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ARTICLE

Assessment of the impact of expenditure items on the cost composition of frozen fruit pulp industry products

Impacto dos itens de dispêndios nos custos dos produtos da indústria de polpa congelada de frutas

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Abstract: This study assessed the impact of production costs in a frozen fruit pulp industry producing 19 types of pulp, using the Activity-Based Costing (ABC) method to quantify direct and indirect costs. Indirect costs were allocated to activities through specific cost drivers unrelated to raw material processing, such as energy consumption, while direct costs were associated with processing lines, including raw materials and packaging. The company was divided into six activity sectors: reception and processing, preparation and filling, storage, packaging and dispatch, administrative, and transportation. Results showed that the administrative sector incurred the highest indirect costs, followed by storage, while direct costs—particularly raw materials—accounted for approximately 51% of total production costs. Seasonality significantly influenced profitability, especially in the processing of passion fruit pulp. Despite isolated losses in some products, such as passion fruit, the company's overall strategy remained effective, maintaining a positive total net margin of 33.1% during the harvest season and 28.2% in the off-season.

Keywords: cost analysis, agroindustry, fruit pulp, ABC method.

Resumo: Este estudo avaliou o impacto dos custos de produção em uma indústria de polpa de frutas congelada, produtora de 19 tipos de polpa, utilizando o método Activity-Based Costing (ABC) para quantificar os custos diretos e indiretos. Os custos indiretos foram alocados às atividades por meio de direcionadores de custo específicos não relacionados ao processamento de matéria-prima, como consumo de energia, enquanto os custos diretos foram associados às linhas de processamento, incluindo matérias-primas e embalagens. A empresa foi dividida em seis setores de atividade: recebimento e processamento, preparação e envase, armazenagem, embalagem e expedição, administrativo e transporte. Os resultados mostraram que o setor administrativo incorreu nos maiores custos indiretos, seguido pelo de armazenagem, enquanto os custos diretos — principalmente as matérias-primas — representaram aproximadamente 51% dos custos totais de produção. A sazonalidade influenciou significativamente a lucratividade, especialmente no processamento de polpa de maracujá. Apesar das perdas isoladas em alguns produtos, como o maracujá, a estratégia geral da empresa permaneceu eficaz, mantendo uma margem líquida total positiva de 33,1% durante a safra e 28,2% na entressafra.

Palavras-chave: análise de custos, agroindústria, polpa de frutas, método ABC.

1 Introduction

Brazil's fruit pulp industries have grown significantly in recent years, mainly with a view to exports while still supplying the domestic market (Associação Brasileira dos Produtores Exportadores de Frutas e Derivados, 2020). Even with a high production and sales capacity for

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frozen fruit pulp, many industries face problems such as the high cost of acquiring raw materials produced in regions far from the industry, marketing aspects, and market competition (Gomes, 2013; Rezende & Oliveira, 2013). For this reason, conducting a robust economic analysis, in which it is possible to describe, detail, and quantify expenditure and income, is a valuable tool to help with decision-making.

According to Arora et al. (2018), the market price of the product can strongly affect the economic viability of the project. More competitive market values differentiate successful companies from those still struggling to gain a foothold in the business world. However, to achieve more attractive prices, it is necessary to work on good cost management, seeking to rethink the manufacturing process, identify the costliest activities, and understand what possible improvements are needed to make the company dynamic and competitive in the market (Braga et al., 2010; Everett & Watson, 1998).

Among the methods available in the literature and used by companies to analyze production costs, the ABC (Activity-based Costing) method stands out. It presents an approach to identifying costs by activity, i.e., the system divides the company's entire processing line into activities and considers that they consume resources that are causing costs. The product, in turn, is a consequence of the activities (Bornia, 2002; Quesado & Silva, 2021).

This costing system allows for a strategic view of the company, identifying its potential, especially when there is greater detail in the cash flow items and when the data absorbed by the method is sensitive and represents a significant portion of the company data. In this way, it is possible to identify weaknesses and needs for improvement, the costliest activities, and, finally, how the sum of direct and indirect costs per activity reflects the organizational dynamics of that company (Quesado & Silva, 2021; Kaldirim & Kaldirim, 2020; Haroun, 2015).

Direct costs can be attributed to an object used in manufacturing the product, such as raw material costs. Indirect costs, on the other hand, are used to give value to the end product but are absorbed in the activities and are not directly related to the product, as in the case of labor in sectors outside the industry processing line, energy costs, and equipment maintenance costs (Blocher et al. 2007).

There are few studies on applying the ABC costing method to food industry analysis. According to Kabinlapat & Sutthachai (2017), few studies adequately illustrate ABC applications in agribusiness. Dwivedi & Chakraborty (2014) used this method in the food processing industry in India, which, like Brazil, is one of the largest food producers in the world. The aim was to demonstrate the efficiency of applying the method based on accurate cost information from the industry, emphasizing that this information could be useful to decision-makers in other industries. Kabinlapat & Sutthachai (2017) applied the ABC method to the cost analysis of a chicken processing industry and concluded that the process is complex and challenging, but despite this, this type of costing manages to provide more accurate and important information for company management.

In the study by Ferreira & Leite (2022), the ABC method was applied in an industry that produces four types of party snacks. The authors justify using ABC costing because the company has many manual activities that require fine accuracy to obtain costs. The data sources were official documents and questionnaires with information collected from employees. The results showed differences concerning the costs calculated by the company's administrative sector. This was to be expected, as the company disregarded direct labor costs and other indirect manufacturing costs when calculating the cost of production and pricing, which was responsible for almost doubling the value of the cost of production, demonstrating the importance of applying a structured method capable of accurately measuring the costs associated with production activities.

