IMPACTS CAUSED BY THE INADEQUATE DEPOSITION OF THE RESIDUE OF THE RIO GRANDE DO NORTE AGROINDUSTRIES

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ABSTRACT

The current consumer market is eager for products with great practicality and quick preparation. Among these, in recent years, a great emphasis has been given to the use of fruit pulps for the preparation of juice and other derived products. This work consists of a balance sheet of the industries making juice from fruit pulps of the state of Rio Grande do Norte (Brazil), with respect to the disposal of waste and the impact associated with the activities developed by them. The work was developed through a bibliographic research and the survey of data in 12 agro-industries of fruits processing in the state of Rio Grande do Norte, by applying a standard questionnaire. The results demonstrate a critical level with the improper disposal of waste in inappropriate places and low rates of preventive practices or the reuse of these. The management of liquid effluents is not treated with the degree of importance that is required and the exposure of emissions to the atmosphere is practically done in a grossly way, without any treatment. The paper explores such results and suggests an alternative proposal for the recycling of the wastes of those industries as food and as a food of animal origin.
Key words: fruit pulps, solid wastes, agro-industries

RESUMO

Impactos causados pela disposição inadequada de resíduos em agroindústrias do Rio Grande do Norte. O atual mercado consumidor é ávido por produtos com grande praticidade e rápido preparo. Dentre esses, nos últimos anos, dado um grande destaque ao uso de polpas de frutas para o preparo de sucos e outros derivados. Este trabalho consiste de um balanço da situação das indústrias de beneficiamento de polpas de frutas do estado Rio Grande do Norte (Brasil), com

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relação à disposição final de resíduos e o impacto associado pelas atividades desenvolvidas por estas. O trabalho foi desenvolvido através de uma pesquisa bibliográfica e levantamento de dados em 12 agroindústrias de processamento de frutas do estado do Rio Grande do Norte, mediante a aplicação de um questionário padrão. Os resultados demonstram um nível de criticidade com a disposição inadequada de resíduos em locais inapropriados e baixos índices de práticas preventivas ou de reuso desses. O gerenciamento dos efluentes líquidos não é tratado com o grau de importância que se requer e a exposição de emissões para a atmosfera praticamente é feito de forma bruta, sem nenhum tratamento. O trabalho explora tais resultados e sugere uma proposta de alternativas para o reaproveitamento dos resíduos dessas indústrias como alimentação humana e como um alimento de origem animal.
Palavras-chave: polpas de frutas, resíduos sólidos, agroindústrias

INTRODUCTION

The tropical fruits production is standing out in the last years as one of the main agroindustrial activities of the northeast region, especially in the Rio Grande do Norte state. The increase in demand for rapid preparation products brought out, in the fruit industrialization area, the frozen natural pulps (Braga *et al.*, 2012).

Since then, this part of the industry has been developed year after year. In the Rio Grande do Norte state there are much kind of these, and the juice extraction waste problem really needs a solution.

There are plenty and really serious consequences to the environment when the waste is disposed incorrectly. However, most part of this waste, especially the bagasse, is basically composed of organic matter rich in sugars and fiber, having such a high nutritional value, that it could even be consumed or supplemented in human food. Besides, it is a great source for manure and animal food, mainly because it contains high carbohydrates concentrations (Ness, 1997; Arnous, 2002; Abdille, 2005).

Some studies that show the fruit processing activities impacts and, consequently, their environmental damage, have been performed. However, all of them mention the data scarcity and appropriate models for this type of industrial sector. Among the few studies that present scenarios and proposals for improvement should be noted: Bastos *et al.* (1997), Bastos *et al.* (1998), EMBRAPA (1999), Yeh (2005), Cunha *et al.* (2006) and Rolphes (2011).

Moreover, there are strong lines of research studying alternatives and potential reuse of food waste associated to these activities, and different processing routes have been developed, such as: Amorim (1999), Gasparetto (1999), Abreu and Nevis (2000), Arnous (2002), Cardoso *et al.* (2011), Da Silva *et al.* (2011) and Braga *et al.* (2012).

Thus, the information sources that diagnose the problems and the environmental aspects and levels of impacts on the environment enables the adoption of environmental policies and guidelines that are better related to significant levels of environmental performance (Rolphes, 2011).

