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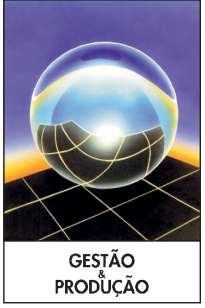

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Evaluation of the application of Cleaner Production techniques in a dairy industry in Southern Bahia

Avaliação da aplicação das técnicas da Produção Mais Limpa em um laticínio no Sul da Bahia

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Abstract: Dairy products are of great importance to the South of Bahia, as they contribute to its development and economic diversification. However, it is necessary to pay attention to the possible environmental impacts caused by the corresponding activities. Thus, the adoption of Cleaner Production (CP) techniques can contribute to improving production processes, as well as providing economic benefits, environmental protection and better working environment. This study aims to identify the techniques adopted and opportunities for CP in a dairy industry in southern Bahia. For this, we carried out a literature review, technical visits and a questionnaire in order to obtain characterization information of the company, CP and environmental management, environmental aspects and impacts related to the production processes. The study revealed that dairy industries are potential polluters, mainly due to their lack of structured environmental programs. Nevertheless, the dairy industry in question was already adopting certain environmental practices and showed interest in learning about others that could contribute to minimizing their impacts and propitiate economic gains. Thus, we successfully identified and presented opportunities for CP.

Keywords: Environmental management; Cleaner Production; Environmental sustainability.

Resumo: *Os laticínios são de grande importância para o Sul da Bahia, pois contribuem para o seu desenvolvimento e diversificação econômica. Porém é necessário atentar para os possíveis impactos ambientais causados pela atividade. Dessa forma, a adoção das técnicas da Produção Mais Limpa (P+L) pode contribuir para a melhoria dos processos produtivos e proporcionar ganhos econômicos, proteção ambiental e melhor ambiente de trabalho. Assim, este estudo teve por objetivo identificar as técnicas adotadas e as oportunidades de P+L em um laticínio no Sul da Bahia. Para isso, foram realizadas uma revisão da literatura, visitas técnicas e aplicações de questionário, a fim de se obter informações de caracterização da empresa, P+L e Gerenciamento Ambiental, aspectos e impactos ambientais relacionados aos processos produtivos. O trabalho revelou que a atividade apresenta potencial poluidor, devido, principalmente, à inexistência de programas ambientais estruturados. Porém, a empresa já vinha adotando algumas práticas ambientais e manifestou interesse em conhecer outras que contribuíssem para a minimização dos impactos e propiciassem ganhos econômicos. Assim, foi possível identificar e apresentar as oportunidades de P+L.*

Palavras-chave: *Gestão ambiental; Produção Mais Limpa; Sustentabilidade ambiental.*

1 Introduction

For a long time, the South of Bahia had its economy rooted in the monoculture of cocoa. However, the emergence and spread of the fungus *Crinipellis perniciosa* (known as "witches'broom") around cocoa crops in 1989 caused a serious economic crisis in the region (Noia, 2011). This condition made it necessary to adopt economic alternatives that would reduce the dependence of cocoa plantations and survive the crisis (Rocha, 2006). Thus, livestock farms became a complementary activity in the region, with cattle

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farms representing the second most important livestock exploration, as well as competing with cocoa in terms of the occupation of the land (Costa, 2012).

The South of Bahia has great prominence in milk production in the state. According to the last agricultural census conducted in 2006 (IBGE, 2006), the region has two of the main dairy industry regions in Bahia: the Far South and the South Coast (Maderi, 2014). This condition favors the emergence and the growth of dairy industry in the region, while contributing to regional development and economic diversification.

In addition to the economic aspect, it is also worth noting the environmental aspects in which dairy products are involved, as there may be several negative environmental impacts associated with their life cycle. Moreover, given the constant changes that occur in the market and in society, it was increasingly necessary to adopt a posture that considers environmental sustainability as a reference to business sectors. Therewith, choosing this sector for purposes of study is justified, when considering the economic changes in southern Bahia, the economic importance of the sector and the need to consider environmental aspects related to the activities of dairy produce.

Based on the idea that dairy products can cause negative impacts on the environment, it is appropriate to use techniques to avoid and minimize these impacts, propitiate production efficiency, economic gains and a better working environment. Thus, the application of preventive techniques such as Cleaner Production (CP) may be appropriate to achieve these objectives.

There are many studies in technical and scientific literature on the application of CP in dairies (Ozbay & Demirer, 2007; Dvarioniene et al., 2012; Kubota & Rosa, 2013; Willers et al., 2014). However, there is a bibliographic gap in the area of production engineering with regards to the application of these techniques on developments in southern Bahia. More specifically, there is a lack of studies with reference to CP in dairy products in the region. Based on this assumption, this study aims to identify the technical and the application opportunities for Cleaner Production in a dairy industry in southern Bahia. For this purpose, we seek to characterize the industry, check their knowledge regarding environmental practices, quantify and qualify the environmental aspects and impacts, as well as propose improvements.

We hope that this study will contribute to the dissemination of knowledge of this subject in the area of production engineering in the dairy sector and other regional companies. Thus, the adopted research method consists of a case study with literature review on the subject and technical visit with a questionnaire. It is believed that literature review, field research and data collection through questionnaire will allow a better understanding of the theme and details of the company's characteristics, thus making it possible to make suggestions for improvements in the proposal P+L.

The work is divided into five sections, including this introduction. The second section includes a literature review on the subject under study. The third section discusses the adopted research method. The fourth section considers the case study on the regional industry. And in the fifth section, we present our final remarks.

2 Literature review

2.1 Sustainable Development and environmental consciousness

Based on studies carried out by the United Nations (UN) in 1987, by means of the World Commission on Environment and Development (WCED), the report *Our Common Future* was released, also known as the Brundtland report. In this report, the concept of Sustainable Development as the ability of present generations to meet their needs without compromising the ability of future generations to meet their own needs was publicly presented (CMMAD, 1991). This concept involves three main objectives: economic growth, environmental protection, and enhancement and welfare of the human being (Elkington, 1998; Robins, 2006); and that to achieve them it is necessary to consider the needs and the influence of all the actors involved: employees, customers, suppliers, government, local communities and the general public (Robins, 2006).