This study aimed to systematically collect and analyze data regarding both direct and indirect production costs within a frozen fruit pulp industry that markets 19 different types of pulp. To achieve this, the industry's cost items were categorized into direct and indirect costs based on distinct classification criteria, allowing for a clear differentiation between expenses directly associated with the manufacturing process and those that support overall operations but are not directly linked to the product. Subsequently, considering the total cost incurred by the company, percentages of these costs were carefully allocated across various production activities using the Activity-Based Costing (ABC) methodology. This approach enabled a detailed identification and quantification of costs by activity, facilitating a deeper understanding of the key factors influencing the cost composition of each type of fruit pulp produced. Ultimately, the application of the ABC method provided valuable insights into cost drivers and resource consumption patterns, thereby supporting more informed decision-making aimed at enhancing operational efficiency and competitiveness in the industry.

2 Theoretical Foundation

Cost assessment in agribusiness projects is an essential element for strategic decision-making, ensuring the economic viability and sustainability of the enterprise. Several methodologies can be applied to estimate and analyze the costs involved, each with specific approaches and different levels of details (Martins, 2025).

Absorption costing method stands out among the most widely used costing methods, which imputes all direct and indirect costs to products, distributing fixed and variable costs proportionally, and is widely used for accounting reports and sales price formation (Martins, 2025). Another relevant approach is variable or direct costing, which considers only variable costs in the composition of the product cost, separating fixed costs to facilitate management analyses, allowing the assessment of the contribution margin (Zanin et al., 2019). Activity-Based Costing (ABC) allows for more precise detailing when identifying and allocating costs according to the activities that consume resources, and is particularly useful in agribusiness, where production processes may involve multiple operations (Kaplan & Cooper, 1998).

According to Varani et al. (2025), the application of the Activity-Based Costing (ABC) method is recommended when a company utilizes shared resources to produce multiple goods or services, as this situation may lead to a bias known as "cross-subsidization," which can compromise the accuracy of profitability assessments.

More sophisticated methods such as Monte Carlo simulation are used to test multiple scenarios and estimate the probability of success or failure of the venture. Additionally, mathematical modeling and optimization tools, such as linear and nonlinear programming, can be applied to minimize costs and maximize returns, making management more efficient (El-Ouardi et al., 2025).

The choice of the most appropriate methodology for assessing costs in agribusiness depends on the complexity of the project, the availability of data and the objective of the analysis. The combined use of accounting, economic-financial and risk management approaches allow for a more robust and well-founded view, contributing to more accurate and efficient strategic decision-making. Moreover, the strategic relevance of the ABC methodology stems from its capacity to deliver not only financial information but also managerial insights, as it differentiates between value-added and non-value-added activities that influence decision-making (Varani et al., 2025).

3 Methodology

3.1 Industry data collection

The data used to develop the Activity-Based Costing (ABC) method refer to the period from January to December 2022 and were obtained from the industry owner, employees, and through direct observation of the frozen fruit pulp processing line. The plant employs 47 workers distributed across different sectors and has a monthly processing capacity of 500 tons of raw material. In 2022, the company operated at 33% of its capacity, processing 165.1 tons of raw materials.

The interview methodology is particularly important, as the company owner and employees are the individuals directly involved in the business and possess extensive experience with its operations. A similar approach was adopted by Gode & Ekergil (2020), who conducted structured interviews to collect objective information regarding production processes and the costs associated with production items.

The data collection included a detailed breakdown of cost variables associated with passion fruit as a raw material, given its importance in the company's business context. Passion fruit represented 26.5% of total raw material purchases in 2022, among the 19 types of fruit pulp produced by the industry. Therefore, the cost analysis for passion fruit considered transportation expenses to the processing plant and price fluctuations per ton during the harvest and off-season periods. Additionally, a 10% fruit loss during the selection stage of the processing line was taken into account.

In addition to passion fruit, in 2022 the company purchased raw materials in the form of fresh fruit or concentrated frozen pulp, including pineapple, açaí, acerola, mulberry, cocoa, mango, cashew, guava, soursop, orange, ambarella, strawberry, tangerine, grape, lemon, cupuaçu, hog plum, and pitanga. Frozen pulp blends obtained from these raw materials were also produced, totaling 19 types of fruit pulp. However, the company also markets pulp mixtures such as acerola with orange, pineapple with mint, detox, mixed, and assorted blends. Consequently, the revenues from these pulp mixtures were divided equally and incorporated into the corresponding base pulps, as they do not originate from additional raw materials and represent a negligible share of total sales.

3.2 Application of the ABC method

The application of the Activity-Based Costing (ABC) method was conducted according to the methodology proposed by Bornia (2002) and involved the following steps: identification of cost items, identification of activities, allocation of indirect and direct activity costs, and assignment of costs to products. Table 1 presents the company's cash flow cost items based on data from the year 2022.

The different cost categories totaled a monthly value of R$ 812,646.51 (Table 1). The cost of raw materials refers to the fruits and/or concentrated frozen pulps purchased for the production of frozen pulp, according to the cost spreadsheet provided by the company. Depreciation values were obtained from an on-site assessment of the equipment, considering an annual depreciation rate of 10%. Taxes correspond to 8.5% of the company's total revenue. The remaining cost items were obtained from the company's accounting office. Labor costs for the various sectors were determined based on the number of operators involved in each industrial activity.

