CHEMICAL ENGINEERING TRANSACTIONS
VOL. 44, 2015
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Chief Editors: Riccardo Guidetti, Luigi Bodria, Stanley Best

ISBN 978-88-95608-35-8; **ISSN** 2283-9216

Quality Control of Tropical Fruit Pulp in Brazil

Carlos Eduardo de F. Silva[a], Edna M. de O. Moura[a], José Edmundo A. de Souza[a], Ana Karla de S. Abud[b]

[a] Technology Center, University Federal of Alagoas, Maceió, Alagoas, Brazil
[b] Food Technology Department, University Federal of Sergipe, São Cristóvão, Sergipe, Brazil.
eduardo.farias.ufal@gmail.com

The practicality and increased consumption of healthier products, combined with Brazil's agricultural nature, third largest producer of fruits, caused in the Brazilian fruit pulp production segment a significant increase in the past decade. Food production standards begun to diversify the requirements from the industrial production point of view, as well as safety need to be included in the concept of product quality. At this work there is a discussion of how Brazil assigns legally the concept of tropical fruit pulp's quality. Brazilian law provides three mandatory aspects to maintain the quality of industrial activity pulps. The first concerns to the production, where industries must have Good Manufacturing Practices (GMP) and Standard Operating Procedures (SOP's), that consist of checklists and worksheets which regulate industrial routine, such as water used in the process, raw material, packaging, ingredients, quality and hygiene of utensils, equipment and furniture, waste generation and food transportation for the consumer centers. If any non-compliance appears, the corrective action is almost immediate, with an efficient traceability of the problem. The second aspect acts in microbiological point of view, in the sanity of the food for man, providing the limits of quantification of total and fecal coliforms by the Ministry of Health and the Ministry of Agriculture, Livestock and Supply for both total and fecal coliforms as for molds and yeasts, as also indicating the sanitary conditions of handling and processing of the product. Finally, the third aspect directs to the physicochemical characteristics of pulp fruit, Identity and Quality Standards (IQS's) and the parameters such as content of total soluble solids (°Brix), pH, acidity, total solids, total sugars and vitamin C, with specific values for each fruit flavor, that indicates whether during cultivation occurred some negligences on the nutritional aspect of the plant or, in the latter case, adulteration during processing and packaging, as addition of preservatives, acidulants or dilution of the pulp to increase yield. Although the Hazard Analysis and Critical Control Points (HACCP) is not mandatory to processing industries of plant foods, it has the function to check any irregular status during the processing of the product and could improve the standardization of the final product. All these measures are recommended by the Brazilian legislation that achieves an innocuous and nutritional characteristics and organoleptic adequate food.

1. Introduction

Brazilian flora is provided with a huge diversity of fruits, many of them with exceptional sensory quality, arousing the market interest for the exotic appeal and nutritional. To know the composition of these fruits has been a research target over the years and it is the essential point to the technological use is performed in such an optimally manner (Mattietto et al., 2003).

Brazil is the third largest worldwide manufacturer of fruits, representing about 6 % of world production (Andrigueto et al., 2013). One of the challenges of this agroindustry is the fruit conservation with high perishability, being given wide attention to the processes that preserve the physical structure and the nutritional and sensory features of the products, mainly taking into account the current trend of consumer market expansion. Among the large correlated propositions are the lack of the products standardization in the production process, since the meadow to the final consumption (Vendrametto et al., 2011).

The fruit pulp has wild value as raw material; it can be made in harvest time, stored and processed at the most proper periods or according to the consumer market demand, like bulk candy, jams, ices, nectars among others (Dantas et al., 2010).

Quality is a critical requirement and several management tools are being created and upgraded not only to supply safe food for the consumer, because contaminated food is a matter of public health, but also for commercial reasons, mainly exportation, that pushed demand, establishing strict criteria for control. As quality benefit, stand out the simplification and organization of the process, decreasing costs and losses. Food quality can be analyzed considering three categories: (1) basic level, that in respect of physicochemical characteristics and innocuousness, essential to any food products; (2) nutritional level, influencing benefits on food for the consumer; (3) quality level of related value to food, with respect to the environment, workers and tradition (Ablan, 1992). This article pursuits to emphasize how Brazilian legislation encompasses in the quality control production of tropical fruit pulp in the nutritional, microbiological or legal characters.