Allied to this, when analyzing the history of environmental management, one can realize that over the 50/60 decades of the last century, many companies disposed of their waste, effluents and emissions into nature, without worrying about or taking responsibility for the environmental impact of those actions. With the passing of time, especially in the decades of 70/80, discussions intensified on the need to protect natural resources and around the accountability of companies for the waste they generate (CNTL, 2003). Treatment actions, the development/improvement of environmental laws and the development of guidelines and regulations for the management of waste are characteristic of this period (Khalili et al., 2015). Thus, we seek pollution control and the enforcement of legislation through corrective actions after the generation of waste, focusing on the use of remediation technologies and control at the end of the process - End-of-Pipe (Barbiere, 2007).

From the 1990s, the approach to pollution prevention gains relevance, which has caused a paradigm shift around environmental issues (CNTL, 2003). Based on the standard of the Environmental Management System – NBR ISO 14001 (ABNT, 2004) and the work of Barbiere (2007) and Saraiva (2008), pollution

prevention can be defined as the use of practices, processes, techniques, materials or products to help prevent and reduce the generation of pollution. Thus, this approach seeks to be proactive and question the causes of waste generation, effluent and emissions, so as not to generate and/or minimize them, therewith achieving environmental protection, improvements in the work environment and productive processes, as well as economic gains (CNTL, 2003).

Another important point is that the evolution of environmental issues also results from expansion of these discussions in the various areas of knowledge, no longer restricted to environmental and related fields, through the economic and social sectors. Examples of this are the works of Anacleto et al. (2012), Carvalho et al. (2012) and Milnitz & Tubino (2013) in making surveys and publications on the subject of analysis.

2.2 Reflections on Cleaner Production

The growth in environmental awareness, the increasing demand for environmentally friendly products and the increasing pressure imposed by corporations with regard to the use of natural resources are examples of factors that have contributed to the increased use of tools and techniques for pollution prevention or reduction of waste generation, waste and emissions in industrial operations (Massote & Santi, 2013). These factors, together with the creation of laws and monitoring of air quality programs, water pollution, energy saving and waste generation significantly contributed to the emergence and spread of the concept of CP, as proposed by the United Nations Environment Programme – UNEP in 1989 (Molinari et al., 2013).

CP is defined as "[...] the continuous application of a preventive and integrated environmental strategy applied to processes, products and services in order to increase efficiency and reduce risks to humans and the environment " (UNEP, 2014). One seeks to adopt practices designed to eliminate the problems in the source, by means of avoiding the generation and of the minimization or recycling of effluents, waste and emissions of all involved processes. Therefore, it establishes the commitment to prevent environmental risks of processes and products, obtaining environmental benefits, economic and occupational health (CNTL, 2003; CETESB, 2008; Medeiros et al., 2007).

CP involves changing of the existing technology, changes in processes and products, work organization system and internal recycling, and is due primarily to reduce in the source, reuse and recycle, respectively. When the waste generated cannot be reintegrated to the company's production process through internal recycling, external recycling is adopted. If these techniques are not sufficient, waste treatment practices, effluents and emissions are adopted as alternative (CNTL, 2003; Barbiere, 2007).

Pimenta & Gouvinhas (2012) state that the adoption of the CP will allow companies to hone the efficiency of their production processes and services, and serve as a search tool for sustainability. Moreover, in small businesses CP does not require sophisticated technologies and radical innovations or major investments, which could result in economic and environmental benefits (Domingues & Paulino, 2009). Thus, based on the work of UNIDO (2002), CNTL (2003), Medeiros et al. (2007) and Pimenta & Gouvinhas (2012), it is possible to describe a number of benefits of applying the CP techniques:

- Reducing operating costs and waste management;
- Optimizing the use of resources, reduction of wastage, disposal/reduction of waste, effluents and emissions;
- Gaining environmental awareness across the entire organization;
- Reducing the risks to employees and improving health and worker safety;
- Improved operating efficiency of the plant, energy efficiency, increased productivity and competitiveness;
- Recovery of certain wasted materials, minimization or elimination of raw materials and other inputs impacting the environment;
- Improving company image and increasing customer satisfaction;
- Improving compliance with environmental standards, reducing fines and penalties for pollution and improving the relationship with environmental agencies and the community.

Despite the advantages, there are certain barriers to their deployment in organizations that need to be overcome. These barriers are of nature: conceptual (limited or incorrect interpretation of CP), organizational (inadequate organizational structure and incomplete information systems), technical (lack of a solid operational base), economical (unawareness of the company's actual environmental costs), financial (incorrect perception that investment in CP represent a high financial risk due to the innovative nature of these projects) and political (insufficient focus on CP in environmental strategies, technological, commercial and industrial development) (Giannetti et al., 2008; Hoof & Lyon, 2013; Aikenhead et al., 2015).

2.3 The dairy industry

2.3.1 General characteristics of the industry

According to IBGE (2015), in 2014 a production of 35.17 billion liters of milk was registered in Brazil, which occupied the sixth position in the global ranking, after the European Union, India, the United States, China and Russia (USDA, 2015). In addition, it is estimated that between the periods of 2012 and 2023, milk production is expected to grow at an annual rate of 1.9%, corresponding to a production of 41.3 billion of raw milk by the end of the period of these projections, which is 17.5% higher than the production of 2014 (Brasil, 2013, 2014). It is estimated that the milk complex is responsible for employing more than 4 million workers, considering the ratio of 4 people involved in the production chain activities for each farmer, estimated by the 2006 agricultural census in 1.3 million (Affonso et al., 2015).