Table 1. List of cash flow cost items in the frozen fruit pulp industry, including their classification by nature, variability, and monthly value for the year 2022.

CASH FLOW COST ITEMS			
ITEMS	CLASSIFICATION BY NATURE	CLASSIFICATION ACCORDING TO VARIABILITY	MONTHLY AMOUNT (R$)
Raw materials	direct	Variable	416,010.74
LB* Reception and Processing Sector	direct	Variable	8,540.49
LB* Preparation and Filling Sector	direct	Variable	11,368.93
LB* Storage sector	direct	Variable	6,459.54
LB* Packaging and Shipping Sector	direct	Variable	24,019.92
LB* Administrative sector	indirect	Variable	28,253.59
LB* Transport sector	direct	Variable	9,024.54
Energy	indirect	Variable	70,849.63
Packaging	direct	Variable	63,400.51
Equipment maintenance	indirect	Fixed	15,524.40
Infrastructure maintenance	indirect	Fixed	6,455.46
Administrative	indirect	Variable	17,057.38
Taxes	direct	Variable	85,668.74
General supplies	indirect	Variable	20,000.00
Depreciation	indirect	Fixed	16,541.67
Outsourced services	indirect	Variable	13,470.99
TOTAL			**812,646.51**

Legend: *LB: Labor. The average exchange rate for 2022 was 1 USD = 5.16 BRL (Instituto de Pesquisa Econômica Aplicada, 2023).
Source: authors.

3.3 Direct costs

To identify the cost of manufacturing products, direct and indirect costs must be measured to understand each item's importance level in the final net margin.

Direct costs are those expenditures directly involved in the composition of product costs. These include raw materials, packaging, taxes, and labor in the reception, processing, preparation, filling, storage, packaging, and shipping/transport sectors.

The direct cost of each raw material was calculated by multiplying the quantity processed in the industry by its cost per ton. For packaging costs, the pulp extraction yield was taken into account to determine the amount of pulp processed and packaged, thereby allocating packaging costs per ton of processed pulp. Tax costs for each type of pulp were based on an average rate of 8.5% of sales revenue for each product. Labor costs in the production sectors were calculated by multiplying the payroll cost per ton of raw material by the total quantity of raw material processed monthly in the industry.

It should be noted that a large proportion of the pulp produced by the industry was obtained from the processing of fresh fruit, including passion fruit—which was evaluated during both the harvest and off-season periods—as well as pineapple, ambarella, and strawberry. In contrast, the processing of acerola, guava, soursop, mango, and grapes relied on both fresh fruit and frozen pulp purchased by the industry. Pulps such as açaí, mulberry, cocoa, cashew, orange, tangerine, lemon, cupuaçu, hog plum, and pitanga were obtained exclusively as secondary raw materials, i.e., frozen pulp. These pulps did not pass through the reception and processing sectors, and therefore no labor costs were incurred in these stages.

The total direct manufacturing cost per ton of product is calculated by summing the direct manufacturing costs of each ton of pulp.

Among the direct costs, raw materials constitute the most significant component for all products. According to information obtained from the owner and the analyzed data, this cost represents the largest share of cash flow expenditures (Table 1).

4 Results and Discussion

Table 2 presents the drivers and selection criteria for indirect manufacturing cost items for the products. The administrative sector is the only sector where labor is not directly associated with production. Consequently, the time driver represents the total monthly employee time required to produce the products, amounting to R$ 28,253.59. Thirteen employees are required to carry out these activities. For the remaining items in the cash flow, the driver is the average total cost for each sector, as obtained from information provided by the company.

Table 2. Description of the drivers, selection criteria, and monthly amounts of indirect cost items in the frozen fruit pulp industry for the year 2022.

INDIRECT COST DRIVERS			
ITEM	**DRIVERS**	**SELECTION CRITERIA**	**MONTHLY COST (R$)**
LB* administrative sector	Time	Cost varies according to the labor time required	28,253.59
Energy	Total cost per sector	Uses the average monthly energy expenditure for each industry activity	70,849.63
Equipment maintenance	Total cost per sector	Uses the average monthly expenditure on equipment maintenance for each industry activity	15,524.40
Infrastructure maintenance	Total cost per sector	Uses the average amount spent per month on infrastructure maintenance for each industry activity	6,455.46
Administrative	Total cost per sector	Uses the average monthly expenditure of the administrative sector for each industry activity	17,057.38
General supplies	Total cost per sector	Uses the average monthly expenditure on general inputs for each industry activity	20,000.00
Depreciation	Total cost per sector	Uses the general purchase price of the equipment	16,541.67
Outsourced services	Total cost per sector	Uses the average monthly cost of outsourced services for each industry activity	13,470.99

Legend: *LB: Labor.
Source: authors.

4.1 Proportion of indirect activity costs across the different sectors of the industry

Table 3 presents the proportional values of the total costs for the drivers used to allocate indirect costs among the different production sectors (activities) of the industry.

Table 3. Proportional values of total cost drivers related to indirect cost items by activity across the different sectors of the frozen fruit pulp industry.