The purpose of this work was to identify main impacts caused by the inadequate waste disposal of fruit pulp industries, through a comparative study of disposal and reuse ways that occur in companies located in rural and urban areas. Parallely, the bagasse was qualified in a way to promote the improvement of reusing process, proposing new ways to an adequate destiny.

MATERIAL AND METHODS

The first procedure taken was the visits to small, medium and large companies located in Natal (capital of the state), metropolitan region and rural area, where the following informations were registered through a questionnaire: forms of deposition; the impact generated by the company; the ways to reuse fruits that are out of the standard quality for the industrial process, the bagasse generated; the processed fruits that have the greatest losses in field; the companies' interest in fighting the hazards caused to the environment and the disposal of wastewater from fruit wash. The questionnaire is shown in figure 1.

A visit to the main center for agricultural products commercialization of Rio Grande do Norte state (CEASA) was also made, aiming to analyze the fruit loss, even before its commercialization.

BASICS:

Corporate Name: Name to which the company is legally registered in public budies.

Location: Full company address.

Fruit Pulp Origin: Informed whether the pulps were produced by the company ben efit or purchased from distributors.

Daily Consumption: Amount of fruit pulp benefited by the company every day.

Products: Variety of industrial products (produced) by the company.

SOLID WASTE

Selective Collection: The presence of any type of gabage selection was evaluated, whether crude or advenced technological collection system.

Main Types of Waste: The main types of solid waste generated by the company were listed (classified according to NBR 10140). Ex.: Cardboard, plastic bags, etc.

Composting: Existence of fertilizers production system that are controlled, so it can be classified as composting.

Final Destination: The place where the waste is disposed was observed. Ex.: public collection system, landfills, etc.

Recycling Systems: In case of recycling methods presented by the company, the types used were registred.

SEWERS AND WASTEWATERS

Rain Water Disposal: The system of rain water flow in the company's production area was characterized. Ex.: If there was any further use of that water, etc.

Sewage: From toilets and canteens.

Daily Amount: Measurement of daily consumption.

Final Destination: If the effluent is directed to the public net, cesspit, etc.

Washing Waters: Wastewaters from the industrial zone wash.

Composition: Qualitative composition.
Daily Quantity: Average amount spent per day.

Differentiation between floor and equipments: It was questioned whether the water used was the same for both washing floor and for washing machines.

Intercrop and Crop Differentiation: It was question ed if there was a difference in wastewater amount generation between these different periods. The quantitative data was registered in affirmative cases.

INDUSTRIAL EFFLUENTS

The wash water effluent is the only one? If not, the further industrial effluents were registered.

Yields of fruit pulp per liter: The existence of quantification for the wastewater amount generated per liter of processed fruit pulp was observed.

Daily Amount: Effluent volume generated per day of process.

Final Destin ation: The place where the effluents generated through the process was evaluated. Ex.: sewage treatment, Rivers or soil deposition, donation to animal breeders, etc.

Intercrop and Crop Differentiation: It was questioned if there was a difference in effluent amount generation between these different periods. The quantitative data was registered in affirmative cases.

Dump Frequency: The fate of losses and fruit pulp out of date or lost during the process was questioned.

ATMOSPHERIC EMISSIONS

Presence of B oilers: The existence of boilers for steam generation was observed, as well as the destination given to the cooling water.

Fuel Type: This topic was necessary to assess the quality of gas emissions generated as a result of burning power.

Release of gases to the atmosphere: In case of gas emission, the type of treatment used to theses gases was registered.

Technical Description: Technical means in the proper treatment before these gases are emitted to the atmosphere were listed.

Intercrop and Crop Differ entiation: It was questioned if there was a difference in gases amount generation between these different periods. The quantitative data was registered in affirmative cases.

Figure 1. Questionnaire used to collect data.

In a second stage, alternative ways for reusing the rests of bagasse and the fruits out of the commercialization and industrialization standards were searched in technical literature.

RESULTS AND DISCUSSION

Fruit Extraction Process

Except for minor differences between the companies, the fruit pulp obtainment process follows the following fases: reception of raw material; washing with water and disinfectant agent (normally chlorine); peeling (if needed); pulp extraction (raw pulp and bagasse production); refining the raw pulp (refined pulp and bagasse production); pasteurization (made in the minority of the companies); envasement and freezing (Gasparetto, 1999).