In the year 2012, Brazil recorded the generation of R$ 26.796 billion in value from the production of 32.304 billion liters of milk, and the inspected milk volume acquired by dairy industries was approximately 22.3 billion liters (IBGE, 2013). IBGE (2013) also shows that from the total milk produced in Brazil - with and without inspection - Bahia produced 1.079 billion liters, which led the state to stand out as the largest producer in the Northeast region (which produced 3.501 billion liters). In 2013, the volume of produced and inspected milk grew in all regions of the country, totaling 23.545 billion liters and indicating an increase of 5.4% over the volume recorded in 2012 (IBGE, 2014a).

Brazil has always been a traditional importer of dairy products, experiencing some periods of trade surplus but since 2008, due to increased domestic consumption, foreign economic crisis which took place this year and the appreciation of the Real, the trade balance for dairy produce has been negative (Brasil, 2014). Data from the Ministry of Development, Industry and Foreign Trade, shows that in 2014 there was a deficit of 101.6 million dollars in the trade balance of dairy products (MilkPoint, 2015).

The milk production chain has great socioeconomic relevance in the Northeast region of Brazil. However, the region presents difficulties such as low technological development, lack of professional management in the properties, limited processing capacity of dairy products, low level of innovation and little dynamism. On the other hand, it is one of the regions that spend the most on milk and dairy products, representing the highest percentage (1.62%) of the population's income (SEBRAE, 2013).

It may be noted that the estimates for the Brazilian population are expected to reach 216 million inhabitants by 2023 (IBGE, 2014b). In light of this, an overhaul of the dairy sector will be necessary. So that the industry can face major challenges such as increased productivity, assurance of sustainability, as well as quality and safety of the products; to take advantage of growth opportunities, offered by the increase in population, income and the possible increase in the consumption of dairy products (Brasil, 2014).

According to the Agricultural Protection Agency of the State of Bahia (ADAB, 2014) there are 88 dairies and 58 milk processing plants registered by the State Inspection Service (SIE). Of these institutions, 20 (10 dairy and 10 plants) belong to the coordinating body region of the city of Itabuna, and 9 (6 dairy and 3 plants) to the coordinating body region of Teixeira de Freitas, both located in the southern state of Bahia (ADAB, 2014). There may be a relationship between the number of establishments and the volume of milk produced, since the region stands out in milk production in Bahia (IBGE, 2006).

2.3.2 Environmental aspects and impacts

According to norm NBR ISO 14001 from ABNT (2004, p. 2), the environmental aspect can be defined as "[...] elements of the activities or products or services of an organization that can interact with the environment." The standard also states that the result of this interaction that causes any modification of the environment, whether adverse or beneficial, should be called an environmental impact. In a complementary way, CETESB (2008) states that environmental aspects are formed by those generating interactions such as energy, water, consumption of raw materials, air emissions, waste and odor; and have a direct relationship with the inputs and outputs of the stages of production processes.

The high water consumption, the generation of effluents with high concentration of organic matter, high energy consumption, residue generation, air emissions, noise and vibration from machines cause negative impacts on the environment (UNEP, 2000; Machado et al., 2001; Dvarioniene et al., 2012).

Effluent discharges are the main causes of environmental impacts in the dairy industry. These effluents are basically made up of varying amounts of diluted milk, floating solids, fine cheese, fat, cleaning and sewage. Effluents have high organic load and also include detergents and disinfectants, lubricants, sugars, fruit pieces, sand, essences and milk products, especially the whey with its high pollution potential (Machado et al., 2001; Ozbay & Demirer, 2007; Saraiva, 2008; Kubota & Rosa, 2013).

The whey is a by-product from the manufacture of cheese, wherein 80 to 90% of milk that enter the process are converted into the whey. Therefore, due to its high nutrient value and organic load, it should not be mixed with the other industrial effluents, which

may pose a major problem when discarded into the environment without prior treatment (CETESB, 2008). Saraiva (2008) points out that buttermilk resulting from the production of butter and whose composition is similar to that of skimmed milk, may also contribute to increased organic load in wastewater.

In regards to water, its seen as the most important natural resource for the dairy industry and its use is linked to the guarantee of proper health and hygiene conditions (Willers et al., 2014). CETESB (2008) provides the information that the amount of water consumed in the process can exceed the amount of processed milk (average value between 1 and 6 liters of water per kg of milk). But the power consumption is associated with the quality assurance of products, mainly submitted to heat treatments, cooling and storage. About 80% of the consumption of thermal energy is obtained by means of burning wood or fossil fuels, thus contributing to atmospheric emissions.

As for the solid waste generated, Boaro (2008) states that these come from the processing plants (through the loss of raw materials, loss of finished products, packaging leftovers, defective packaging, returned goods and ash from boilers), from administrative areas and from personal care (involving paper, plastics, packaging, paper towels and toilet paper in both areas). Moreover, we can mention the sludge arising from wastewater treatment plants, which may have negative impacts on the environment and on human beings, whenever disposed in improper way.

Atmospheric emissions, on the other hand, are the result of smoke generated in the burning of wood, fuel oil or natural gas for heating boilers, burning of diesel in the trucks carrying the raw materials and the manufactured products (Boaro, 2008). Additionally, refrigerant gases arising from any leaks in the cooling pipes, hot exhaust milk evaporators, odors and vapors from the cooling towers (CETESB, 2008).

2.4 Cleaner Production and dairies

Environmental concerns with the dairy industry have expanded the focus generally more centered around water quality, to also cover issues related to greenhouse gases emissions and air quality (Place & Mitloehner, 2010).

Starting from the idea of the existence of environmental impacts linked to the activities of dairies, one should primarily avoid the generation of pollutants. The first level of activity of CP involves the adoption of measures that will modify products and processes (CNTL, 2003). Changes in the product aim to improve durability and product quality standards, as well as the use of substitute inputs that have, maintain or improve the final characteristics of the product. If already existing in the process, one can then adopt the so-called good practices (housekeeping) to establish administrative and technical procedures and enable the minimization of waste generation (Medeiros et al., 2007). The second and third levels involve internal and external recycling, respectively (CNTL, 2003).