	COST ITEMS	LB* administrative sector	Energy	Equipment maintenance	Infrastructure maintenance	Administrative	General supplies	Depreciation	Outsourced services
	DRIVERS	Time, h** (%)	Cost by sector (%)	Cost by sector (%)	Cost by sector (%)	Cost by sector (%)	Cost by sector (%)	Cost by sector (%)	Cost by sector (%)
ACTIVITIES	Reception and processing sector	0.0%	40.0%	32.0%	20.0%	0.0%	16.6%	15.8%	16.6%
	Preparation and filling sector	0.0%	10.0%	26.0%	20.0%	0.0%	16.6%	15.1%	16.6%
	Storage sector	0.0%	41.1%	38.5%	20.0%	0.0%	16.6%	67.7%	16.6%
	Packaging and shipping sector	0.0%	0.5%	3.0%	20.0%	0.0%	16.6%	1.0%	16.6%
	Administrative sector	100.0%	8.0%	0%	20.0%	100.0%	16.6%	0.0%	16.6%
	Transport sector	0.0%	0.0%	0%	0.0%	0.0%	16.6%	0.0%	16.6%

Legend: *LB: Labor, h**: hour.

According to Kabinlapat & Sutthachai (2017), identifying activities can be challenging because processes in the food industry involve numerous interconnected operations, which complicates their measurement. Therefore, in this study, the identification of activities followed the approach of Kabinlapat & Sutthachai (2017), based on the operating procedures of the production sectors and consultations with plant employees during the cost measurement of the activities.

4.2 Activities of the Reception and Processing Sector

Labor costs in the administrative sector are nil (0%), as employees in this sector do not directly participate in production activities.

The energy consumed in the reception and processing sector is attributed to equipment used for washing and sanitizing, selection and quality control conveyors, cutting and pulping machines, pumps, and other electrical devices such as control panels and scales. According to a company survey, this sector accounts for 40% of the industry's total energy consumption used to operate all equipment, based on energy usage, operational capacity, and operating time. This calculation also includes the energy costs associated with water treatment and pumping, as the company relies on artesian wells, with the total water consumption cost expressed in terms of electricity expenses.

The allocation of equipment maintenance costs across the industry sectors was based on the value of each piece of equipment, using an average of 1% of equipment value, except for cold rooms, which have high equipment values but require lower resources for basic maintenance, as noted by Silva et al. (2025). Accordingly, the reception and processing sector has equipment generating a total maintenance cost of R$ 4,967.80 per month, representing 32.0% of the industry's total maintenance expenditure. In contrast, the maintenance of sector infrastructure was distributed evenly among all five production sectors, representing 20% of the total maintenance expenditure, since the transportation sector does not utilize industry infrastructure (Table 3).

In the composition of costs for general inputs, the industry treats this expenditure as fixed, encompassing all resources necessary for company operations but not measurable in detail. These costs may include various processing line inputs, office supplies, emergency materials, personal protective equipment (PPE), and similar items. Consequently, spending on general inputs was distributed equally across all industry sectors, representing an average of 16.6% per sector.

Depreciation costs were applied to all equipment operating in each processing sector of the industry and allocated proportionally based on the quantity and value of equipment in each sector. Depreciation was calculated assuming an annual loss of 10% of the equipment value, equivalent to 0.83% per month. The monthly depreciation for all industry equipment amounts to R$ 16,541.67 (Table 1). In the reception and processing sector, ten pieces of equipment with a total value of R$ 315,000.00 result in a monthly depreciation of R$ 2,614.50, representing 15.8% of the industry's total monthly equipment depreciation (Table 3).

Outsourced services encompass costs related to waste disposal, laboratory analyses, accounting, pest control, consultancy, brokers, and other services not specifically detailed by the company but which support all industrial activities. These costs were allocated equally among all activities, resulting in a share of 16.6% per activity (Table 3).

4.3 Activities of the Preparation and Filling Sector

Labor costs for the administrative sector in this activity are nil (0%), as employees do not directly participate in the preparation and filling operations (Table 3).

Energy consumption in the preparation and filling sector is associated with pumping operations in pipes and tanks, two refrigerated tanks with agitators, and five electric filling machines. Despite this, the activity consumes less energy and water than the reception and processing sector. Consequently, it accounts for 10% of the industry's total energy consumption, corresponding to R$ 7,085.00, in agreement with the data provided by the company accounts.

Equipment maintenance costs in this sector correspond to 1% of the total equipment value, equivalent to R$ 4,000.00, representing 26.0% of total maintenance expenditures. On average, 20% of the total maintenance value is allocated to infrastructure maintenance. Costs for general supplies and outsourced services were evenly distributed across sectors, representing an average of 16.6% per sector (Table 3).

The preparation and filling sector utilizes equipment valued at R$ 300,000.00. Considering a monthly depreciation rate of 0.83%, the resulting monthly depreciation amounts to R$ 2,490.00, representing 15.1% of the total equipment depreciation.

4.4 Activities of the Storage Sector

Labor costs for the administrative sector in this activity are nil (0%), as employees do not directly participate in storage operations (Table 3).

During the daily processing period, the pulp freezing tunnels operate for an average of 160 hours per month, after which the products are stored in cold storage chambers. The cold rooms, however, operate continuously for 24 hours a day, totaling 720 hours per month without temperature fluctuations.

According to manufacturers of this type of equipment (RESFRIAR, 2026), a cold storage or freezing room of the size used in the industry (approximately 5.7 m × 5.4 m × 2.4 m) consumes between 5.00 kW/h and 15.00 kW/h on average. Considering the quantities, dimensions of the tunnels and chambers, and the storage or freezing time of the products, the energy cost of a freezing tunnel was calculated using the maximum power value, resulting in 2,400 kW per month. An average power of 10.00 kW/h was used for the cold rooms, meaning each cold room consumes 7,200 kW per month.

