COST ANALYSIS IN OBTAINING PROTEIN SUPPLEMENTS BY ENRICHMENT AND FOAM-MAT DRYING OF PINEAPPLE SKIN

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ABSTRACT

Brazil stands out as one of the main global animal feed producers. A promising strategy is the manufacture of protein supplements for animal feed, by enrichment of fruit wastes. The process analyzed was the enrichment of pineapple peel with yeast *Saccharomyces cerevisiae* remaining at rest for 48 hours for the cell growth. The next step consists of drying the enriched product to obtain a supplement with 12% moisture content. Two types of dryers were analyzed: oven and solar dryer bioreactor. Labor costs, energy consumption, equipment investment and raw materials were considered for the cost analysis. It was found total production costs of 54.75 R$/kg and 52.64 R$/kg for the stove and the solar dryer respectively. Based on the prices of supplements offered in commerce, the selling price was estimated at R$ 20.00/kg. The break-even point for oven drying was found 6.66kg/day whereas for drying in the solar dryer it was 6.37kg/day; that is, processing approximately 49kg/day of pineapple skin. This means that capacity above these values makes the process viable for large-scale production. The studies showed the economic viability for the production of this supplement since optimized conditions were chosen.

Keywords: Break-even point. Drying. Pricing. Protein enrichment. Waste.

1 INTRODUCTION

Animal feed is of great importance in the agri-food sector, serving for correct nutrition and ensuring health and productivity for pets and livestock. Grass feeding suffers from climate variations and is insufficient to obtain the minimum necessary vitamins and proteins [1]. Therefore, feed is essential for the correct care of these animals. According to Agri-Food Outlook 2024, Brazil produced around 83.32 tons of animal feed in the year 2023, being the third largest producer in the world, with a lot of exports of broiler chickens and growth in the aquaculture sector [2]. In the same study, the main factors that influence animal feed production in Brazil are production costs, food trends and adverse climate [2]. Therefore, studies on processes and feasibility for animal feed production in Brazil are relevant in order to optimize the production chain. Animal feed is a homogeneous formulation in the form of flour with moisture less than 13% [3]. Then, protein supplements are added to improve the nutritional and energetic properties. The production of protein-enriched supplements from agro-industrial waste promotes economic and environmental sustainability due to the low cost involved and better use of residues [4]. Usually, a drying step is necessary in order to obtain a flour with moisture content adequate to storage. One alternative is the foam-mat drying technique, based in the formation of bubbles into the sample by adding a foaming agent. The objective is to improve the heat and mass transfer by increasing the superficial area and reducing the operation time [5,6]. Eggs white is often used as foaming agent because their capability in producing stable bubbles. Another alternative, aiming to reduce energy costs, is solar drying [7], although limited by availability and favorable atmospheric conditions. Then, protein supplements are added to improve the nutritional and energetic properties. Therefore, this summary aims to identify the costs involved in the production of animal supplements using the pineapple peel residue with protein enrichment by *Saccharomyces cerevisiae* followed by foam-mat drying or solar drying.

2 MATERIAL & METHODS

The cost analysis was based on data from experiments carried out on a laboratory scale. The process consists of the following steps shown in Figure 1.

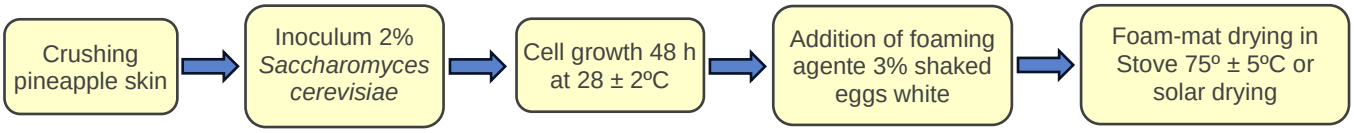

Figure 1 Flow chart of the process

Were identified fixed and variable costs, just taking into account those directly involved in the process. However, it is important to notice that there are other indirect costs, such as taxes, factory location, management, transportation and storage not included in this preliminary study. For fixed costs, investment in equipment, labor and energy consumption were considered. Equipment costs were calculated with a useful life of 10 years and operation on 5 days a week (240 days per year). An employee with an 8-hour working day was stipulated for the operation. The energy costs directly involved in the process were calculated based on the stove's power of 500W, the time used to use the equipment and the energy cost in kWh provided by the local electricity company in Sergipe. The energy cost considered is the residential modality without benefits or for industries, with a value of R$ 0.66591 per KWh consumed, according to ANEEL resolution number 3,318 of April 16, 2024. The variable costs include the raw material

pineapple peel, the yeast used to enrichment by cell growth and eggs white as foaming agent. All the prices of the ingredients were obtained in the local market.

3 RESULTS & DISCUSSION

The calculations were carried out for 10 kg of pineapple peel as a reference, where 2% yeast and 3% egg white as foaming agent were added. Therefore, for 10 kg of pineapple peel residue, 0.300 kg of egg white and 0.200 kg of yeast were added, obtaining an initial total mass of the fresh product equal to 10.5 kg of material to be dried. The initial moisture content of fresh pineapple skin is 89%, eggs white, 85% and yeast 1% Therefore, the 10.5 kg have 1.343 kg of dry mass, as seen in Table 1.

Table 1 Mass balance int he enrichment and drying process.

Raw material	Initial moisture (%)	(%)	(kg)	Dry mass (%)	Dry mass (kg)
Pineapple peel	89	100	10	11	1.100
Eggs white	85	3	0.3	15	0.045
Saccharomices cerevisiae	1	2	0.2	99	0.198
Total	-	-	10.5	-	1.343

The aim is to obtain an enriched product containing 12% final moisture which will correspond to a final production of 1.504 kg of protein supplement.