In figure 2, some examples of pulp extraction stage and bagasses generation process in the companies researched are shown:

Figure 2. Extraction of the pulp process (bagasse generation).

A bibliographic research was realized to look for ways of reusing the bagasse from the fruit industrialization, looking for alternatives that could be applied to all the typical fruits of this region. The forms presented here are just some diverse ways found in the literature for an environmentally solution.

Studies on the reuse of pulp extraction waste were found, mainly on the rejects area of the juice industry, candy industry, etc. (Amorim, 1999; Gasparetto, 1999; Abreu and Nevis, 2000; Braga *et al.*, 2012).

Gasparetto (1999) studied the use of bagasse from mango jelly manufacture for enriched flours formulation. The product was obtained by dehydration in a spouted bed and was composed by 30% of bagasse, mixed with sugar, pulp and cassava flour, in average. Each 100g of the product presented: 20 mg of ascorbic acid, 60 g of sugars and 4,5 g of fibers. Being considerate and approved as an excellent source of fibers for human alimentation.

Protzek *et al.* (1998) studied the reuse of the dehydrated fruit bagasse, mixed with wheat flour in order to add it on breads, biscuits and other products, mainly where the wheat is rare.

The individual components extraction of the bagasse, like the fiber for example, has been an object of study. Lima *et al.* (2000), by washing and drying the fruit bagasse, obtained concentrated fiber, to supplement products that do not have this component.

Amorim (1999) studied the residue use of some fruit pulps extraction to use it as animal food. He dehydrated the pulps bagasse in stove for about 24 hours on 60-70ºC. In table 1, the characterization obtained is shown. An excellent nutritional value of the material has been observed and, depending on the animal, the mix, in optimized proportions, can be an excellent source of income and ~~of~~ impact minimization.

Table 1. Chemical characterization of the dehydrated rests of the pulp extraction (Amorim, 1999).

Fruit	Soluble Solids (ºBrix)	Lipids (%)	Proteins (%)	Fibers (%)	Humidity (%)
Ananas comosus	72,14	0,54	4,12	15,70	5,90
Malpighea glabra	44,64	2,40	9,15	38,03	8,18
Anarcadium occidentale	50,14	2,56	9,99	25,75	9,41
Annona muricata	47,94	5,72	7,15	29,36	8,70
Mangífera indica	46,64	2,86	3,97	45,62	4,58
Passiflora edulis	19,34	2,28	3,65	63,00	6,94

Concerning the food formulation using industrialization fruit residue, Ribeiro *et al.* (2000) studied the candy in syrup from "Passion Fruit (*Passiflora edulis*)" peels, which was received with great acceptance. According to the authors, its technical viability is proven, suggesting studies on its usage as school meals, especially in poor communities.

Abreu and Neves (2000) studied and qualified the fermentation conditions of mango seeds in order to use them as nourishment similar to the cocoa powder. It's been observed that the mango seed lipid composition is similar to the cocoa almond's, differing in fatty acids proportions. The higher amonts of stearic acid and linoleic acid, which are known to be beneficial to the human health as it doesn't take part in the cholesterol formation in the organism, can be considered one of the advantages of consuming this product.

The principal commercialized and industrialized fruits in the Rio Grande do Norte state, as well as in the whole northeast region, are showed in table 2 together with the crop production data in the state.

Table 2. Fruit production in Rio Grande do Norte (IBGE, 2011).

Fruit	Annual Production (tons* or thousands fruits**)	Fruit	Annual Production (tons* or thousands fruits**)
*Ananas comosus***	147205	*Annona muricata* **	1405
*Malpighea glabra**	12683	*Mangífera indica***	91696
Anarcadium occidentale **	616341	*Passiflora edulis* **	20027

In table 3, the medium values of efficiency in the fruit pulp extraction, obtained in the companies searched are presented.

Table 3. Efficiency of pulp extraction.

Fruit	Efficiency (%)
Ananas comosus	62,5
Malpighea glabra	62,5
Anarcadium occidentale	68,0
Psididium guajava	77,5
Annona muricata	35,0
Mangífera indica	50,0
Passiflora edulis	30,0

These values show that 50% of the fruit, in average, is generated as waste during the production process.