The conventional electricity tariff in Espírito Santo in 2022 was R$ 0.674 per kW/h. Consequently, the monthly expenditure for three freezing tunnels amounted to R$ 4,852.80, and for five cold rooms, R$ 24,264.00, totaling R$ 29,116.80. This represents 41.1% of the industry's total energy expenditure (Table 3).

The monthly cost of maintaining the cold rooms and freezing tunnels, as reported by the company's accounting office, was R$ 5,974.40, corresponding to 38.5% of the industry's total equipment maintenance costs. On average, 20% of the total maintenance expenditure is allocated to infrastructure. Costs for general inputs and outsourced services were evenly distributed across all sectors, representing an average of 16.6% per sector (Table 3).

The storage sector operates equipment valued at R$ 1,350,000.00. Applying a monthly depreciation rate of 0.83% results in a depreciation cost of R$ 11,205.00, representing 67.7% of the total depreciation of the industry's equipment (Table 3).

4.5 Activities of the Packaging and Shipping Sector

Labor costs for the administrative sector in this activity are nil (0%), as employees do not directly participate in packaging and shipping operations (Table 3).

The packing and shipping department operates only one piece of electrical equipment (a packing conveyor) and a scale, resulting in low energy consumption. The conveyor functions

upon receipt of customer orders from the sales department, allowing the pulp to be packaged and moved to dispatch chambers. For this activity, energy costs were estimated at 0.5%, equivalent to R$ 354.25 per month.

Equipment maintenance costs for this activity amount to R$ 500.00, representing 3.0% of the industry's total maintenance expenditures. On average, 20% of the total maintenance is allocated to infrastructure. Costs for general supplies and outsourced services were evenly distributed across all sectors, averaging 16.6% per sector (Table 3).

This activity uses equipment valued at R$ 20,000.00. Applying a monthly depreciation rate of 0.83% results in a depreciation cost of R$ 166.00, corresponding to 1% of the total maintenance expenditure (Table 3).

4.6 Activities of the Administrative Sector

This activity involves 100% of the workforce dedicated to the administration of the industry, including employees responsible for purchasing, sales, and human resources, as well as engineers, bricklayers, security guards, cleaners, and delivery drivers. The cost corresponds to the total monthly salaries of these employees, each working 160 hours per month.

Costs attributed to the administrative sector include software licenses, telephony and internet services, certain legal services, computer and air conditioning maintenance, vehicle maintenance and depreciation, rent, travel expenses, and other administrative expenditures. The total administrative cost is fully allocated to this activity (100%) (Table 3).

The administrative sector does not have equipment contributing to maintenance costs (0%). Infrastructure maintenance accounts for an average of 20% of the total value. Costs for general supplies and outsourced services were evenly distributed across all sectors, representing an average of 16.6% per sector (Table 3).

4.7 Activities of the Transport Sector

Labor costs for the administrative sector in this activity are nil (0%), as employees do not directly participate in transport operations (Table 3).

The only expenditures associated with the transport sector are general inputs and outsourced services, which were evenly distributed across all sectors, representing an average of 16.6% (Table 3). Costs related to energy, equipment maintenance and depreciation, and infrastructure are not attributed to the transport sector, as these activities occur externally to the industry. However, maintenance of the vehicles (cars and trucks) used in this sector is included under the administrative sector.

4.8 Allocation of Costs by Activity

The allocation of costs by activity (Table 4) was performed based on the proportional values of total cost drivers for the indirect cost items across the various industry sectors (Table 3), as described in Equation 1.

$$C = P_{at} * TC / 100 \quad (1)$$

C represents the cost assigned to the activity; *Pat* denotes the proportion of the resource consumed by the activity; and *TC* is the total cost of the expenditure item.

Table 4. Determination of Total Cost (TC, R$/t of raw material) and Indirect Costs (R$) of expenditure items by activity across the different sectors of the frozen fruit pulp industry, based on 2022 expenditures.

	COST ITEMS	LB* Administrative sector (R$)	Energy (R$)	Equipment maintenance (R$)	Infrastructure maintenance (R$)	Administrative (R$)	General inputs (R$)	Depreciation (R$)	Outsourced services (R$)	TC (R$/t*)
ACTIVITIES	Reception/ processing sector	0.00	28,453.67	4,992.77	1,291.09	0.00	3,333.33	2,624.61	2,245.17	274.65
	Preparation/ filling sector	0.00	7,113.42	4,056.63	1,291.09	0.00	3,333.33	2,500.02	2,245.17	124.40
	Storage sector	0.00	29,236.14	6,006.93	1,291.09	0.00	3,333.33	11,250.92	2,245.17	323.21
	Packaging/ shipping sector	0.00	355.67	468.07	1,291.09	0.00	3,333.33	166.11	2,245.17	47.60
	Administrative sector	28,253.59	5,690.73	0.00	1,291.09	17,057.38	3,333.33	0.00	2,245.17	350.51
	Transport sector	0.00	0.00	0.00	0.00	0.00	3,333.33	0.00	2,245.17	33.79
	TOTAL	28,253.59	70,849.63	15,524.40	6,455.46	17,057.38	20,000.00	16,541.67	13,470.99	1,139.59

Legend: LB*: Labor; t*: ton; TC: Total Cost per ton of Raw Material. The average currency exchange rate for 2022 was 1 USD = 5.16 BRL (Instituto de Pesquisa Econômica Aplicada, 2023).