The daily fixed costs in the production of the protein supplement can be seen in Table 2.

Table 2 Fixed costs of the process

Resources	Quantity (units)	Value (R$)	stove (R$/day)	Solar Dryer SBD (R$/day)
employee	1	2,081.43	69.38	69.38
scale	1	273.74	0.114	0.114
shaker	1	169.90	0.0708	00708
Solar bioreactor dryer (SBD)	1	1,500.00	-	0.625
Stove	1	2,089.83	0.8707	-
Aluminum container	1	1.80	0.00075	-
Power	-	0.66591	2.93	-
Total	-	6,117.37	73.37	70.19

For the solar dryer bioreactor, energy costs are not considered, as the equipment uses solar radiation for the drying process. The employee's cost is equivalent to a minimum wage plus social charges and taxes.

Variable costs are those of the materials required in processing 10 kg of residues to obtain 1.504 kg of supplement: pineapple skin, yeast, eggs white and package. Since pineapple peel is a residue that is not available for sale, its value was estimated and set R$ 1.00 per ton. For protein enrichment, 2% of the yeast *Saccharomyces cerevisiae* was used. The price of the packaging was found by searching online stores. To calculate the costs of the egg price, only the value corresponding to the egg white was considered, considering that the yolk will be used for another specific purpose, such as food production, for example. It was found a value of R$ 9,00 for 68 unities in the wholesale local market corresponding to R$ 0.13 each egg white. Table 3 shows the variable costs resulting in R$ 8.98 to produce 1.504 kg of supplement, or R$ 5.98/kg

Table 3 Variable costs for processing 10kg of pineapple skin to produce 1.504kg of protein supplement

Materials	Quantity	Price (R$)	Amount used	Costs (R$)
Pineapple skin	1000 kg	1.00	10 kg	0.01
Eggs white	10 units	0.13	10 eggs	1.30
yeast	500 g	19.06	200 g	7.624
Package	1 bag	0.05	1 bag	0.05
Total	-	-	-	8.98

Based on fixed and variable costs, the total cost for the daily production of 1.504 kg of protein supplement with drying in a stove will be R$ 82.35 and in the solar dryer bioreactor it will be R$ 79.17, that is 54.75 R$/kg and 52.64 R$/kg respectively. The selling price of protein supplements in Brazil varies depending on their formulation. Taking into account that it is possible to obtain a product with 20% crude protein by enriching fruit waste with yeast [7], it was estimated that a competitive selling price would be R$ 20.00. Based on this value, the break-even point (BEP) was calculated to determine the capacity from which production would become profitable. Figures 2 and 3 and Table 4 show the break-even points for the production of protein supplements in the stove and in the solar dryer bioreactor. It is observed that, in the stove, the BEP is 6.66 kg/day, whilst the BEP corresponds to 6.37 kg/day in the SBD. Notice that there is practically no significant change, just a small difference of 290g in favor of the SBD, which is precisely equivalent to a reduction in fixed costs, when compared to oven drying. Therefore, it must be processed more than 49 kg of pineapple skin per day to reach profit.

Tabela 4 – Identification of the break-even point in the daily production of protein supplements.

Variables	Stove drying	Solar drying
Fixed costs (R$)	73.37	70.19
Selling price (R$/kg)	20.00	20.00
Variable costs (R$/kg)	8.98	8.98
Break-even point (kg/day)	6.66	6.37

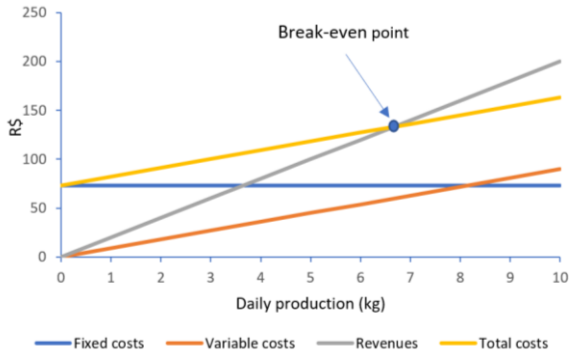

Figure 2 Break-even point for protein supplement production in stove

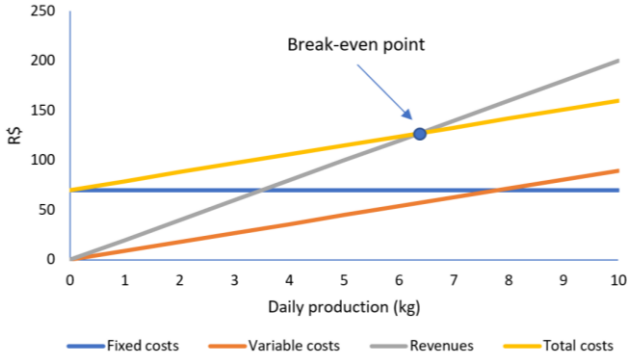

Figure 3 Break-even point for protein supplement production in solar bioreactor dryer

4 CONCLUSION

The study showed that the production of a protein supplement is viable, based on protein enrichment of pineapple peel, enriched with *Saccharomyces cerevisiae* yeast. By adopting foam mat drying techniques and taking advantage of resources previously considered waste, it is possible to improve the efficiency of processes and reduce their environmental impact. In this work, wo types of dryers were proposed, stove and solar bioreactor. Direct costs for production were taken into account, identifying the break-even point for production in both types of dryers, which it was approximately 7 kg of dry supplement with 12% moisture. That is, the initial mass of the process, composed of pineapple peel, yeast and egg whites. must be greater than 49 kg to obtain profit. This result will serve to optimize production capacity in subsequent work, leading to large-scale industrial production.

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