Solid Waste Generation

The most serious problem observed in almost all of the companies, was the large amount of organic material wasted throughout the process. The generation of the residues begins in the standardized fruit selection stage, where a big number of fruits with good quality for consumption are threw away because of the required specification for the process (figure 2), both in the aspect of maturation as in the degradation. This way, they are transported to places where they can be reused as animal food (in most of rural companies) or they can be wasted, being thrown for public cleaning system collection and destined to landfill or embankment (urban companies). In the same way, the residue coming from the peeling stage get similar treatment that the out standard fruits get, contributing with environmental damage.

Figure 2. Residues from the selection and peeling stage.

The last organic residue generated by the pulp extraction is the bagasse coming from the refine and pulp extraction stage (Figure 2). As well as the other residues, this cause environmental impact. However, because it is a more refined product with more concentrated nutritional qualities, these residues are receiving more attention from the producers, who are looking for more economically and viable ways to deal with them.

An example is the composting process for fertilizer fabrication, but there's a big problem of accomplishing this process: the lack of technical knowledge for implanting and monitoring the composting, that leads to problems such as: odor emanation, leachate production, vectors proliferation, and others that affects the quality of the produced organic compose. These problems are related to factors that affect the microbial activity and normally should receive a proper operational control, among which: humidity, oxygenation, temperature, nutrient concentration, pH and particles size (Pereira Neto, 1996).

In visited companies located in rural areas it was observed that some of them perform the composting operation, and are suffering the formerly mentioned

problems, mainly because of the absence of monitoring (Figure 3). In the urban companies where the area available is reduced, the bagasse is not used in recycle process. By the other way, it has been deposited, directly in the public cleaning collect system.

Figure 4. Forms of residue destination of the pulp extraction.

These wastes, in addition to recycling as organic fertilizer, has its noblest use as alternative sources of food. Among the main uses there are: the reuse of dietary fiber (Amorim, 1999; Gasparetto, 1999); use as a fermentation medium for biomass production (Cardoso *et al.*, 2011; Da Silva, 2011; Braga *et al.*, 2012) or even in animal feed. In industries located in rural area, the attempt to reuse is clearer.

As the representative volumes of waste are managed as common urban solid waste, the landfills are overloaded and the leachate production is higher.

Washing Wastewaters

Another environmental problem observed regards to the discard of the wastewaters from fruit washing, containing organic matter, inorganic insoluble residues and chlorine residue in high concentrations. This effluent is headed directly to the sewage net without a previous treatment (Figure 4).

Due to high concentration of organic matter in this effluent, mainly in the form of BOD (Biochemical Oxygen Demand), the installation of an effluent treatment plant in these production cycles is required. However the techniques can be adapted to different biological mechanisms. Like most companies visited have large non-used areas, the stabilization ponds techniques application becomes quite appropriate for that context.

Figure 5. Deposition of residue washing waters.

The scenario identified in the visited industries were similar to that described by Bastos *et al.* (1997) and Bastos *et al.* (1998), who showed no major temporary changes in the segment. This refers to stability and lethargy in the technical and legal care requirements associated with such activities.

Air Emissions

The visited companies that use the pasteurization process present in its structure the presence of steam generators, which consume fuel or natural gas for producing the heating means of the equipment. It was observed that there isn't an adequate management plan (check the packaging and timber selection) and that there is no element of emissions control installed in the companies surveyed. Such behavior is similar to that described by EMBRAPA (1999), Cunha (2005) and Braga *et al.* (2012).

CONCLUSIONS

With this comparative study between two types of fruit pulp extraction companies, it was observed that urban companies generate a higher environmental impact level, mainly because the rural companies attempt to reuse the bagasse. A better commitment from the managers is required in what concerns the implantation of residue reusing systems mainly as human and animal food.

Deeper studies concerning the reuse of wastewater generated during the washing fruit process is required, as the deposition forms found are causing damage to the environment.

Numerous alternatives to the use of agro-industrial residues in this segment were also observed, mainly adding value to products that can be generated with a new processing of waste from this industry segment.

It was observed that the management of air emissions is neglected by the surveyed organizations and that the environmental agencies do not define clear public policies to the minimum requirements for their operation, since all companies surveyed have license health and environmental licenses to operate.

Given the various ways to reuse waste, the absence of political attitude aiming the reuse of this material is no acceptable, knowing that in Brazil and in the northeast, in particular, there is such a high level of malnutrition.

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