In this study, it was considered that the total cost per ton of raw material associated with the reception and processing sector does not apply to certain raw materials—namely, acai, cocoa, cashew, orange, tangerine, lemon, cupuaçu, hog plum, and pitanga—since the company only purchases frozen pulp for packaging, totaling 8.67 tons. Consequently, costs for this sector were disregarded for these raw materials. For the remaining raw materials, totaling 165.1 tons, the total cost per ton included all activities across the different industry sectors (Table 4).

It should be noted that breaking down the cost of expenditure items by activity enabled the calculation of the cost per ton of raw material, which is the primary asset to be transformed into the final product. As shown in Table 4, the highest total cost per activity is associated with the indirect costs of the administrative sector, followed by those of the storage sector. This is attributable to indirect labor costs and the allocation of resources for plant administration, which are fully assigned to the administrative sector, resulting in the highest total cost per ton of raw material processed. The storage sector incurs high costs in energy, equipment maintenance, and depreciation, due to having the most expensive equipment in the plant, thereby increasing the total cost per ton of raw material.

Munaretto & Diedrich (2007) report that the ABC costing methodology enables the determination of the costs of company activities, allowing for the assessment of each activity's influence on the composition of industry revenues.

Based on the monthly indirect costs per activity (Table 4), the indirect manufacturing cost per product for each activity was calculated (Table 5), as described in Equation 2.

$$CA = \frac{X*Y}{M} \quad (2)$$

CA represents the cost of the activity for each product (R$); X denotes the total cost per ton of raw material for each activity (R$/t); Y is the quantity of raw material (t) purchased per month for the production of each product; and M is the total quantity (t) of raw material purchased per month by the industry.

Finally, the total cost associated with all activities involved in processing each ton of product was calculated, as described in Equation 3.

$$FPV = \frac{\sum CA}{p} \quad (3)$$

FPV represents the total cost per ton of final product (R$/t); CA denotes the cost of the activity per product (R$); and p is the quantity of product produced (t).

Table 5 shows that, although passion fruit pulp is assigned different raw material costs for the harvest and off-season periods, it is treated as a single product with identical indirect costs for each production activity.

Indirect costs per production activity varied significantly among the raw materials, with passion fruit pulp exhibiting the highest total cost (Table 5). It should be noted that the costs for activities in the preparation and filling, storage, packing, shipping, and transportation sectors encompass all items required for producing all types of pulp in the industry, including raw materials used for extraction as well as secondary raw materials purchased as frozen pulp. The primary factor influencing differences in costs per activity for each type of pulp is the extraction yield, which determines the actual amount of pulp processed. Consequently, the total value obtained from Equation 2 must be multiplied by the pulp yield—for instance, guava processing has an extraction yield of 90%, which represents the quantity of pulp available for use by the industry.

Table 5. Determination of Indirect Costs per Activity in each manufacturing sector and Total Costs (TC, R$/t) for different types of fruit pulp, based on 2022 Expenditures.

Products	Reception and processing sector (R$)	Preparation and filling sector (R$)	Storage sector (R$)	Packaging and shipping sector (R$)	Administrative sector (R$)	Transport sector (R$)	TC (R$/t*)
Passion fruit pulp in harvest	72.85	9.90	25.72	3.79	92.98	2.69	207.93
Passion fruit pulp in the off season	72.85	9.90	25.72	3.79	92.98	2.69	207.93
Pineapple pulp	32.31	10.25	26.62	3.92	41.24	2.78	117.13
Acai pulp	0.00	0.13	0.34	0.05	0.37	0.04	0.93
Acerola pulp	44.46	17.12	44.48	6.55	56.75	4.65	174.02
Mulberry pulp	0.51	0.23	0.60	0.09	0.65	0.06	2.15
Cocoa pulp	0.00	0.36	0.94	0.14	1.02	0.10	2.56
Ambarella pulp	8.54	2.71	7.04	1.04	10.90	0.74	30.97
Cashew pulp	0.00	1.80	4.68	0.69	5.08	0.49	12.74
Guava pulp	25.17	10.26	26.66	3.93	32.13	2.79	100.94
Soursop pulp	40.86	12.03	31.26	4.60	52.16	3.27	144.19
Orange pulp	0.00	0.38	0.97	0.14	1.06	0.10	2.65
Mango pulp	34.11	8.50	22.06	3.25	43.54	2.31	113.78
Strawberry pulp	6.58	2.68	6.97	1.03	8.40	0.73	26.39
Tangerine pulp	0.00	0.18	0.47	0.07	0.13	0.05	0.89
Grape pulp	3.21	1.45	3.78	0.56	4.10	0.39	13.49
Lemon pulp	0.00	1.20	3.11	0.46	3.38	0.33	8.47
Cupuaçu pulp	0.00	1.40	3.63	0.53	3.93	0.38	9.86
Hog plum pulp	0.00	1.11	2.87	0.42	3.12	0.30	7.82
Pitanga pulp	0.00	0.17	0.43	0.06	0.47	0.05	1.17

Legend: t*: ton; TC: Total Cost per ton of Raw Material. The average currency exchange rate for 2022 was 1 USD = 5.16 BRL (Instituto de Pesquisa Econômica Aplicada, 2023).

