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IMPLEMENTATION OF A RESIDUAL YEAST PROCESSING SYSTEM TO PRODUCE ANIMAL FEED

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ABSTRACT

Highlights: Brazil is one of the largest ethanol producers in the world. In the 2018/2019 harvest more than 33 billion litres of alcohol were produced, much of it in the southeast and central-west regions. Among the processes for the manufacture of ethanol, the most important is fermentation, because it is at this stage that the product of interest is generated, as well as the insertion of yeast that actively promotes the transformation of the raw material. The yeast processing after use in the fermentation process is an alternative to add value to a by-product**. Objective:** To evaluate the technical feasibility of implementing a yeast processing system for the production of animal feed in a plant located in the southwest of the state of Goiás. **Design/Methodology/Approach:** For the elaboration of this project, a case study was carried out on the technical feasibility of the implementation of a yeast processing system aimed at the production of animal feed, in a plant that currently performs the deposition of this waste in the vinasse tank. The project was based on the definition of the equipment and the sequence of operations required for the industrial processing of the residual yeast. Data were collected from the yeast production of the mentioned unit, referring to the harvest period of the year 2019 as a quantitative reference of raw material. **Results:** The study concludes that in the industry in question, it is technically feasible to implement the beneficiation system coupled with the pre-existing structure**. Research limitations:** Access to exact information about project implementation cost and costs attributed to machinery. **Practical implications:** Revenue input through a protein-rich residue, which is currently discarded, in addition to reducing costs with effluent treatment steps**. Originality/value:** The case study carried out in an already active ethanol plant allows the utilization of the plant structure itself for the adoption of an additional processing stage of a residue, serving as a stimulus for more sustainable production.

Keywords: Ethanol; yeast; production; reuse.

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1. INTRODUCTION

Brazil is one of the largest ethanol producers in the world. Together with the United States, international production reaches the 40 billion litres of ethanol mark. Adding the two countries together, they represent 70% of world production according to the Embrapa Agency for Technological Information (AGEITEC, 2019). There are currently 349 production plants authenticated by the National Petroleum Agency (ANP) to manufacture alcohol in the country (ANP, 2019). The 2018/2019 harvest in Brazil reached a total of 33.14 billion litres of ethanol, which shows a growth of 21.7%, that is, there was an increase of 5.9 billion litres compared to the last period according to the National Supply Company (CONAB, 2019). Within this scope, the southeast region is the largest producer in the country, closely followed by the central-west region (ANP, 2019).

In ethanol manufacturing, generally speaking, the only fossil fuel used in the process is for moving the machinery. In this way, all the electricity and heat needed to make the transformations in the process are obtained in the process itself, that is, all this energy is renewable, obtained through the burning of sugarcane bagasse, integrated into a cogeneration system prepared to supply the entire industry, and can still generate extra energy to be sold to the integrated national grid (Rodrigues and Ortiz, 2006).

Since every production process generates some type of residue, it is no different at sugar and alcohol plants. There are several residues generated during the process and, fortunately, most are reused as fertilizers in the fields producing the raw material. The main residue produced is stillage: for each litre of alcohol 11 to 14 litres of stillage are generated. Currently, regulation P4.231, according to the Environmental Company of the State of São Paulo (CETESB, 2006), determines the appropriate criteria and procedures for vinasse disposal on the soil. In the solid residues section, the great protagonist is bagasse: for each ton of processed sugarcane 140 kilos of residue are produced. As mentioned, bagasse is responsible for electric and thermal energy (Rodrigues and Ortiz, 2006).

The alcohol plant has a high production and this results in the generation of solid, liquid and gaseous waste from the manufacturing field. In a certain way, all waste causes some environmental impact that corresponds to some modification of the environment, either favourable or opposite to it. Therefore, the environmental risks are real, requiring a lot of attention to the destination of this waste, which is capable of generating the pollution in the atmosphere, soil and water. In this sense, there are already systems and technologies such as, for example, exhaust fans in the boiler chimney to minimize these impacts and to achieve the cleanest possible process (Leonardo et al. 2012).