In their "Technical Environmental Guide for the Dairy Products Industry", CETESB (2008) present twenty-seven (27) opportunities to obtain CP in dairy products. These opportunities may be observed in Chart 1 and cover water consumption, energy consumption, waste, residues and emissions; involving source reduction, recycling/reuse and recovery.

In his work, Boaro (2008) suggests the use of tools such as Life Cycle Assessment (LCA) - a management tool that evaluates the full cycle of a product, process or activity, from extraction to final disposal - and Ecodesign - process to create, design a product/process with less damage to the environment. Moreover, the development of Standard Operational Hygiene Procedures (SOHP) and Good Manufacturing Practices (GMP), which is a set of measures aimed at ensuring the health quality of the final product and promoting consumer safety (Maderi, 2014). For Saraiva (2008), with the deployment of SOHP, GMP and personnel training it is possible to reduce the consumption of water, wastewater and consumer cleaning products.

In the works of Willers et al. (2014) we can identify CP initiatives that seek to minimize the consumption of water and the generation of waste effluents from production processes. These initiatives involve the levels of CP such as source reduction, internal recycling and biogenic cycles. On the one hand, Kubota & Rosa (2013) suggest the development of a technical system for the reuse of water, internal recycling of the whey, closed cooling systems, reuse and reduction of the water used. On the other hand, Ozbay & Demirer (2007) present CP opportunities in milk processing and cleaning operations, considering that the water used and the loss of milk are the main aspects that can be improved without much technical difficulty and high cost.

3 Research method

The adopted research method consisted of bibliographic research and case study, with technical visits and application of a questionnaire (Marconi & Lakatos, 2003). We conducted a literature review in order to help understand the concepts discussed, to see what has been discussed and to support the definition of the research problem. For this, indexed journals were searched in databases such as Science Direct, Scielo and Journals Portal Capes, books, graduation papers, theses and dissertations.

In order to make a more detailed study, we have chosen the production area of a dairy industry in the municipality of Itabuna, southern Bahia as

Chart 1. Cleaner Production opportunities in dairy processing.

		Environmental Aspect				
		Water	Energy	Effluents	Waste	Emissions
	Opportunity					
1	Receiving control of raw materials and auxiliary products	*		*	*	
2	Control of stored materials			*	*	
3	Reduction in loss of milk			*	*	
4	Sludge separation in the clarification			*	*	
5	Use of continuous system for milk pasteurization		*			
6	Heat energy recovery		*			
7	Using buttermilk			*		
8	Whey utilization			*		
9	Dry elimination of salt from cheese after salting			*	*	
10	Control and recovery from brine	*			*	
11	Dry cleaning of surfaces	*		*	*	
12	Use of pressurized water for surface cleaning	*		*		
13	Use of foam system for surface cleaning	*		*	*	
14	Use of CIP (clean in place)	*		*		
15	Use of single-use detergents	*		*		
16	Recovery of cleaning products	*		*		
17	Periodic control of the boiler emissions					*
18	Condensate recovery	*				
19	Safe storage and handling of dangerous and hazardous goods			*	*	
20	Minimizing packaging waste				*	
21	Solid waste segregation and resource recovery				*	
22	Wastewater neutralization	*		*		
23	Cogeneration		*			
24	Best practices for reducing water consumption	*		*		
25	Best practices for reducing energy consumption		*			
26	Best practices for the reduction of air gaseous					*
27	Best practices for waste management				*	

Source: CETESB (2008).

research object. The choice of the city is due to its economic importance in the region and the number of establishments registered with the State Inspection Service SIE (twenty in total) under its coordination office (ADAB, 2014). Notwithstanding, the choice of dairy is related to the fact that it is classified as medium-sized (Bahia, 2009) and located in the municipality of the coordinating body.

We have performed a technical visit to raise awareness around the theme of the project, during which we presented the CP and study proposals to the production manager. Subsequently, there were three more visits in the production period in order to allow greater contact with the manager, observing the productive environment and in order to apply the questionnaire. We have produced a semi-structured questionnaire composed of 52 mixed character issues (open and closed), and the interviewee could add comments, as needed. The questionnaire was organized in order to obtain quantitative and qualitative data on the characterization of the company; CP and Environmental Management and environmental aspects and impacts. With these data, it was our goal to map out the company profile, identifying practices, environmental aspects and impacts of its activities, as well as proposing improvements based on CP proposals .

As for the characterization of the company, we have sought information such as: number of existing employees, processing capacity and average volume of milk received per day, produced and/or processed by the company, the system and the planning of production and issues regarding licensing, registration and inspection. In terms of environmental issues, it was intended to identify the existence of any environmental management programs, the company's intention to adopt environmental character techniques, the company's level of knowledge about the techniques

and application of CP and knowledge of possible impacts of its activities and processes. To identify the environmental impacts, we have developed questions about general aspects as key inputs, machinery and equipment, quality control, maintenance, stock and storage, hygiene/cleaning and environmental conditions (noise, vibration, temperature, layout, hygiene and safety) addition of water and energy resources, generation of effluents, waste and emissions.

In relation to water and energy resources, we have sought information on average fuel consumption, the main source of supply, the knowledge of the products and/or processes that consume more water and energy, the existence of a program to reduce and control consumption, the main difficulties when trying to reduce water and energy consumption; and the existence of some concern around the reuse of water. In relation to effluents, waste and emissions, we intended to identify the destination of whey and buttermilk, the existence of any effluent/residues/emission treatment or what has been done in case there was none, the company's knowledge on the consequences of improperly disposing of their effluents, waste and emissions, the use of fuels or gas emission sources in the atmosphere, in which processes there is greater generation of effluents, waste and emissions, and the existence of reduction programs or alternative adopted to prevent and/or reduce effluents, waste and emissions.

The data collected through the questionnaire were interpreted using descriptive analysis and use of figures and Chart, based on the literature, on the Technical Environmental Guide for the Dairy Products Industry (CETESB, 2008) and in the handout of the Cleaner Production Program Implementation (CNTL, 2003), in order to identify the technical and CP opportunities in dairy and consequent suggestions for improvements.

