▲	▲		36	50.0
Biological and edaphoclimatic conditions of foods	▲	▲	○	○	▲	▲	▲	▲	56	77.8
Specificities influence degree	63	57	17	17	47	63	57	47		
(%) Specificities influence degree	100	90.5	27.0	27.0	74.6	100	90.5	74.6		

Table XII. Correlation matrix between research units and the specificities as well as the specificities influence degree and specificity relative weight

Notes: ▲= strong influence – weight = 9; ⊗ = average influence – weight = 3; ○ = low influence – weight = 1; In blank = No influence
Source: Prepared by the authors

of production, the specificity in question directly affects the supply of products for the retail market.

The authors of this work also highlight that the seasonality of consumption can be better managed through the establishment of organizational strategic plans, developing studies of future scenarios (forecast) to deal with this variable. Another resource widely used by the research units is the sale of its products through futures contracts, which allows enhanced security for agents involved, especially in times of economic crises and monetary fluctuations.

The specificities, Seasonal availability of raw materials and Quality and health surveillance also stand out by the high relative weight presented (83.3 per cent). The Seasonal availability of raw materials, according to Akridge *et al.* (2012), is directly linked to the harvest periods and the product consumption scenario. Additionally, in the research, it was noted that the production of agribusiness products and raw materials management are linked not only to the product scenario but also to the amount paid to the raw material producer, which results in changing the product to be manufactured (sugarcane industry and rubber) and sometimes in production rate (poultry sector).

The specificity quality and health surveillance is mainly related to the performance and behavior of the agribusiness sector with processed products, which in most cases studied are derived from plants and animal. So they need further attention in relation to compliance with existing health conditions, as well as in ensuring a high quality product. These features address the needs for follow standards such as Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Point (HACCP) and traceability systems.

The biological and edaphoclimatic conditions of foods stand out with the relative weight 77.4 per cent. According to Zuin and Queiroz (2006), the edaphoclimatic aspects are mainly related to factors related to climate and that can affect production. In this respect, there is a strong influence not only related to absence or excess of rain, which affect sectors such as, rubber, sugarcane and silk, but also related to heat waves, which significantly affect the poultry industry and pig farming. In addition, there is the possibility that this natural phenomenon can quickly trigger reactions of biological agents to contaminate the production, affecting all activity.

The perishability of final products (52.4 per cent) strongly affect the sectors that deal with products having a period of validity for reduced for consumption, as occurs for the cases studied in poultry, food, sugarcane (sugar) and pig farming sectors. On the other hand, there are products that reduce perishability after being processed, for example, in silk and rubber industries, these products can therefore be stored and traded in opportune moments.

The Sociological aspects of foods (50 per cent), according to Chandrasekaran and Raghuram (2014), are a more recent thematic of study by the researchers, and is related to the notion that "we are what we eat". In these scenarios, companies that work directly with the production of products for public consumption are strongly influenced, for example the poultry sector that required in recent years to start campaigns and strong actions in favor of egg consumption. It can also be mention the awareness about the benefit of pork consumption, the concern to generate and offer healthier foods that contain lower levels of fat and salt, as it has in the food sector and, finally, the importance of sugar consumption to the world population.

The perishability of raw materials affects several agribusiness sectors, but for the research units, this factor showed a relative weight of 27.8 per cent, with strong influence for sugarcane and poultry sector, which work with products of short period of validity (eggs) and which lose quality during processing (sugarcane). Other sectors suffer lower impact by this influence, because they have a longer period of validity of its raw material, allowing these companies dealing with more "gap" time during processing, but

on the other hand, is identified a waste associated with need for quick distribution to final consumers to prevent waste of the processed product.

Another analysis to be performed is the verification of how the specificities affect each research unit, which is given by means of Specificities Influence Degree. From that some aspects can be highlighted:

- For Research Units A and F, which operates in poultry and sugarcane sectors, there was a strong influence of all the specificities. This fact can be attributed to a characteristic that granted them similarity related to perishability of product. During the analysis, the final products obtained from each activity are highly perishable, which does not allow for storing them.
- Such characteristic is similar among Research Units B and G, which operate in the pig farming and food sector, but these have lower impact on the perishability of the raw material, which gives thus a lower Specificities Influence Degree.
- The Research Units E and H operate in rubber and natural silk spinning sectors, which had similar specificities because they produce products of natural origin. However, after they are processed, they can be stored for a longer time, a fact that differs from the others described sectors. Both the raw materials, as the processed product, have a low perishability rate because they can be stored and sold at moments that are consistent to market strategies adopted by companies.
- Finally, Research Units C and D, which operate in the Agricultural machines and Poultry farming equipment sectors showed during the study a very close characteristic to metal-mechanical and manufacturing industries, a fact which explains the low influence of specificities.