Among the processes for the manufacture of ethanol, the most important is fermentation, because it is at this stage that the product of interest is generated, as well as the insertion of yeasts that actively promotes the transformation of the raw material.

From a limited quantity of active yeast that is inserted in a mixture of sugarcane juice and molasses, the mixture is fermented, transforming sucrose into ethanol. The yeast is then centrifuged, isolating the wine from the yeast. Then, the yeast (yeast) returns to the tank, where it is treated to start again, as the fermentation is continuous. During the reaction, it is necessary to separate a part of the yeast to prevent the biomass from increasing in an uncontrolled way, thus maintaining a fermentative balance, since they are living microorganisms and proliferate in an incessant way (Costa, 2004).

The yeast that is discarded from the process has the same characteristics as the yeast that returns to the process, that is, around 11% alcohol. For each litre of ethanol processed, an excess of 25g to 30g of yeast is produced, reaching the mark of 420 thousand tons of yeast only in sugar and alcohol mills (Costa, 2004).

The fraction of yeast that is discarded must be reused because it is a waste product and its disposal causes environmental impacts. In most industries, the yeast is discarded in the vinasse dam, which is conducted together with the vinasse to the field to be fertilized.

The inevitability of the application of the by-product has encouraged countless studies, which reveal that the micro-organisms show a high nutritional capacity and are now added as a supplement in animal feed. Moreover, the yeast has a high accumulation of vitamins, great amino acid balance, and also acts as a natural antibiotic and improves the taste of the feed (França and Rigo, 2011). The implementation of a yeast processing system for animal feed production would be a solution to this problem, aiming at an improvement in the process, higher profit for the industry and reduction in environmental impacts caused by the disposal of yeast erroneously.

Given the above, this work proposes to evaluate the technical feasibility of implementing a structure for yeast processing in a plant already in operation, as an alternative to the disposal of this input along with the stillage. The general objective is to perform the sizing of a system for the reuse of yeast aimed at the production of animal feed.

2. METHODOLOGY

For the elaboration of this project, a case study was carried out on the technical feasibility of the implementation of a yeast processing system aimed at the production of animal feed in a plant that currently performs the deposition of this waste in the vinasse tank. The industry is located in the interior of the state of Goiás, specifically in the Southwest region.

The project was based on the definition of the equipment and the sequence of operations necessary for the industrial processing of the residual yeast. Data were collected from the yeast production of the mentioned unit, referring to the period of the 2019 harvest as a quantitative reference of raw material. Associated with this, it was performed the consultation of scientific texts available in the literature on the subject as a way to define the best procedure for the generation of the product of interest, in this case, the animal feed, based on the pre-existing machinery in the industrial unit, to reduce the initial investment of implementation of this project.

3. RESULTS

The dimensioning of a processing system was carried out, starting with the preparation of the raw material, followed by drying to obtain the powder, which will be used as a supplement in the animal ration.

Before the drying stage, the yeast is submitted to a previous fermentation, known as endogenous fermentation, to increase the protein content. In this stage, the yeast will be conditioned in a suitable recipient to promote fermentation, which takes place under cellular stress conditions.

The yeast, when leaving the fermentation vat, before the drying process, needs to go through an additional step which consists in the preparation of the yeast cream. This preparation is called endogenous fermentation. At this stage, the yeast is subjected to a stress condition, i.e. it consumes its carbohydrate stores until all sugar is exhausted. The result of this stage is an increase in the amount of cellular protein of the yeast cream (Martins, 2009).

The industry in question has auxiliary fermentation tanks of small size that could be relocated and directed to the endogenous procedure, dispensing with the acquisition of new equipment.