4 Results and discussion

4.1 Characterization of the studied company

The dairy industry is located in the urban area, has 43 employees and has a processing capacity of 24,000 liters of milk/day. However, currently in the off season (from May to September), the daily reception of milk ranges from 9,000 to 10,000 liters and in harvest periods it can reach 18,000 liters/day. Based on Resolution No. 3925 of 2009 of the State Council for the Environment – CEPRAM, defining the local environmental impact activities, the dairy industry can be classified as medium-sized because its processing capacity is between 10,000 and 50,000 liters of milk received/day (Bahia, 2009). However, during periods of dry season it operates similarly to small dairy industries.

The company processes various kinds of products, among which: bagged pasteurized milk - "soft belly" - (7,000 liters/day); yogurt: natural (skim) and passion fruit pulp, soursop, strawberry, coconut, fruits, plums and peaches - (between 3,000 and 4,000 liters/day in total); butter (50 kg/day); and cheese - frescal, mozzarella, provolone and silver - (117 kg/day). In addition to these products, once per month the company produces cream cheese (21 kg); and milk caramel sauce (70 liters). In regards to these last two products, the company said there was no physical conditions to produce them in large quantities.

The dairy production system is based primarily on pre-sale, in which orders are made at the time of delivery of the previous supply and serves as input to the production schedule, made up to two days in advance. However, for certain products that have a daily demand such as strawberry and plum yogurt, the company also prepares a demand forecast and adopts the minimum stock strategy. Due to the uncertainty of the volume of milk being received every day, there is a variation between the predicted amount of milk for processing and the real volume, sometimes forcing production to be adjusted and reprogrammed. In relation to the case file, the activities are initiated in the morning, running from Monday to Saturday and for 8 hours a day. That said, there is no specific day to produce each product, as this will depend on the applications and the expected demand.

The dairy industry has an environmental license, registration with the State Inspection Service (SIE) and is seeking registration with the Federal Inspection Service (SIF), to expand its activities to other states. They usually receive monthly visits from a health inspector of the regional headquarters in Itabuna (ADAB), who provides guidance to the dairy, performs the collection of product samples and checks production data and controls. The environmental agency of the city also collects samples for analyzes of waste and effluents and the Federal Police inspects possible tampering using ammonia and caustic soda. The company said it had received no fine or warning from regulatory, health or environmental agencies until the date of this study.

4.2 Cleaner Production and Environmental Management

During the technical visit for the presentation of CP and of the study objectives, the company's production manager said he did not know the existing CP techniques but was receptive and interested both in knowledge and in a possible application. Thus, in subsequent visits we have noticed his interest and provision to contribute to the research and consequent gains offered by the implementation of CP.

Later, on the second visit we have also observed an unawareness of other tools such as the Life Cycle Assessment. In regards to environmental management, the company knows the importance and existence of the Environmental Management System (EMS) but does not know its full contents. However, the business has already received advice from SEBRAE on solid waste control and asked SENAI for an environmental management course, which was not done. Moreover, we have punctuated the adoption of certain environmental practices, which will be presented in section 4.3.5, and the intention not only to learn about the content but also the implementation of an EMS system according to ISO 14001.

There is not an environmental program structured in the company and in many cases it is unaware or has no clear application of an environmental tool. However, there is interest in knowing and applying practices and tools aimed at improving production processes and environmental protection. Still, the company believes it is possible to reduce the environmental impact with minimal investment with the implementation of environmental management tools, as well as obtaining advantages such as lower costs and better working environment.

The company knows the risks related to food quality, environmental impact and safety. Therefore, it owns a laboratory for quality control, a technical intern for job security who supports the company in the coordination of the issues of implementation of the guidelines of the standard NR12 (safety at work around machinery and equipment) and interest in adopting environmental practices.

4.3 Environmental aspects and impacts of the studied company

4.3.1 General production features

With the information provided by the dairy industry and from the CNTL (2003) and CETESB (2008) guidelines, we have elaborated a flowchart for the production processes (Figure 1) and have carried out qualitative and quantitative analysis on the general aspects of production.

The first stage of the production process is the receipt of fresh milk, which can arrive either in isothermal tankers – bulk collection with capacity for 9,400 liters (every four days on average) and 50 liter buckets (daily). Upon receipt, the quality control of raw materials is carried out, subjecting them to