Final considerations

While exploring the literature on lean production system are glimpsed numerous studies that portray different industrial segments and over various optical and aspects related to the theme. However, it is noted that this literature is scarce when analyzing the agribusiness sector, with few studies on this topic.

To achieve the purpose of this research, we used multiple case studies in companies acting in different branches of the agribusiness sector. As a descriptive characteristic of research with the theory refinement purpose, we used an open type research questionnaire, documental analysis and on-site visits.

This strategy for data collection has been demonstrated suitable for the construction of the research that has been carried out from the steps proposed by Yin (2013). A limitation of the method used that is inherent in case study is the impossibility of generalizing the data, which are true to the sample in question. However, it allows for important propositions for future research.

The conduction of case studies to the eight research units has identified an important set of information for the agribusiness sector that is little explored in the areas of industrial engineering, although of major importance for the national economy.

It was observed that the research units were acting towards obtaining a better organizational performance, having the driving practices that seek to take the continuous improvement of its processes at different levels of formalization. The comparative tables presented in results section have shown that there is a concern of organizations to visualize a plan in the long term and not rather of immediate profits, even if in some units such planning still occurs in a lower formal manner.

When comparing this research to the evaluation studies of the degree of adherence to the lean production system, for example, Lucato *et al.* (2014) it is noted that the level of

implementation of concepts is not distinguished among the best organizations. This study indicates that as agro-industrial organizations are used with a Lean philosophy, they lack a closer proximity to the academic environment. This academic contact to develop joint studies for a sector with specific characteristics and world economic importance.

It was shown in the cases studied that certain priority in conducting the processes management, which is presented with relevance in research units, and they use various techniques and tools of lean production system to support such improvements.

At this point, it should also be pointed out that the techniques and tools of lean production system, although used by organizations, are not demonstrated similar among research units regarding the use, nor are responsible in a direct way for a good degree of adherence index to lean production system. Such aspects confirmed what other studies have indicated, that the techniques and tools should be selected according to organizational need, being the study an indication that this is also true for the agribusiness organizations.

The research units operate in a good degree of improvement in their production systems, valued item in the Problem-Solving category. However, they still need improve the structure of the teams that have acted on these issues and especially in developing leaders for dissemination of organizational philosophy, a fact noted in the principle that evaluates such aspect.

The supplier management appears at a good level. Much of this performance relates to family-run management model adopted, in which there are closer dealings between customer and supplier, which makes this with a better performance to other items when evaluated. However, in some research units, there is still a need to be better managed through the formalization of the process.

Even showing a good/great degree of adherence to lean production system, the research units have opportunities for further improving of their agribusiness systems, and they need to continue with their activities and studies for organizational advancement, which is one of the premises to achieve perfection of the lean philosophy.

Finally, it is identified that the specificities for the agribusiness systems are of a strong influence to the research units under study, having as highlight the seasonality of consumption; seasonal availability of raw materials; quality and health surveillance; and biological and edaphoclimatic conditions of foods.

The research units that perform processing products are directly impacted by agribusiness specificities due to the natural characteristics of their products, and should pay attention in the management of such aspects. On the other hand, research units acting in the sector, but with characteristics closer to the manufacturing industries, have a smaller influence of such specificities.

This study met its purpose of contributing to the refinement of an already established theory, but one that's rarely explored in the study object. It also allows to, based on data identified, cite future gaps and surveys to researchers which will assist the most competitive management for an important segment of the world economy. It points out as research agenda:

- development of a conceptual study for association between the use of lean production techniques and tools such as a mechanism for overcoming or minimizing the effects of the specificities in the agribusiness units, facilitating the decision-making process;
- the conduction of similar case studies to this one, expanding the number of cases in companies operating in the same area, such as poultry (important segment in the studied region), to diagnose and point out its own model for lean implementation and management; and
- from the identification that the agribusiness units are applying lean concepts, to establishing studies of survey type, for mapping the regional or state level, on the

impact of the use of lean philosophy due to profitability gains, market share, customer evaluations and so on.

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