Subsequently, the alcohol is removed through distillation columns. Currently, the industrial unit addressed in this study has distillation columns for the purification of ethanol, which could also be used for the removal of residual ethanol from endogenous fermentation, so there would be no additional cost with the acquisition of this equipment.

After that, it will be directed to the purification and dehumidification stages, carried out in two phases: the first stage is the use of the centrifuge, which allows the separation of two substances of different densities, and the second stage is the drying by atomization, also known as "spray dryer", which consists of steam drying, that is, the yeast is dehydrated through hot air, the yeast is atomized in very tiny drops in the internal part of the compartment, where they come into friction with the hot air, evaporating quickly and becoming dry particles at the exit of the chamber. Once dried, the powder is bagged and made available for sale.

The dehumidification and purification operations would require the plant approached in this study to purchase equipment in the specific case of drying by atomization since for alcohol processing there is no similar procedure. Thus, at this point of processing, there would be the need for financial investment, as well as the availability of space in the industrial plant to accommodate such machinery.

It is also worth mentioning that the adoption of the yeast processing system implies the implementation of a specific flow system for the displacement among the units, which brings costs with piping and pumping systems.

To accommodate the powder obtained at the end of the processing it is necessary the acquisition of specific machinery, being this another investment point to consolidate the project.

Next, the description of the necessary equipment for the implementation of a residual yeast processing unit in the plant previously specified. The choice of machinery was based on the processing needs linked to the production.

- Positive displacement pump
- Drying chamber
- Rotary disk atomizing head
- Heat exchanger
- Ventilator
- Rotating valve
- Exhaust
- Cyclones
- Conveyor
- Bucket lift
- Lung silo

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- Packing system

After removing the alcohol from the yeast through a distillation column, the yeast is routed through a positive displacement pump to the drying chamber, moving ahead with a rotating atomising disc. Rotating at high rotation, the yeast cream is atomized in mist condition. This mist, in contact with the hot air conceived by steam through the heat exchanger and blown by a fan, dries immediately, launching itself to the bottom of the chamber in the shape of a cone. The product of interest is isolated inside the chamber using a valve, where it finally results in a dry powder ready for packaging.

Currently, the plant under study has its system for generating energy from burning sugarcane bagasse, which is used for steam production. The energy generation exceeds the consumption of the plant itself, which is directed to the national energy grid and marketed. In this sense, part of the steam generated could be applied in the drying of yeast, without the need for major investments in terms of energy.

The finest fragments that cannot reach the bottom of the chamber because they are lighter, tend to be dragged by the exhaustion and are finally recovered in the cyclone. The process air is directed to the atmosphere through the chimneys. What is generated at the end is transported by conveyor belts to a bucket list, which supplies a buffer silo and also serves to maintain the feed packaging system.

The buffer silo is a structure that should be included in the project because there is no similar structure in the industrial plant, as well as all the exhaustion system because the ones that operate in the unit already meet other demands of the industry, so there is the need to create a specific structure for the processing of residual yeast.

All the description of the purification stages implies inclusion and adaptation to what already exists in the industrial unit approached. Such addition can happen inside the plant with the insertion of a designated place to finish the production of feed. To better clarify the process, Figure 1 follows.

In yeast drying, there are other types of processes. One of them is the rotating roller, which is based on the drying of yeast through direct contact with the hot surface of the rotating roller, reaching a temperature around 200ºC (Landell Fillho et al., 1994). The spray dryer process, on the other hand, makes it possible to obtain a product of higher nutritional quality because the maximum temperature reached and the contact time is much shorter than those presented in the first system, allowing a better standard of the grain, colour and especially in the conservation of amino acids, in addition to a lower cost (Furco, 1996; Ghiraldini and Roseli, 1997). The spray dryer system was chosen because of these factors and because the unit operations are closer to those that are already adopted in the sugar cane processing plant, enabling the reuse of machinery and the saving of resources.