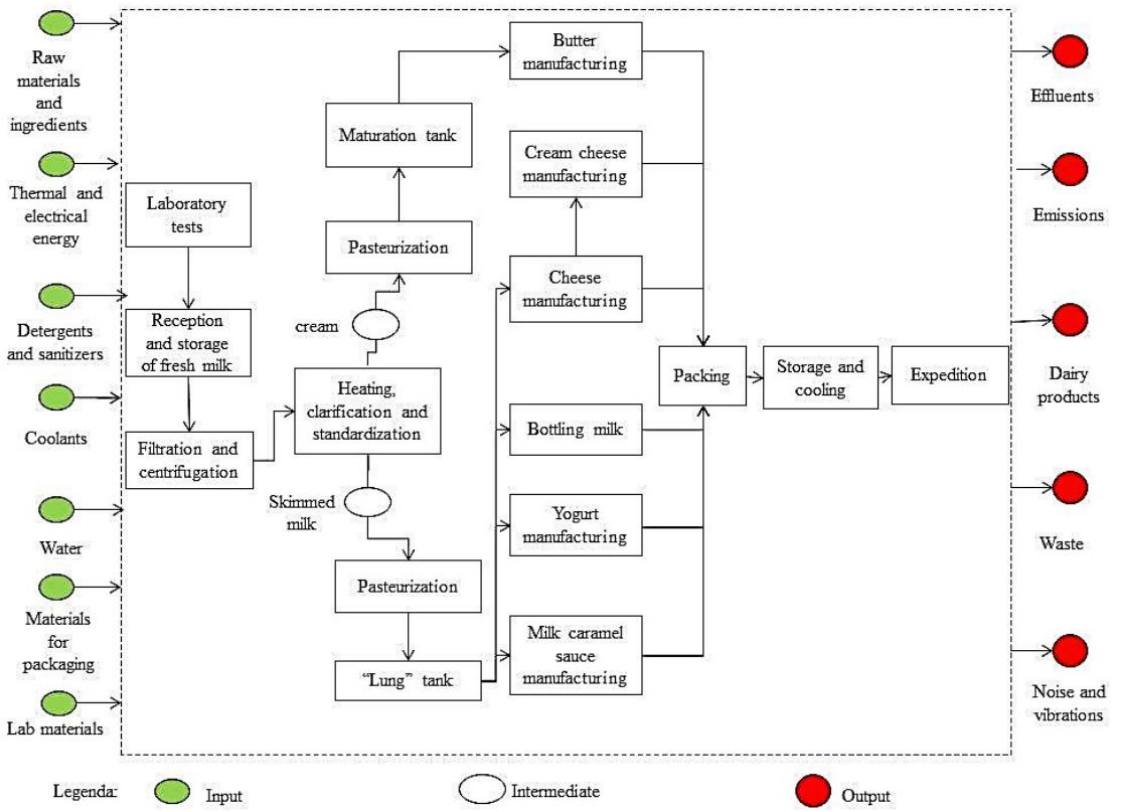

Figure 1. Flowchart of the manufacturing processes of the dairy researched. Source: Authors, adapted from the CETESB (2008).

laboratory tests (density, acidity, freezing point, fat, lactose and protein) for approval or disapproval.

All the fresh milk received in buckets is sieved, filtered in line filters and stored in cooling tanks which keeps milk at 4°C, allowing it to stay for as long as the next day, if necessary. The milk that arrives in tankers is connected directly to the line filter without passing through the sieve.

After filtering and cooling, the milk goes on to a centrifuge and passes through another line filter, following through to the production area. In the production area, the milk coming out of the centrifuge passes through the pasteurizer (with capacity to process up to 6,000 liters of milk/hour), which heats it up to 60°C and then follows on to the clarification/standardization (processes up to 5,000 liters of milk/hour) in which the company gest cream and skimmed milk. The cream will be pasteurized and matured in the maturation tank at a later stage, for the manufacture of butter. The milk coming out of the clarification/standardization will be pasteurized and packaged in a "buffer/lung tank" (with 6,000 liters) and distributed across the production lines of bagged milk, yogurt, cheese (mozzarella cheese is used to make cream cheese) and milk caramel sauce. Once the manufacturing stages are through, the products are packaged, stored, cooled and shipped.

Chart 2 shows the products and their respective raw materials and ingredients, packaging and main machines and equipment necessary for their production after maturation (butter) and storage in the buffer tank (other products).

During the stage of laboratory tests, we have identified the use of raw material, sulfuric acid chlorides, silver nitrate and alkaline and acid solutions samples, in addition to laboratory equipment/materials (density meter, test tubes, and ultrasound apparatus, among others). Notwithstanding, we have identified boilers, cooling towers, cooling systems in the finished products storage area and sanitary barrier as ancillary units to the production processes (local hand hygiene and shoes) as well as the entrance to the local production area.

Storage of the raw material (milk) whenever performed is made in cooling tanks. The ingredients are stored in a room at room temperature, on properly identified wooden pallets, except the yeast that is placed in the refrigerator. Both filling as transportation packaging are stored in a sanitized shed, and are arranged according to their frequency of use. As for the finished products, these are stored in a cold room and the company adopts FIFO (first in-first out) - the first products manufactured are the first to be shipped.

During the hygiene and cleaning processes, chlorinated water is used to wash the floor, machinery, pasteurizer, cheese vat and milk tanks. The company adopts the CIP (Clean in Place) procedure, internal cleaning of a piece of equipment without relocation or disassembly, and use alkalizing (caustic soda) and acid detergent, and as sanitizer they use paraseptic acid. For the cleaning of surfaces such as vats, cheese Chart, yogurt table, yogurt maker, mixer and table butter the company uses a slightly alkaline detergent, sanitizer and hand wash. The buckets, on the other

Chart 2. Raw materials and ingredients, packaging and machines and equipment used in the dairy processing plant.

Product	Raw materials and ingredients	Packing	Machinery and equipment
Bagged milk	Milk	Plastic film and plastic returnable box for transportation	Milk filling
Yogurt	Milk, sugar, yeast, pulp, flavorings and colorings.	Plastic jars, plastic labels and corrugated boxes for transportation.	Yogurt Maker and filling
Cheese	Milk, yeast, salt, calcium chloride and rennet.	Heat shrinkable plastic film and corrugated cardboard box for transportation.	Two double walled tanks, vacuum forming, vacuum package (only the provolone) and polishing machine packaging.
Butter	Milk cream, salt and other additives.	Plastic jars, plastic labels, stamps of aluminum and corrugated boxes for transportation.	Butter churn
Cream cheese	Mass of mozzarella, cream and water.	Plastic jars, plastic labels, stamps of aluminum and corrugated boxes for transportation.	Tub with swizzle stick and double wall.
Milk caramel sauce	Milk, sugar and glucose.	Plastic jars, plastic labels, stamps of aluminum and corrugated boxes for transportation	Tub with swizzle stick and double wall.

Source: Authors.

hand are sanitized and cleaned with a slightly alkaline detergent and vaporized water. The floor are washed with a hose, which in the morning is used to remove the larger residues and at the end of production, a neutral detergent is used. The company adopts the manual for Good Manufacturing Practices and Standard Procedures of Operational Hygiene.

In terms of the conservation status and maintenance of machines and equipment, the company performs preventive maintenance based on the schedule provided by the machine suppliers and which depends on each type of equipment, as well as corrective maintenance which aims at acting quickly on potential leakage problems during the operation. In both cases, there are two employees responsible for the performance of these activities.