2. Methodology

An analysis was made of the production process ordinarily used by small and medium size industries in Brazil, inferring the most important stages control and legal aspects that can supply a quality fruit pulp to the consumer. To study the Brazilian legal aspect about the quality control during the industrial processing of tropical fruit pulp a review about standard legislation was performed, seeking to sum up and highlight the principal important items. The most principal documents consulted were:

- Decree Nº 326, July 30,1997, from Ministry of Health, referring to the Technical Regulation on Hygiene and Sanitary Conditions and Good Manufacturing Practices for establishments Producers / industrializers Food;
- Decree Nº 368, September 4, 1997, MAPA. Technical Regulation on Hygiene and Sanitary Conditions and Good Manufacturing Practices for Developers of Facilities / Industrializers Food;
- Normative Instruction Nº 01, January 7, 2000, MAPA. Approves the Regulation General Technical for fixing the Identity and Quality Standards for Fruit Pulp.
- Resolution RDC N° 275, October 21, 2002, ANVISA. It offers the Technical Regulation on the Standard Operating Procedures and the Good Practice Checklist Facilities Producers / Industrializers Food;
- Resolution RDC N° 216, September 15, 2004, ANVISA. Good Manufacturing Practices for Food Services;
- Normative Instruction Nº 12, September 10, 1999, MAPA. Regulated identity standards and minimum quality characteristics for fruit pulp for consumption as a beverage.
- Resolution RDC Nº 12, January 02, 2001, ANVISA. Microbiological Quality Standards for Foods.

3. Results and Discussion

3.1 Industrial Processing

During the industrial process, the pulping stages are from the acceptance of raw material, preselection or selection of suitable fruits to the entry in the industrial flow, freezing/ripeness to fruits which amount is insufficient or in inappropriated ripeness to the fruit characteristics, wash and rinse, peeling and cutting to fruits that can not be placed in pulps, filling and finally freezing.

At the acceptance, on reaching the industry, by an appropriate transportation, fruits are heavy to have understanding about the real capacity of processed fruit, reducing the weight of discarded fruit after selection. The selection is one of the most important stages, because it is responsible for the final classification of the fruit that will be processed. At this stage, the fruits are exposed on a suitable table where they are analyzed for maturation, firmness, bruised, defects caused by fungi, rodents and insects. All defective fruits are taken to not compromise the quality of the final product. The freezing/ripeness is made in the selection when there are unripe fruits or in excess, there are no possibilities to be processed on that day, it has been separated and taken to maturation or the freezing, respectively. The wash and rinse is a mandatory process because the raw material tends to arrive at the industry with a burden of microorganisms, dirtiness and, in particular, soil acquired during the harvest and the transportation. The wash aims to reduce the number of initial microorganisms to a minimum acceptable. At first, the fruits are submitted to immersion in water without chlorine, to remove the excess of dirtiness, and after, with high concentrations of chlorine for a certain period of time (commonly 10 to 100 ppm for 15 minutes), depending on the fruit which is been processed. Finally, the rinsing is performed with clean water, removing the chlorine excess from the last wash, with no water waste.

The peeling and cutting are made in fruits like pineapple, mango, passion fruit, graviola etc., as they require prior preparation for pulping. The peeling is made using knives or rightly sanitized equipments, being removed stalks and seeds to take the fruits to the depulper, where fruit pulps are extracted from the fibrous material, passing through the sieve. There are seeds separation and skin waste and to be conducted through a tubing

from a tubing of the same equipment to the filling machine. The speed of the pulping machine influences the yield and temperature also changes its efficiency, depending on the type of raw material.
Filling pulps is made as soon as possible to keep the characteristics of fresh fruits, being packaged in returnable monoblock boxes, avoiding the garbage creation for the environment. These are stored in freezing chamber with suitable temperature. When they leave the freezing chambers, the frozen fruit pulps are packaged in cold store and the temperature changes around -18 to -23°C, until the distribution.
It can be observed, on Figure 1, that selection procedure of raw material and thermal exercise key role to the packaged fruit pulp quality control at the end of the process. An improper raw material from any amount, as small as it may be, it infects the entire production batch and that is why the selection is not only essential but it must be made with a high level of efficacy. The use of cooling of this tropical product has the function to decrease bacterial activities and respiratory of the fruits, just as well biochemical reactions derived from enzymatic processes and/or darkening, during the storage and after the pulp processing.

