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TECHNICAL AND ECONOMIC FEASIBILITY STUDY FOR IMPROVING COCOA PRODUCTION – CASE STUDY IN NOVO REPARTIMENTO – PA, BRAZIL

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ABSTRACT

Cocoa production significantly contributes to Brazil's economy, as the country is the seventh largest cocoa producer in the world. A substantial portion of Brazil's cocoa production comes from family farming, where cocoa bean processing relies on artisanal methods and manual labor. Therefore, there is a need to enhance technology in cocoa bean production, seeking even incremental innovations to increase productivity. This article presents a technical and economic feasibility study for implementing a new management system in the cocoa bean fermentation process on a farm in Novo Repartimento, Pará State (Brazil). The study aims to increase bean production for further processing, suggesting that these changes will improve productivity, reduce costs, and ultimately achieve greater profitability.

INTRODUCTION

Cacao (*Theobroma cacao* L.) originates from the Amazon basins and is currently cultivated in several tropical countries. The dominant species of *T. cacao* L. are Criollo, Forastero, and Trinitario, out of the 22 species in this genus (Balentic et al., 2018). Cocoa has significant economic and social importance worldwide (Franco et al., 2019). Côte d'Ivoire is the world's leading producer, followed by Ghana, accounting for 39% and 4.6% of global cocoa production, respectively (STATISTA, 2022; FAO, 2020). Brazil ranks as the seventh-largest cocoa producer. Cocoa production boosts the economy because, besides being used to manufacture chocolate, cocoa beans produce cocoa powder and cocoa butter, the latter widely used in the food, pharmaceutical, and cosmetics industries. However, Brazil once held higher positions in the ranking. Until the mid-1970s, Brazil was the largest cocoa producer in the world, producing 350,000 tons annually. This ended abruptly in 1989 due to witches' broom disease caused by the fungus *Crinipellis perniciosa*, which devastated cocoa plantations, especially in Bahia, the main producing state at the time, leading to a sharp decline in production and the collapse of thousands of farms (Teixeira et al., 2015). Through

agrotechnology, clones and hybrid seeds resistant to witches' broom were developed (Guimarães et al., 2022). Since then, national production has been recovering, with Pará and Bahia now the main producing states (Franco et al., 2019). However, production still does not meet demand, making the country an importer.

Currently, 90% of the world cocoa market is sustained by bulk cocoa production, while the remaining 10% consists of fine-flavored cocoa (Cocoa of Excellence, 2022). Fine-flavor cocoa refers to beans with a softer flavor, aromatic quality, and low bitterness, derived from high-quality production with proper practices during processing stages (Santos et al., 2020; Beckett, 2009; Afoakwa, 2014). Internationally recognized, fine-flavored cocoa has high added value and can reach prices up to three times higher than bulk cocoa (Papalexandratou et al., 2019). In Brazil, a significant portion of cocoa production originates from family farming, where cocoa bean processing is done using artisanal methods, predominantly relying on human labor (Higuchi et al., 2022). Consequently, there is a need for process optimization and increased efficiency to achieve high productivity and quality. Actions to improve processes include mechanization and physical rearrangement to increase production and better control of process variables.

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Examples include planting and pruning equipment (FGV, 2019), machines designed to facilitate the extraction of cocoa beans and reduce accidents (Josué et al., 2019; Srikanth et al., 2020), mechanical and automatic fermenters that reduce handling efforts and allow temperature control (Koffi et al., 2017; Rivera & Valdivia, 2018), and dryers that reduce drying area and worker exposure to the sun (Santos et al., 2014). Despite these efforts, there remains a strong need to optimize cocoa bean processing to increase production and profitability. The value of investing in technologies for production processes necessitates an economic feasibility study to avoid losses for farmers. An example is Andrade et al. (2021), who conducted a study to encourage farmers in southern Bahia, aimed at generating income and environmental recovery of the Atlantic Forest. In economic feasibility analysis, Dobbs (1988) outlines four main components: (1) cost estimates, (2) examination of markets for the product or service, (3) analysis of pricing possibilities, and (4) analysis of profit potential and break-even points.