The acai, cocoa, cashew, orange, tangerine, lemon, cupuaçu, hog plum, and pitanga pulps do not incur costs in the reception and processing activity, as these raw materials are purchased by the industry as frozen pulp (secondary raw materials) and are directed straight to the preparation and filling sector.

The total cost per ton of raw material accounts for each product's pulp yield, as raw material expenditure includes the total fruit load used by the industry. For instance, processing 43.8 tons of passion fruit typically yields 13.14 tons of pulp (30% extraction), while 19.43 tons of pineapple produce 13.6 tons of pulp (70% extraction). Consequently, the indirect cost per activity for passion fruit pulp is higher than that for pineapple pulp (Table 5). Although both fruits pass through the same activities in all production sectors as primary raw materials, the volume of passion fruit processed in the reception and processing sector is more than double that of pineapple, resulting in a higher total cost for passion fruit pulp.

It is worth noting that this result does not imply that the total cost of producing these pulps indicates lower profitability for pineapple compared to passion fruit, or vice versa, as direct costs have not yet been considered.

The total manufacturing cost of the products, encompassing both direct and indirect costs (by activity), is presented in Table 6. It represents the sum of direct costs and the indirect costs allocated to each activity.

Table 6. Direct Costs (DC), Indirect Costs (IC), IC/DC Ratio (%), and Total Manufacturing Costs (R$/t) of frozen fruit pulp products, based on 2022 expenditures.

Products	Direct costs (R$)	Indirect costs (R$)	IC*/DC* ratio (%)	Total Cost (R$/ t*)
Passion fruit pulp in harvest	15,802.64	207.93	1.32	16,010.57
Passion fruit pulp in the off season	19,203.65	207.93	1.08	19,411.59
Pineapple pulp	5,973.84	117.13	1.96	6,090.97
Acai pulp	4,913.10	0.93	0.02	4,914.03
Acerola pulp	5,819.65	174.02	2.99	5,993.67
Mulberry pulp	8,902.65	2.15	0.02	8,904.80
Cocoa pulp	2,625.93	2.56	0.10	2,628.49
Ambarella pulp	5,065.52	30.97	0.61	5,096.49
Cashew pulp	2,041.43	12.74	0.62	2,054.17
Guava pulp	2,698.76	100.94	3.74	2,799.70
Soursop pulp	6,572.30	144.19	2.19	6,716.49
Orange pulp	2,756.52	2.65	0.10	2,759.17
Mango pulp	2,795.94	113.78	4.07	2,909.72
Strawberry pulp	2,998.27	26.39	0.88	3,024.66
Tangerine pulp	1,457.39	0.89	0.06	1,458.28
Grape pulp	6,282.39	13.49	0.22	6,295.88
Lemon pulp	4,195.60	8.47	0.20	4,204.07
Cupuaçu pulp	4,310.08	9.86	0.23	4,319.95
Hog plum pulp	5,607.73	7.82	0.14	5,615.55
Pitanga pulp	9,591.20	1.17	0.01	9,592.37

Legend: t*: ton; IC*: Indirect cost; DC*: Direct cost. Average currency conversion rate for 2022: 1 USD = 5.16 BRL (Instituto de Pesquisa Econômica Aplicada, 2023).
Source: authors.

Direct costs constitute the largest portion of the total product cost (Table 6), as raw materials are the most significant expense in the fruit pulp industry, followed by labor costs (Silva et al., 2025).

According to Ferreira & Leite (2022), the direct cost of raw materials exceeds the total indirect manufacturing cost, highlighting the significant impact of raw materials on projects and the challenges companies face in reducing manufacturing costs when direct costs are difficult to control.

The total cost per ton of passion fruit pulp purchased in the off-season can reach up to three times that of pineapple, soursop, and acerola pulps, which are processed from fresh fruit in the industry (Table 6). Pitanga pulp, purchased as frozen pulp from other industries, has the second-highest total cost among the pulps processed by the company. However, it exhibits the lowest indirect manufacturing cost, with an IC/DC ratio of 0.01%.

Mango pulp exhibited the highest IC/DC ratio, four times greater than that of passion fruit pulp produced from fruit purchased during the agricultural season. Although indirect production costs are higher for passion fruit, its lower extraction yield (30%) compared to mango pulp (55%) results in significantly higher direct production costs for passion fruit (Table 6).

Table 7 presents the profit data obtained from the ABC costing analysis for the different types of frozen fruit pulp. Total revenue and total manufacturing cost for each pulp type are highlighted, with monthly profit calculated as the difference between them. The net profit margin for each pulp is expressed as the ratio of its monthly profit to the industry's total revenue.

Table 7. Income statements for Total Revenue (TR), Total Manufacturing Cost (TMC), Monthly Profit (MP), and Net Margin (% MP/TR) for each fruit pulp, relative to the industry's total revenue, based on 2022 expenditure data.