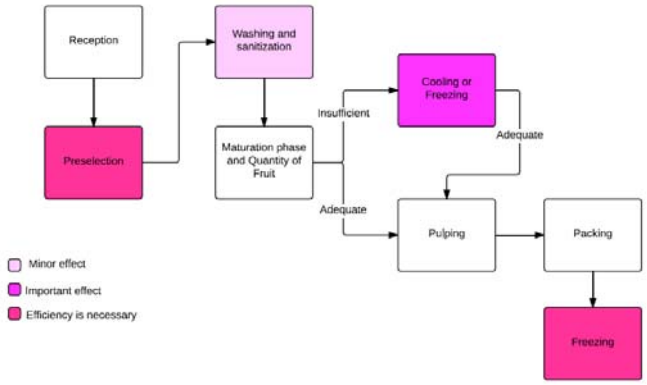

Figure 1: Industrial process of fruit pulp production.

Physic and physiological injuries on the fruits start to unleash the enzymatic darkening (an example of shocks, abrasions, CO_2 excess or “chilling”), presenting themselves as colorful polymers (amino acid molecules) result of compound phenolic oxidation. These fruit damages lead to the cell rupture and consequently cells disaggregation, making susceptible the enzyme contacts related to the darkening with the resent phenolic groups (Porte and Maia, 2001; Vilas Boas, 2002). These reactions can cause unfavorable changes to the expected quality to the products, like the aroma deterioration and organoleptic characteristics, nutritional value reduction and the useful fruit life. The enzymatic darkening is caused mainly because of the enzyme polyphenol oxidase (PPO) action (Vilas Boas, 2002), highly noticeable in light-colored fruits like cashew, graviola, custard apple, among others.

3.2 Identity and Quality Standards for Tropical Fruits

Currently, the legislation predicts limits in the physical and chemical analysis for the quality control of pulps, the identity and quality standards (IQS´s) and parameters such as acidity, pH, °Brix, total solid content, total sugars and vitamin C, setting minimum standards required to the pulps. Table 1 presents the IQS’s for fruits like acerola, cocoa, cupuacu, graviola, acai, passion fruit, cashew, mango, guava, pitanga, grape, papaya, caja, melon and mangaba, as well as passion fruit juice, cashew, cashew with high pulp content, clarified cashew or cashew wine, pineapple, pear, apple, lemon, acid lime and orange. Such standards are determined according to the natural characteristics of each fruit and serve as basis to check if there were any neglect during the fruit growing or even tempering by water addition or any chemical products, like acidulants. The Brazilian legislation mentions fruit pulp to be an unfermented product, not from concentrate or diluted, obtained for pulpy fruits crushing (Brazil, 2000).
Pulps must be prepared with sane fruits, clean, exempt from soil matter, vermins, animal or vegetable sewage. It must not contain pieces of inedible parts of the fruit not oddly substances to its normal composition. Also, it is necessary to observe the presence or absence od dirt, vermins and larvae (Santos et al., 2014).

Table 1: Identity and quality standards of some tropical fruits

FRUITS	°Brix (20°C)	Acidity (g citric/100 g)	pH	Vitamin C (mg/100 g)	Total Natural Sugars (g/100 g)	Total Solids (g/100g)
Acerola	≥ 5.5	≥ 0.80	≥ 2.8	≥ 800.0	4.0 - 9.5	≥ 6.5
Pineapple	≥ 11.0	≥ 0.30	-	-	≤ 17.0	≥ 14.0
Cocoa	≥ 14.0	≥ 0.75	≥ 3.4	-	10.0 – 19.0	≥ 16.0
Caja	≥ 9.0	≥ 0.90	≥ 2.2	-	≤ 12.0	≥ 9.5
Cashew	≥ 10.0	≥ 0.30	≤ 4.6	≥ 80.0	≤ 15.0	≥ 10.5
Guava	≥ 7.0	≥ 0.40	≥ 3.5	≥ 40.0	≤ 15.0	≥ 9.0
Graviola	≥ 9.0	≥ 0.60	≥ 3.5	≥ 10.0	6.5 – 17.0	≥ 12.5
Papaya	≥ 10.0	≥ 0.17	≥ 4.0	-	≤ 14.0	≥10.5
Mango	≥ 11.0	≥ 0.32	3.3-4.5	-	≤ 17.0	≥ 14.0
Mangaba	≥ 8.0	≥ 0.70	≥ 2.80	-	≤ 8.5	≥ 10.0
Passion fruit	≥ 11.0	> 2.50	2.7 - 3.8	-	≤ 18.0	≥ 11.0
Melon	≥ 7.0	≥ 0.14	≥ 4.5	-	≤ 12.0	≥ 7.5
Pitanga	≥ 6.0	≥ 0.92	2.5 – 3.4	-	≤ 9.5	≥ 7.0

3.3 Microbiological Control of Final Products

In Brazil, the microbiological and sanitary quality of traded pulps is governed by RDC, resolution No. 12, January 02, 2011, ANVISA (National Sanitary Surveillance Agency), that confirms the technical regulation about microbiological standards for food (Brazil, 2001), as shown the hygienic and sanitary standards in table 2, with thermotolerant coliforms control and *Salmonella*.