Based on the foregoing, this article presents a technical and economic feasibility study for a new management system for the cocoa bean fermentation process at a farm producing both fine and bulk cocoa, located in Novo Repartimento, Pará State (Brazil). The project aims to increase production and improve processing. Production indexes of the farm were evaluated to estimate

future production results, along with costs of inputs and labor, to determine revenue and profit from the implementation of cocoa pod breaking automation and physical rearrangement in the fermentation and drying stages, and thus determine the investment's break-even point.

MATERIAL AND METHODS

Current processing process at the case study farm

The studied farm is located in Novo Repartimento, PA, and has a plantation area of approximately 55 hectares (550,000 m²), with 30 hectares of trees currently in production and 25 hectares of new trees expected to produce in 2 or 3 years. During the harvest season, monthly production is 7,300 kg, dropping to 1,500 kg in the off-season. Total annual production is 55 tons. The farm is expected to reach maximum production in 3 years, when the young seedlings mature, yielding around 100 tons of fine cocoa per year.

The farm's current processing facility is simple and built based on empirical knowledge. Consequently, the plant lacks a consistent production flow and has no expansion potential. Figure 1 shows the farm's fermentation house and drying area. The processing on the farm occurs in five main stages, as shown in the flowchart in Figure 2 and described below.



FIGURE 1. Fermentation house and drying area in the experimental farm.

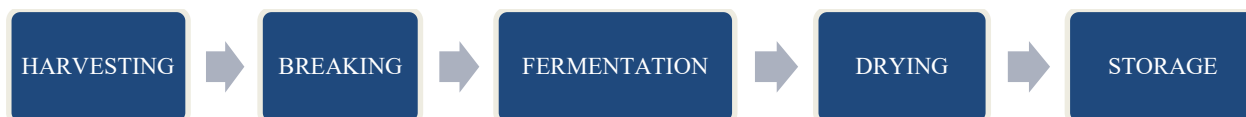


FIGURE 2. Process flowchart.

The first step in cocoa processing is harvesting, where only ripe pods are meticulously selected based on their sugar content, a crucial factor for successful fermentation. Pod maturity directly affects the bitterness, astringency, and pH of resulting cocoa beans (De Vuyst & Leroy, 2020). After harvesting, pods are carefully heaped within the plantation and subsequently cracked open. This critical stage demands meticulous handling to prevent damage to the beans nestled within the pulp and to ensure minimal contamination.

The experimental farm relies on manual labor for harvesting and cracking cocoa pods. Workers use machetes,

large knives specifically designed for agricultural tasks. A breaking rate of 360 kg h⁻¹ is achieved on the farm. Harvesting occurs in three distinct periods, while pod breaking is conducted in two. Each breaking session typically fills three wooden fermentation boxes lined up in a row. Table 1 details the farm's schedule for harvesting and breaking activities during a typical work week within the harvest months. It is important to note the highlighted discontinuity (shaded gray) in the breaking activity between Tuesday and Wednesday. This overnight gap creates an incomplete production line, necessitating the use of a

separate line for the cocoa beans broken on Wednesday morning to prevent them from mixing with the previous day's cocoa mass.

On the same day as breaking, beans must be transported for fermentation. To do so, two tractors are used to transport them from the plantation area to the

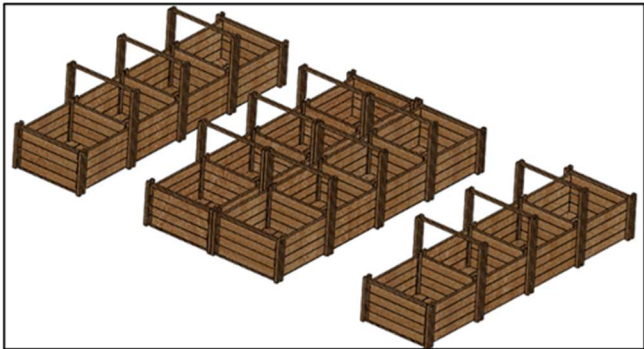
fermentation house, in addition to other agricultural activities. Fermentation occurs in square inert wooden boxes with a volumetric capacity of 0.8 m³ (Figure 3a). The farm has four production lines, each with three boxes for filling and one empty box for agitation. Figure 3b illustrates the current fermentation setup on the farm.