Product	Revenue/t* (R$)	Total Revenue (R$)	Manufacturing costs/t* (R$)	Total Manufacturing Cost (R$)	Monthly Profit (R$)	Net Margin (%)
Passion fruit pulp in harvest	13,851.81	178,390.77	16,010.57	206,192.40	-27,801.63	**-3.09**
Passion fruit pulp in the off season	13,851.81	178,390.77	19,411.59	249,992.40	-71,601.63	**-7.97**
Pineapple pulp	6,529.09	45,596.32	6,090.97	42,536.67	3,059.65	**0.34**
Acai pulp	12,288.19	3,892.90	4,914.03	1,556.76	2,336.14	**0.26**
Acerola pulp	7,030.11	86,703.68	5,993.67	73,921.02	12,782.65	**1.42**
Mulberry pulp	16,342.00	5,187.77	8,904.80	2,826.83	2,360.94	**0.26**
Cocoa pulp	8,240.14	10,302.51	2,628.49	3,286.35	7,016.16	**0.78**
Ambarella pulp	7,390.40	18,353.32	5,096.49	12,656.62	5,696.70	**0.63**
Cashew pulp	6,386.34	42,590.05	2,054.17	13,699.13	28,890.92	**3.21**
Guava pulp	5,748.86	75,804.42	2,799.70	36,916.89	38,887.53	**4.33**
Soursop pulp	9,013.75	98,511.92	6,716.49	73,405.00	25,106.93	**2.79**
Orange pulp	8,313.02	10,702.33	2,759.17	3,552.21	7,150.12	**0.80**
Mango pulp	6,346.52	111,492.64	2,909.72	51,116.64	60,376.00	**6.72**
Strawberry pulp	10,467.51	140,720.02	3,024.66	40,661.96	100,058.06	**11.13**
Tangerine pulp	6,819.53	11,020.47	1,458.28	2,356.61	8,663.86	**0.96**
Grape pulp	8,937.44	17,087.35	6,295.88	12,036.99	5,050.37	**0.56**
Lemon pulp	7,371.05	11,719.60	4,204.07	6,684.25	5,035.34	**0.56**
Cupuaçu pulp	8,014.34	14,840.82	4,319.95	7,999.60	6,841.22	**0.76**
Hog plum pulp	8,308.04	12,196.06	5,615.55	8,243.53	3,952.53	**0.44**
Pitanga pulp	17,360.03	3,817.47	9,592.37	2,109.36	1,708.11	**0.19**
Total		**898,930.43**				**28.19** TNM** **33.06** TNM***

Legend: t*: ton; TNM**: Total Net Margin of passion fruit pulp in the off-season; TNM***: Total Net Margin of Passion Fruit Pulp in the Harvest Season. Average exchange rate for 2022: 1 USD = 5.16 BRL (Instituto de Pesquisa Econômica Aplicada, 2023).

Sales revenue for each pulp type was used to calculate monthly profit. The sales price is a key factor in ensuring market competitiveness, serving as the industry's commercial strategy relative to competitors. In this context, net profit margins for each pulp can be adjusted to enhance business viability. Table 7 shows that passion fruit pulp is less profitable in the off-season than during the harvest, even though both exhibit negative net margins. This is primarily due to higher direct production costs, particularly raw material costs, in the off-season. According to the Associação Brasileira das Centrais de Abastecimento (2024), passion fruit prices can drop by up to 35% during the harvest season compared to the off-season.

The product with the highest net margin in 2022 was strawberry pulp, which, despite having lower revenue per ton than passion fruit pulp, benefits from a high extraction yield of 90%, compared to 30% for passion fruit. Mango pulp, in contrast, achieved a net margin of 6.72% with an extraction yield of 55%.

The data presented in Table 7 correspond to the 2022 cash flow. These figures are influenced by factors such as harvest and off-season periods and the total volume of raw materials processed in the industry. According to Silva et al. (2025), increasing the amount of raw material processed reduces idle capacity and improves economic performance indicators. Consequently, net profit margins may vary depending on idle processing capacity, and under conditions of high idle capacity, revenue may be insufficient to cover production costs (Richartz & Borgert, 2014).

This study highlights that passion fruit pulp incurs a loss when sold individually (negative net margin); however, the industry considers it a product with competitive appeal in the frozen fruit pulp market. Overall, the company operates with a positive net profit margin, reaching up to 33.06% during the passion fruit harvest season (Table 7).

Pricing strategies can be applied across product lines. According to Cogan (1999), captive pricing aims to increase profits by selling complementary products at higher prices while keeping basic products relatively inexpensive, thereby maximizing the overall profit of the product line. Another approach, bait-and-switch pricing, involves offering a highly desirable product at a low price to attract customers and redirect them toward purchasing additional products.

Quesado & Silva (2021) highlight that the ABC costing method has evolved over the years and now provides a strategic perspective, enabling companies to identify strengths and weaknesses and understand organizational dynamics. This study illustrates how the results reveal the entrepreneur's overall profit-making approach while offering sufficient information to adjust strategies if necessary.

5. Conclusions

The ABC costing analysis showed that direct costs, mainly those related to raw materials, represent about half of the total production cost in the frozen fruit pulp industry. Indirect costs were mostly concentrated in the administrative and storage sectors, strongly influenced by energy consumption.

Seasonality significantly affected profitability, particularly for passion fruit pulp, which presented negative margins in both harvest (-3.09%) and off-season (-7.97%) periods. However, the company maintained positive overall results (33.06% and 28.19%, respectively) due to efficient production capacity use and product diversification.

In general, the study highlights that raw material costs, seasonal price variation, extraction yield, and idle capacity management are key factors in the industry's economic performance. The findings reinforce the need for effective cost control and adaptive pricing strategies. Future research should include more companies and explore sustainability, technological innovation, and supply chain improvements to strengthen competitiveness in the sector.

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LMS: Data collection, Analysis and interpretation, writing of the manuscript. ACR: Analysis and interpretation. EDR: Conception/design of the study, Analysis and interpretation, critical review.

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