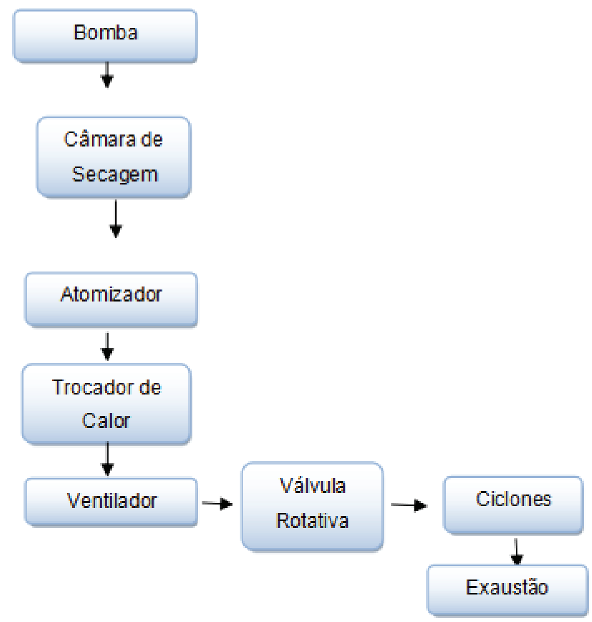

Figure 1. Spray-dryer Flowchart
Source: Santos, 2015.

Quantitative aspects of production

The industry where the study was conducted began its activities in 2008. It is suitable for the production of ethanol and sugar, however, the process is focused on the manufacture of alcohol. Currently, in the plant, the yeast surplus generated during the production is disposed of along with the vinasse in a dam. This study corresponds to the 2019 harvest. Thus, Table 1 shows the amount of wet yeast discarded over a period of eight months.

Table 1. Discarded wet yeast

Months	Wet Yeast (kg)
May	163.050
June	173.700
July	203.350
August	183.780
September	190.240
October	186.010
November	180.500
December	189.370
Total	1.470.000

Source: Elaborated by the authors

The collection of information about the yeast surplus was obtained through the mass flow, which is measured by an instrument installed in the pipe that registers the data when the yeast passes through it, thus leading to an average of the product that could be reused.

In his work, Myiada (1978) indicates an efficiency of 90% which is equivalent to the humid yeast transformed into powder, in an industrial processing process aiming at the production of ration. Following this concept, 90% of 1,470,000 kg of wet yeast is equivalent to 1,323,000 kg of dry yeast. This would be the quantity to be transformed in powder for ration.

The percentage indicated above refers to the process efficiency suggested for the operation, because productive processes present losses associated with each one of its stages, and the percentage presented is indicative of low dissipated energy, according to Januzzi (2007). This is a value observed experimentally that will be used as a reference for the project described in this work due to the similarities in the unit operations.

It is worth mentioning that efficiency may vary from process to process because each one has an amount of matter to be lost. According to Fialho et al. (1983), the yeast mass converted into powder is 93.80%. For Lima (1983,) the mass of yeast transformed is 92.44%. Specificities of the operation end up changing the percentage, which can only be clearly defined when the unit is already in operation.

Thinking about the nutritive aspect of the dry yeast, some of its constituents were analyzed, represented in Table 2.

Table 2. Approximate composition of dry yeast obtained after processing

Main Components	Composition (%)	Equivalent mass (Kg)
Protein	30,77	406.164,0
Amino acids	25,75	339.900,0
Lipids	1,10	14.520,0
Fibre	0,13	1.716,0
Ash	9,81	129.492,0
Calcium	1,48	19.536,0
Phosphorus	0,75	9.900,0

Source: Elaborated by the authors.

Table 2 presents the percentage composition of each substance according to the characterization performed by Myiada (1978). Observing each constituent, a simple rule of three was applied, taking into account the amount of 1,320,000 kg to find the mass-produced of each of the components of yeast.