TABLE 1. Farm activities for one week.

Day	Period	Activity
Monday	Morning	Harvesting
	Afternoon	
Tuesday	Morning	Breaking
	Afternoon	
Wednesday	Morning	Breaking
	Afternoon	
Thursday	Morning	Harvesting
	Afternoon	
Friday	Morning	Breaking
	Afternoon	



(a)



(b)

FIGURE 3. Farm's fermentation setup. (a) Fermentation room. (b) Fermentation filling boxes.

Box filling is fragmented due to the lengthy cocoa-breaking process (6 days), which hampers production fluidity and prevents the fermentation plant from being used to its fullest potential. The Gantt diagram (Figure 4)

illustrates how the farm's boxes are filled over 21 days, with the horizontal bars representing the fermentation time. It shows that lines remain empty for 2 to 5 days between fermentation rounds.

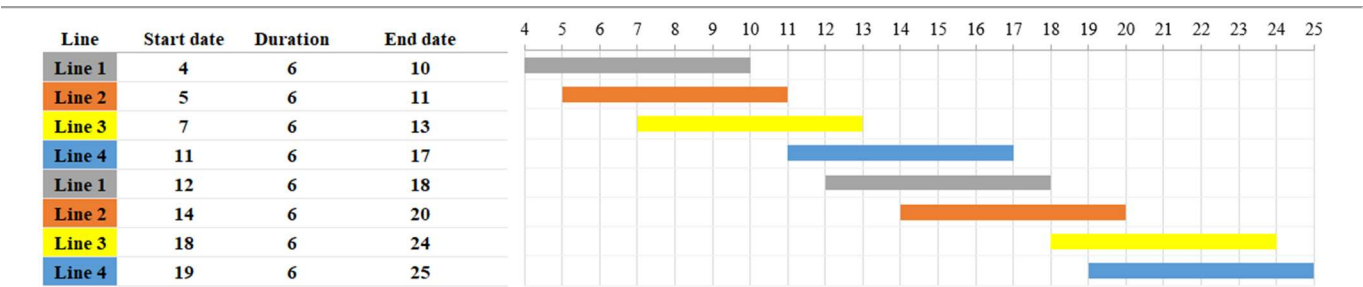


FIGURE 4. Gantt diagram for box filling used on the farm.

After the fermentation stage, the drying process begins to reduce the moisture content in beans from 50% to 7%. This process can be done artificially using wood-fired ovens or naturally with solar heat on drying platforms. These platforms can be flat structures made directly on the ground or suspended with a movable cover system to protect the beans from rain and ultraviolet rays (Schlüter et al., 2019).

The experimental farm uses a natural drying system, with platforms measuring 1.40 m wide by 12 m long (Figure 5a). Each batch of cocoa mass from one box requires two drying platforms. During the process, six boxes are filled per week, requiring 12 platforms to hold the entire weekly production. However, since the farm only has eight platforms, the excess cocoa mass is placed on a tarpaulin on the ground. Figure 5b illustrates the farm's drying facility.