Table 2: Microbiological parameters for pulp fruits.

FRUITS, FRUIT PRODUCTS AND SIMILAR						
FOOD GROUP	MICROORGANISM	Tolerance for INDICATIVE Sample	Tolerance for Representative* Sample			
			n	c	m	M
Concentrated or non-concentrated pulps, with or without heat treatment, refrigerated or frozen.	Coliforms at 45°C/g (Fecal coliforms)	10^2	5	2	10	10^2
	Salmonella sp/25 g	Aus	5	0	Aus	-

*For representative sample, the legislation recognizes the terms:
m: is the limit that in a three-class plan, separates an acceptable product batch or lot with intermediate acceptable quality.
M: is the limit that in a two-class plan, separates the acceptable from the unacceptable product. In a three-class plan, M separates the lot with intermediate acceptable quality from the unacceptable lot. Values above M are unacceptable.
n: is the number of units to be taken randomly from the same batch and analyzed individually. In cases where the standard set is the absence in 25 g, as for *Salmonella* sp and *Listeria monocytogenes* and other pathogens, it is possible to mix the aliquots taken from each sample unit, respecting the w / v (one part by weight of the sample to 10 parts by volume of broth medium in culture).
c: the maximum acceptable number of sample units with counts in the range of m and M (three classes plan). In cases where the microbiological standard is expressed by "absence", c is equal to zero, and applies the two classes plan.

The MAPA (Agriculture, Livestock and Food supply Ministry), that relates more to hygiene parameters in manipulation and processing, through the normative instruction Nº 12 of 1999 (Brasil, 1999), regulated the identity standards and minimum quality requirements for fruit pulp consumption like beverage, establishing maximum values 1 MPN/g of coliforms and 5 x 10^3 CFU/g of moulds and yeasts. It can be seen that the focus are on fruit manipulation techniques, employees' hygiene, hygiene in the storage and cleaning condition and maintenance of industrial activity. While ANVISA worries about the consumer health, MAPA encompasses industrial hygiene during the processing.

3.4. Good Manufacturing Practices (GMP), Standard Operating Procedures (SOP´s) and Hazard Analysis and Critical Control Points (HACCP)

The right to acquire safe food is guaranteed to consumers by Article 6th of Chapter III of the Brazilian Consumer Defense Code (CDC), with the responsible producers for food safety and application of management tools that are appropriate to the required limits by legislation and, consequently, to the high quality standards (Brazil, 1990).

From available tools, it can be quoted the Good Manufacturing Practices (GMP), which contemplate the Standard Operating Procedures (SOP's), the Microbiological Risk Assessment (MRA), Quality Management (ISO series), the Total Quality Management (TQM) and the Hazard Analysis and Critical Control Points (HACCP) (Furtini and Abreu, 2006). GMP's, which include SOP´s, are required by Brazilian legislation to any establishment producer/food handler. They are considered in 77% of certification processes, national and

international, which 50% use it only for certification. It is considered, then, that its compliance is a basic procedure to obtain safe food (Peretti and Araujo, 2010). They are typically used eight Standard Operating Procedures (SOP's) for a small-sized factory:

1. Installment hygiene, equipment and utensils. Provides, along with the work instructions the procedures for the proper hygiene facilities, equipment and utensils, to ensure that does not happen contamination of the product during and after processing. There are as many prepare cleaning solutions, the frequency (daily, weekly, quarterly) and as well as spreadsheets that refers on the need, compliance and validation of hygiene.
2. Water potability. It focus on the procedures for cleaning/disinfection of water containers and the potability frequency/periodicity control.
3. Hygiene and health of handlers. Points out procedures for personal hygiene and health control of handlers, in order to avoid, mainly, dangers of microbiological order.
4. Waste Management. Contains all the direction of transmission and waste removal generated during the processing, as well as its periodicity and complementary procedures generated by this activity.
5. Preventive maintenance and equipments calibration. Governs needed procedures for preventive maintenance in order to avoid long stops for corrective action caused by lack of maintenance and misuse, as well as equipment calibration for appropriated measures and warranty uniformity on the final product.
6. Integrated Vector Management and urban pests. Extends the set of preventive and corrective actions that intended to prevent pests and vectors in the internal environment of the factory, it may cause public health problems. Includes disinfestations by contractors companies, as usual actions that should be taken by the employees and production supervisor.
7. Selection and receipt of raw materials, packaging and ingredients. Establishes the needed procedures for the receipt and selection of raw materials and ingredients and management of packaging.
8. Food gathering program. Ensures the responsibility to receive their products with expired shelf life and also products that for any reasons, have become harmful to the consumer and as well as possess lot traceability, check and solve the causes of the problem.

The Hazard Analysis and Critical Control Points (HACCP) advices about how to raise the biological hazards, chemical and significant physical that can occur in the production of a particular food in a processing line and also how to control the Critical Control Points (CCP) during production (Profeta and Silva, 2005). Brazilian legislation began to quote the HACCP in 1993, by fishing, but only in 1997 and 1998 the 40 and 46 decrees from MAPA made a manual for vinegars and beverage industries and forced the gradual implementation in the animal products industries, respectively, and a necessary requirement to GMP's, along with SOP´s. Therefore, the fruit pulp industry is not required to implement the HACCP yet.

Some deployment attempts in the area of plant food such as olive oil and fresh-cut vegetables, have been published, showing that it is a natural tendency to absorb the HACCP as control system (Pardo et al., 2003; Cruz et al., 2006). However, the current legislation only requires HACCP for production / industrial animal origin food industries such as meat, milk, honey and derivatives, with the fruit processing industry at the moment, still exempt from this requirement, which tends to be imposed gradually over the years and needs its base formed.

The four mentioned actions, the 5S program, GMP's, SOP's and HACCP are the basis of the quality pyramid (Figure 2), where it is found that, to reach the national recognized standardization and internationally, it must be with the well-formed actions and adapted to the real condition of the industry.

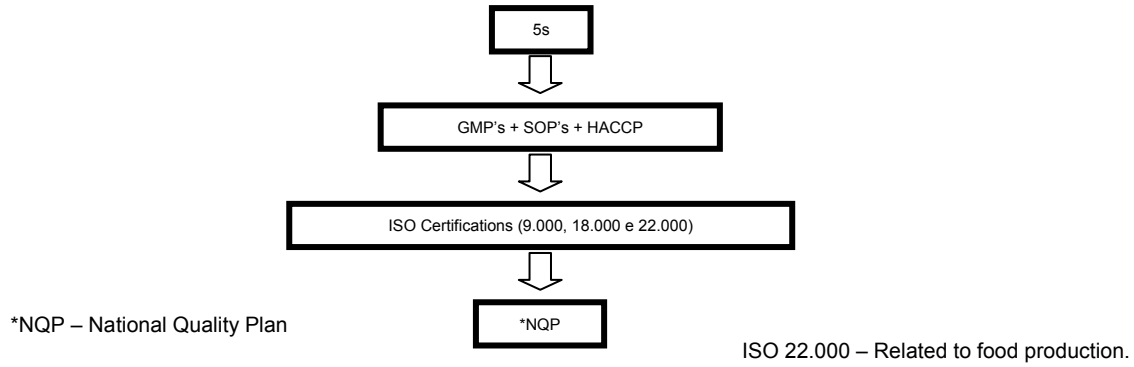

Figure 2: Quality flowchart directed to food industry.

The investigations to be proposed by HAPPC are intended to identify, through an examination of raw materials and all relevant steps in the production chain, including to the use by the customer or final consumer, the presence or possibility of health danger and consumer integrity, such as:

- Microbiologically sensitive food that promote microbial growth or toxins production;
- Pathogenic organisms or toxic substances;
- Inadequate heat treatment, or time combinations and inadequate temperature;
- Inadequate procedures used after heat treatment
- Environmental conditions that allow the transfer of pathogenic microorganisms or toxic substances for food by air, water or other vectors (Profeta and Silva, 2005).

Therefore, standardization of operational quality control of the industry and its adoption in plant food processing industries will be a gain to the company and the consumer.