Battisti et al. (1985), reports have found the value of 39.5% of gross protein. Zanutto (1997), on the other hand, found a protein value of 37%, Kill et al. (1999), says that the total protein value is 32%. In a study with swine, Myiada (1978) observed that crude protein was around 30%. For Angeli & Thomazini (1980), the dried yeasts show a chemical formation close to 6% of humidity and 45% of crude protein.

Therefore, the difference mentioned among the authors about the percentage of protein is acceptable according to the yeast type and the process condition. In this study, a literature reference was chosen to estimate the mass balances, however, when the unit is in operation, it will be possible to characterize the yeast composition once it is discarded using laboratory tests.

The yeasts are calling the attention of several researchers because they have great nutritional benefits for society, both in human food, enriching flavours and in animal food (Dziedak, 1987).

In a work developed by Santucci et al. (2003), yeast derivatives are applied in the enrichment of tube noodles, to improve the nutritional configuration of this food. In this opportunity, tests were performed in a pilot plant where the yeast extract came from an alcohol production plant.

During the fermentation process, even before entering the phase of preparation for drying the yeast, the plant has analysed for yeast concentration. The collection point is just after the yeast has passed through the centrifuges. The percentage of yeast in the total mass varies between 70% and 80%. This is important information, as it will be this material that will be dried.

Up to now, in the project, the technical feasibility of implementing this system is being addressed. However, it is important to take into consideration the economical viability of the implantation of this ration factory through yeast processing. Based on the literature and the feed market value, it was found the average selling price of this product worth R$ 850.00 a ton (SANTOS et al., 2015).

Through this information, it is possible to calculate a probable forecast of the gross revenue of the production of the 2019 crop according to Table 3.

Table 3 shows that the industry could have increased its gross income up to R$ 1,124,549.25 if it had this yeast processing for the production of feed. Besides, there is a significant and progressive demand for the commercialization of dry yeast, as it is admired for its great nutritional value.

The national production of feed showed a growth of 5.2% in the first half of the year 2020, according to the national

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union of the animal feed industry (SINDIRAÇÕES, 2020). The forecast, according to the same body, is to close the year 2020 with a record production of 81 million tons, indicating the demand for consumption favourable to the expansion of this segment.

Table 3. Forecast of gross revenue after the implementation of the yeast processing system in the plant under study.

Month	Yeast powder (Kg)	Average price of feed (R$)	Gross Revenue (R$)
May	146.745	0.85	124.733,25
June	156.330	0.85	132.880,05
July	183.015	0.85	155.562,75
August	165.402	0.85	140.591,70
September	171.216	0.85	145.533,60
October	167.409	0.85	142.297,65
November	162.450	0.85	138.082,20
December	170.433	0.85	144.868,05
Total	1.323.000	0.85	1.124.549,25

4. CONCLUSION

It is concluded with this work that it is possible to dimension a system of yeast reuse for the production of animal feed in a sugar-alcohol plant in operation, taking advantage of part of the machinery and the pre-existing unit operations. The plant has conditions to insert this productive process parallel to the ethanol production, aiming a higher profit during the harvest and contributing to softening the environmental impacts caused by the discard of the humid yeast.

The study was able to determine the yeast surplus that could be reused through equipment that measures the mass flow. Through these flows, it was obtained the amount of waste to be reused. By consulting the work of some authors it was possible to estimate the amount of dry yeast that would be manufactured, about 90% of the yeast would be transformed into powder, thus having great efficiency. Besides, the work managed to define a series of equipment necessary for the yeast processing through researches and by similarity in the process with other plants that already produce the animal feed.

And, at last, it was accomplished the analysis of the technical viability of implantation of this system, which was proved taking into consideration the equipment so that the industry already has and the new equipment that would be acquired, that is, the industry has enough conditions to implant the spray dryer system. Economic aspects were also briefly approached, demonstrating that the gross revenue could have an increase of over one million reais per year.

It is worth mentioning as a suggestion for future works that pertinent calculations be made regarding the cost of implementing the feed processing unit and the average return time of the investment defined as payback study.

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