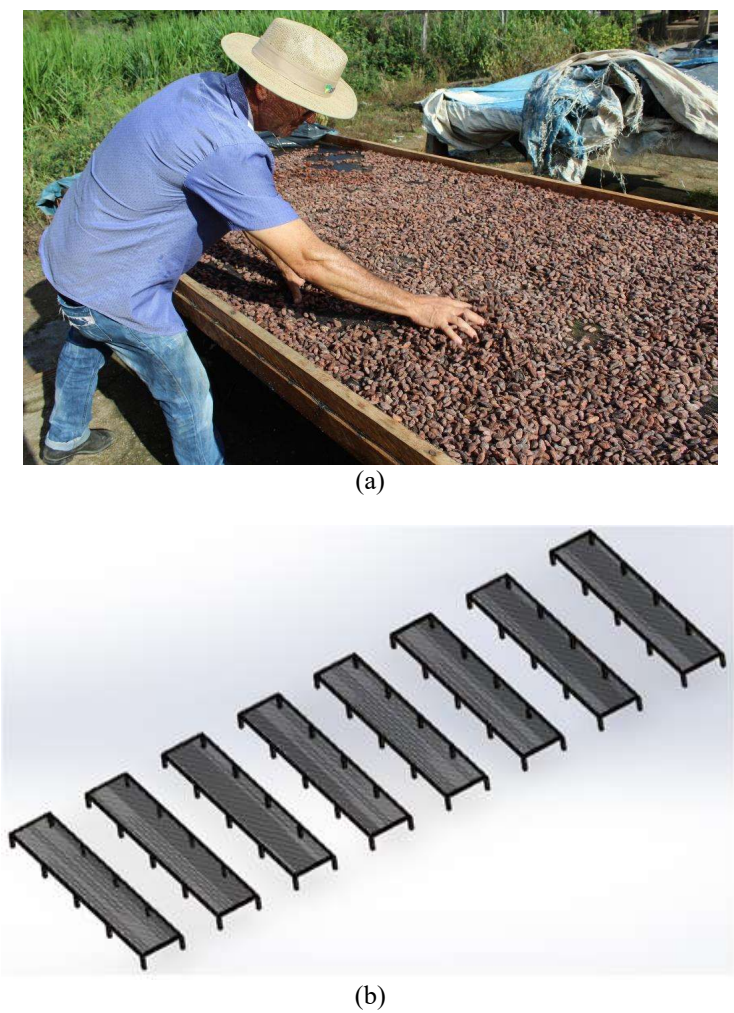


FIGURE 5. Farm drying setup. (a) Cocoa beans on the drying platforms. (b) Illustration of the drying setup.

After drying, the beans are packed into sacks and transported to the warehouse. Storage should occur in a dry, well-ventilated area with natural lighting, protected from insects and rodents, preferably on a wooden floor (Hamdouche et al., 2019).

On the farm, storage is done in a wooden shed with a dirt floor; a record of the warehouse can be seen in Figure 6. Inputs used on the farm, such as fuel, minerals, and lubricants, are also stored in the same location. This exposure is detrimental, as the cocoa absorbs odors from the environment.



FIGURE 6. Sacks of cocoa beans in storage.

Improvement Project

To maximize cocoa yield and reduce processing time, the farm plans to acquire a cocoa pod breaking machine (Figure 7) with a breaking rate of 1200 kg wet mass per hour. This equipment reduces pod processing time

by approximately 70% compared to manual labor. Additionally, the purchase of an agricultural cart is proposed, which will be attached to the tractor to assist in transporting the harvested cocoa. Another plan is to use cocoa shells in power generation (Bandeira et al., 2023).



FIGURE 7. Cocoa pod breaking machine.

The machine will be installed near the fermentation area, which will undergo a physical rearrangement to accommodate both stages. The space will measure 20 by 8.36 meters with a height of 4.5 meters. Figure 8 illustrates the design of the fermentation warehouse.

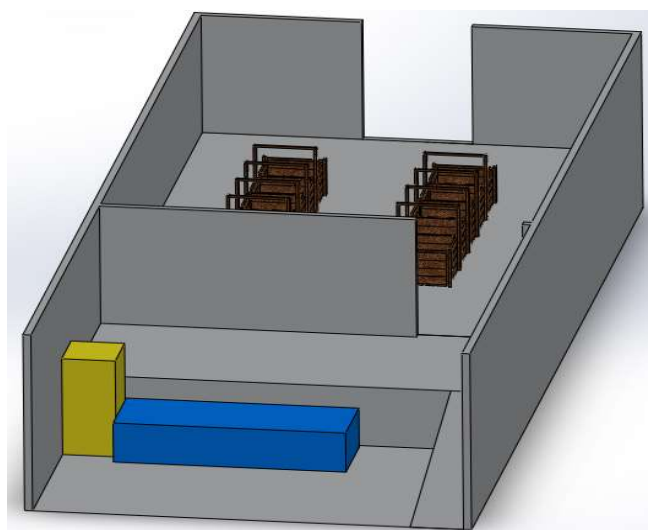


FIGURE 8. Isometric drawing of the fermentation warehouse.

The machine will ensure that the farm experiences only two instances of cocoa pod breaking per week, maintaining consistent harvest times. Table 2 summarizes the optimized activity schedule proposed, accounting for

the reduced time required for cocoa pod breaking with the machine's implementation. Notably, the breaking activity will occur within a single timeframe on both Wednesday and Friday.