4. Conclusions

In Brazil, the quality control of tropical fruit pulps production activity are regulated in three focal points, where the first is the IQS's (Identity and Quality Standards) for fruit pulp, delimiting the physicochemical characters minimum and/or maximum for each type of fruit, respecting its natural characteristics; the second treats about the sanitary-hygienic or microbiological conditions, having legislation on sanitary condition of the final product or the hygiene conditions of the industrial plant and, finally, the third requires all food industries possess the Good Manufacturing Practices (GMP) and Standard Operating Procedures (SOP´s). Although in Brazil the HACCP (Hazard Analysis and Points of Critical Control) is not mandatory for vegetable processing industry, its adoption will improve the standardization and quality control within the processing of pulp industries.

References

Ablan E.,1992, Quality policies in spanish agrofood system (original title in Spanish).Agroalimentaria 10,63-72.

Andrigueto J.R., Nasser L.C.B., Teixeira J.M.A., 2013, Integrated fruit production: concept, history and the evolution of the agricultural system of integrated production - ASIP (original title in Portuguese) <www. agricultura.gov.br> acessed 03.07.2014

Brazil, Ministry of Civil House, 1990, Law No. 8078 of September 11, 1990. Provides for consumer protection and other measures (Consumer Defense Code) (original title in Portuguese). Federal Register, September 12, 1990.

Brazil, Ministry of Agriculture, Livestock and Supply, 1999 Instruction No. 12/99, of 13.09.99. Identity and Quality Standards for Fruit Pulps (original title in Portuguese). Federal Register, September 13, 1999.

Brazil, Ministry of Agriculture, Livestock and Supply. 2000, Normative Instruction No. 01 of 07 January 2000. Approves the General Technical Regulation for fixing the Identity and Quality Standards for Fruit Pulp (original title in Portuguese). Federal Register, January 10, 2000.

Cruz A.G., Cenci S.A., Maia M.C.A., 2006, Prerequisites for implementation of HACCP system in a lettuce minimally processed line (original title in Portuguese). Food Science and Technology 26 (1), 104-9.

Dantas R.L, Rocha A.P.T., Araújo A.S., Rodrigues M.S.A., Maranhão T.K.L., 2010, Quality Profile pulp of fruits Marketed in the city of Campina Grande/PB (original title in Portuguese). Revista Verde 5(5), 61-66.

Furtini L.L.R., Abreu L.R.., 2006, Use of HACCP in Food Industry (original title in Portuguese). Revista Ciência Agrotecnológica 30(2), 358-63.

Mattietto R.A., Soares M.S., Ribeiro C.C., 2003, Physical and physicochemical characterization of mangaba (*Hancornia speciosa* Gomes) fruit from Belém-PA (original title in Portuguese). In: Simpósio Brasileiro sobre a Cultura da Mangaba, 2003, Aracajú - SE.

Pardo J.E., Snachez J.E., Perez J.I., Andres M., Alvaruiz A., 2003, Application of the Hazard Analysis and Critical Control Point (HACCP) system in a bottling line of virgin olive oil. Grasas y Aceites 54(1), 58-64.

Peretti A.P.R., Araujo, W.M.C., 2010, Scope of security requirement in quality certificates of the food chain in Brazil (original title in Portuguese). Gestão & Produção 17 (1), 35-49.

Porte A., Maia L.H., 2001, Physiological changes, biochemical and microbiological minimally processed foods (original title in Portuguese). CEPPA 19 (1), 105-118.

Profeta R.A., Silva S.F., 2005, HACCP - Hazard Analysis and Critical Control Points in Sugar Company (original title in Portuguese). In: XXV ENEGEP – Encontro Nacional de Engenharia de Produção, 2005, Porto Alegre - RS.

Santos F.A., Salles J.R.J., Chagas Filho E., Rabelo R.N., 2004, Qualitative analysis of frozen fruit pulps produced by SUFRUTS (original title in Portuguese). Higiene Alimentar 15 (119), 14-22.

Vandrametto L.P., Di Augustini C.A., Bonilla S.H.A, 2011, Integrated Fruit Production in Brazil and its interface with the Cleaner Production (original title in Portuguese). In: 3° International Workshop Advances in Cleaner Production: Cleaner Production Initiatives and Challenges for a Sustainable World, 2011, São Paulo - SP.

Vilas Boas E.V.B., 2002, Quality of plant foods (original title in Portuguese). Lavras: UFLA/FAEPE.