In regards to the production environment, the company provides training and promotes the awareness of the staff about the use of Personal Protective Equipment (PPE). However, according to the production manager, there is no specific action in the company procedures that seeks to monitor, minimize or avoid noise generation and vibrations. This could be seen at the time of the visit, when we identified that the production environment was very noisy, often causing fatigue and discomfort when the protective equipment was removed. The main cause of noise generation was assigned to a pasteurizer which is located within the production area.

The lack of ventilation was another aspect observed in the manufacturing environment because the installed exhaust fans were not enough to control the heat. Furthermore, because of the relative isolation of the location, due to hygiene and food safety reasons, machine noise was amplified and the internal temperature was elevated. Measures, such as the use of water from the yogurt maker, formerly used in the production environment and thus contributing to its increase in temperature, resulted in a decrease in ambient temperature but this was not enough.

The flow of people, materials and products was slightly confusing because there were many plastic boxes for bagged milk packaging kept in the production environment, which often prevented the visibility of all processes and in some cases, hindered the transit operators. On the other hand, in terms of the general physical aspect of the processing site, the state of conservation of walls and floors and the use of safety equipment were essential elements and should be considered satisfactory.

4.3.2 Water resources

The main source of dairy water supply is the municipal service but the company also uses secondary sources such as artesian wells and rainwater. Rainwater falling from the roof is collected through gutters and pipes and stored in two fiber tanks with 10,000 liters capacity each, used in the boiler and in the cooling tower. In turn, water from the municipal service is used in manufacturing products and internal washing of the machines; water from the well is used to wash the floors. With regards to consumption, the company does not count and neither knows how to estimate the average daily or monthly volume of water used (treated water + well water + rainwater) but it is known that between June and September 2014 the average water consumption of municipal services was 259.7 m^3/month.

When it comes to water consumption, the company pointed out the cleaning process as its largest consumer, considering that the CIP cleaning consumed on average 400 liters of water/day to clean the pasteurizer, filling machine and storage tanks. Moreover, the company could not tell the water consumption for the cleaning of other machinery, tools and floors, nor the average amount consumed by product and/or process. In addition, the dairy industry has no control over or program on water consumption, despite the adoption of certain practices such as use of rainwater and reuse of water in the yogurt maker to wash the floors. Still, according to the production manager, the adoption of certain practices is related to the level of interest in innovation of products and processes, resulting in the reduction of certain costs.

4.3.3 Energy resources

The main source of electric power supply to the dairy is the external electricity supply from private power service companies, and the average consumption of the last twelve months was 400 KWh. Moreover, the main source of thermal power generation is the boiler which in turn is powered by wood from the reforestation of eucalyptus. The average amount of wood used is 64 m^3 and lasts on average 30 to 40 days.

The machines that consume electricity the most are the pasteurizer and the yogurt maker but the company does not account for how much is consumed. In addition, the company has not felt the need to apply awareness actions about consumption rationing in the company, so that the dairy turns off its machines from 6 to 9 pm only to meet the arrangements with a contractual party from the electric power supply company.

4.3.4 Effluents, residues and emissions

The main effluents identified in dairy industry included "discarded" milk, water used for hygiene/cleaning, laboratory products, cheese whey, buttermilk and sewage. When fresh milk is not approved during the reception and laboratory analysis stages, it is returned to the producer but if the milk that has been processed

and bagged suffers any damages on its packaging or in the milk itself, it will be discarded. Laboratory effluents as chlorides, silver nitrate, alkaline and acid solutions are poured into the laboratory sink, which in turn goes into the treatment and sewage system. In contrast, discarded sulfuric acid is packaged in gallons and then goes into the tank for neutralization.

There is a wastewater treatment system which removes excess of organic products, mostly fat and then discards them into the sewage system. All effluents go to the treatment plant, except for sewage coming from the bathroom which goes straight to the municipal sewer system and for the whey that is donated to animal feed. The whey is pumped from the production area to the outer area of the company where they it is stored in tanks of 5,000 and 10,000 liters to be donated and/or collected. In periods where there is a large amount of whey and there is no way to donate it, the company sends it to a treatment plant in Ilhéus (neighboring municipality).

The company has considered using the whey for dairy drinks, for which there is a study and project design. However, it was not put into practice yet due to the belief that it would be necessary to create a new production line and a new brand to differentiate the dairy drinks from the yogurts. In addition, the company said it was conducting a feasibility study because the serum volume is variable and in harvest periods there is an excess of whey, while during off-season periods, its amount is reduced.

In terms of percentage the company discards an amount of whey ranging from 60 to 90% of the milk used. For the production of unripe cheese for example, in September 2014 the company required 19,000 liters of milk and at the time of preparation alone has generated approximately 10,200 liters of whey. In turn, mozzarella cheese produced 10,692 liters of serum, representing over 90% of the milk used. Only to produce all the different types of cheese, in September the company used 30,868 liters of milk, which produced approximately 20,892 liters of whey (when considering only unripe cheese and mozzarella). In harvest periods the volume of milk used to make cheese can reach 20,000 liters of milk per week.

For solid waste, at the beginning of 2014 there was a planning for control of solid waste and effluents but the company does not carry out specific internal actions such as segregation of waste, monitoring or reduction attempts. Much of the waste goes to municipal collection. On the other hand, boiler ash is used for fertilizers in the company and many materials as packaging waste is collected by a recycling company. Even so, the company is considering to send certain types of waste to institutions involved with arts and crafts. Reverse logistics is applied for ingredients and packaging whenever there is a problem. As an example, if there are any damaged bags of sugar, those are returned to the supplier. In the case of yogurt, if there are any problems with the packaging, whenever possible the product is reused and the bottles are returned to the supplier.

The company failed to explain what could happen to the improper disposal of waste and effluents but claimed that they can be considered a loss because they involve costs. In addition, in relation to the resulting sludge from the wastewater treatment system, this is removed periodically and the company is interested in using it to power the boiler to reduce the consumption of firewood. In this sense, one can check the feasibility analysis of the sludge used as fuel in the works by Felder & Azzolini (2013).

With regards to air emissions, the company is aware of the main gas emissions caused by its activities which come from wood-burning gases in the boiler, emissions of the truck fleet (three vehicles) and sewage treatment gas but there are no specific actions to remediate them. An important note is to check that the wood to be used in the boiler was in the outside area of the dairy, without any protection. This may cause the wood to absorb moisture, emit soot in which case a greater quantity of fuel for steam production will be required. On the other hand, the company affirmed its desire to replace wood with natural gas. In addition, the boiler is always powered whenever production is taking place to maintain the temperature without increase to the consumption of wood to reheat it. However, the vicinities have placed regular complaints due to the smoke generated by the company, even after the company increased the height of its chimney.

4.3.5 Cleaner Production techniques and opportunities

Based on CETESB (2008), it was possible to identify actions that had already been implemented at the dairy before the survey was conducted and that are related to CP. In addition, we have sought to classify these actions according to the level of CP and verify the environmental benefits and economic aspects involved. This can be seen in Chart 3.

In addition to the implemented actions, we have identified some application opportunities of CP that could contribute to the reduction of environmental impacts, reducing costs in the long-term and improving the working environment. Within these opportunities we have included those submitted by CETESB (2008) - Chart 1 and can be seen in Chart 4.

CP allows not only for economic and environmental benefits but also benefits in the work environment. This is because its application enables a better relationship and quality in the work environment, training of employees and better relationships with suppliers, customers and society as a whole.

Chart 3. Cleaner Production techniques in the studied dairy industry.

Actions implemented	Level	Environmental Benefits	Economic Aspects
Control of incoming raw material, establishing acceptance criteria, operating procedure, training and qualification of personnel.	Source reduction	- Reduces waste and the consumption of water and energy.	- Reduced costs of raw materials, waste disposal/treatment and/or rejected products, - Investments in human resources, the costs of equipment for testing.
Control of materials stored with adoption of the FIFO system	Source reduction	- Reduction of losses of materials and waste generation and/or effluents.	- Cost reduction
Preventive Maintenance	Source reduction	- Reduction in the amount of waste and polluting load;	- Avoids shutdowns costs, production and quality losses.
Whey for animal feed	Recycling	- Reduction in volume and organic and inorganic charge of final effluent.	- Reduction in effluent treatment costs, gains from the sale.
CIP cleaning	Source reduction	- Lower water consumption; reduction in volume of the final effluent.	- Reduction in water consumption and materials detergents and sanitizers; additional energy costs;
Adjusting storage of sulfuric acid	Source reduction	- Prevention of accidents and associated impacts.	- Additional costs for neutralization.
Use of rainwater and Yogurt Maker	Reuse and source reduction	- Reduction in water consumption;	- Reduction in water bill;
Turn off the machines between the 18:00 and 21:00 of the night.	Source reduction	- Reduction in energy consumption.	- Reduction in energy bill

Source: Authors, based on information from the dairy industry and CETESB (2008).

Chart 4. Cleaner Production Opportunities.

Aspect	Opportunity	Environmental and economic aspects
Environment and workplace safety	- Isolate the pasteurizer; - Install more wind extractors; - Monitoring and control of temperature, noise and vibration; - Follow the standard NR 17 (ergonomics).	- More safety and comfortable workplace; - Quality and productivity gain; - Employee more satisfied with the work; - Need more investment.
Water resource	- To develop a monitoring and control program of water management; - Train and educate employees to reduce consumption; - Use of pressurized water and foam system for surface cleaning; - Use of dry cleaning (removal of waste by sweeping or compressed air).	- Reduction of water consumption; - Reduction of effluent generation; - Reducing of treatment costs; - Additional costs of waste management; - Investment in equipment and training.
Energy resource	- To develop a monitoring and control program of electrical and thermal energy consumption; - Personal training; - Energy recovery and maintenance of steam pipes; - To develop cogeneration projects; - Firewood storage in suitable place.	- Reduction of energy consumption and costs; - Reduction of air emissions; - Use of cleaner fuels (natural gas, for example); - Additional costs for project development, implementation and maintenance.

Source: Authors, based on information from dairy industry and CETESB (2008).

Chart 4. Continued...

Aspect	Opportunity	Environmental and economic aspects
Effluents, emissions and wastes	- To develop a monitoring and control program of waste, effluents and air emissions; - To use the whey/buttermilk; - Properly disposal of laboratory waste; - Solid Waste Management; - To offer training courses to employees; - To treat for reuse the sludge; - Wastewater neutralization.	- Reduction of waste, air emissions, effluents; - Reduction treatments costs; - Investment and additional in equipment and training - Reduction of losses; - Sludge storage costs; - Business opportunities with the sale of coproducts; - Cost reduction of environmental liability and accident with the laboratory waste.

Source: Authors, based on information from dairy industry and CETESB (2008).

5 Final considerations

The study enabled us to understand the functioning of the dairy industry and how it stands on environmental issues. We have identified that even in the case of a medium-sized company (Bahia, 2009) there is potential for pollution, mainly due to lack of structured programs aimed at minimizing water and energy consumption; in addition to no generation and/or minimization of effluents, waste and emissions. Moreover, the lack of monitoring and control in water and energy consumption, and issues related to the production environment such as temperature, noise and vibration makes the company unaware of the real impact of its activities on the environment.

On the other hand, it is clear that despite the lack of structured environmental programs in the company, the management is interested in discussing and implementing actions accordingly. Examples are: interest in knowing the environmental management system and environmental techniques, collection of initiatives, storage and use of rainwater, donation and possible use of the whey, CIP cleaning, among others.

Thus, it appears that, even without the knowledge of what Cleaner Production is, before the study the dairy had already adopted some of its techniques. Starting from this observation, it was possible to identify both these techniques as the application of other opportunities, involving questions about the production environment, hygiene, security, water resources, energy resources, effluents, waste and emissions.

In light of this, it can be said that the proposed Cleaner Production measures for the dairy industry aim towards a more sustainable development in the sense that they can contribute to a better working environment, better interaction with the environment and greater production efficiency with consequent cost reduction.

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