TABLE 2. Optimized activity schedule proposed.

Day	Period	Activity
Monday	Morning	Harvesting
	Afternoon	
Tuesday	Morning	Harvesting
	Afternoon	
Wednesday	Morning	Breaking
	Afternoon	
Thursday	Morning	Harvesting
	Afternoon	
Friday	Morning	Breaking
	Afternoon	

By optimizing the layout, the boxes can be filled on Wednesday mornings and Friday afternoons. The proposed fermentation plant will feature two lines, each designated for a specific breaking batch. The design allows for future expansion by adding more boxes, meeting the projected annual demand. Figure 9 illustrates the proposed layout model. This model keeps the number of lines constant while increasing the number of boxes on each line. This physical rearrangement ensures that each breaking batch immediately supplies a fermentation line, and another line will always be available at the end of fermentation. This approach facilitates better space utilization, a more even distribution of boxes, and enhanced fermentation capacity.

The platforms will be resized to 2.20 meters in width by 12 meters in length and will be organized linearly, with each line accommodating the quantity of cocoa that emerges from a fermentation line. This change reduces the number of platforms and, consequently, the need for corridors between them, freeing up space for a small agricultural trailer to move (see Figure 10a). Figure 10b shows the dimensions of the trailer, featuring side lids with hinges that can open at an angle to facilitate cocoa distribution onto the platforms. These adjustments will streamline operations, ensuring a smooth transition from one activity to the next, and maximizing efficiency.

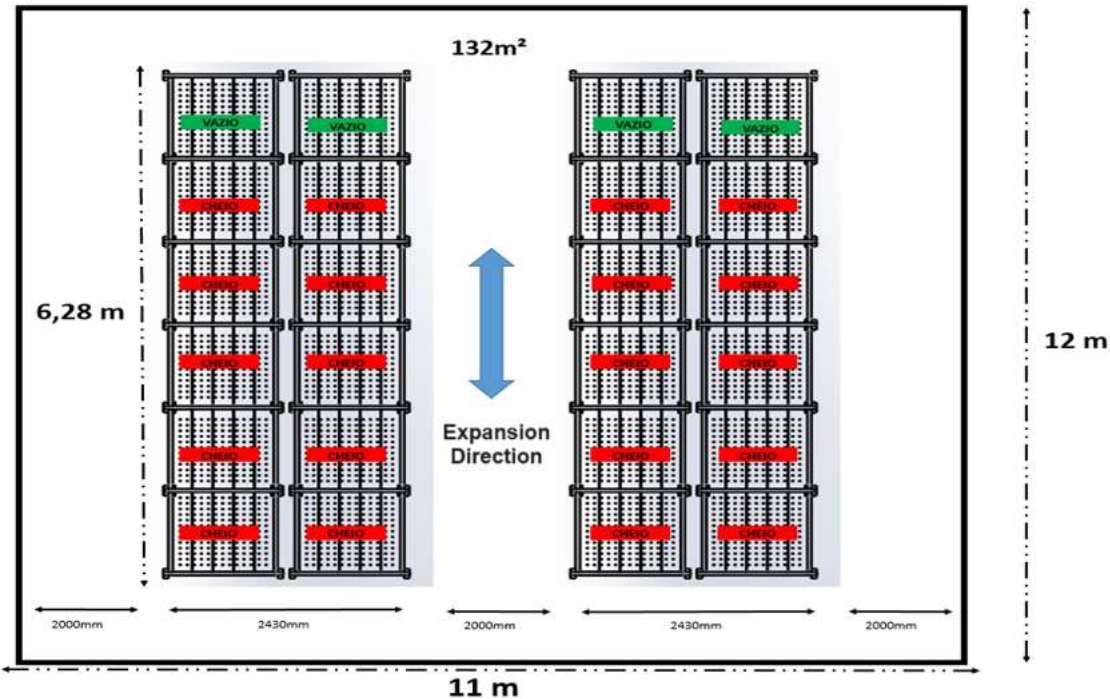


FIGURE 9. Fermentation line expansion layout.

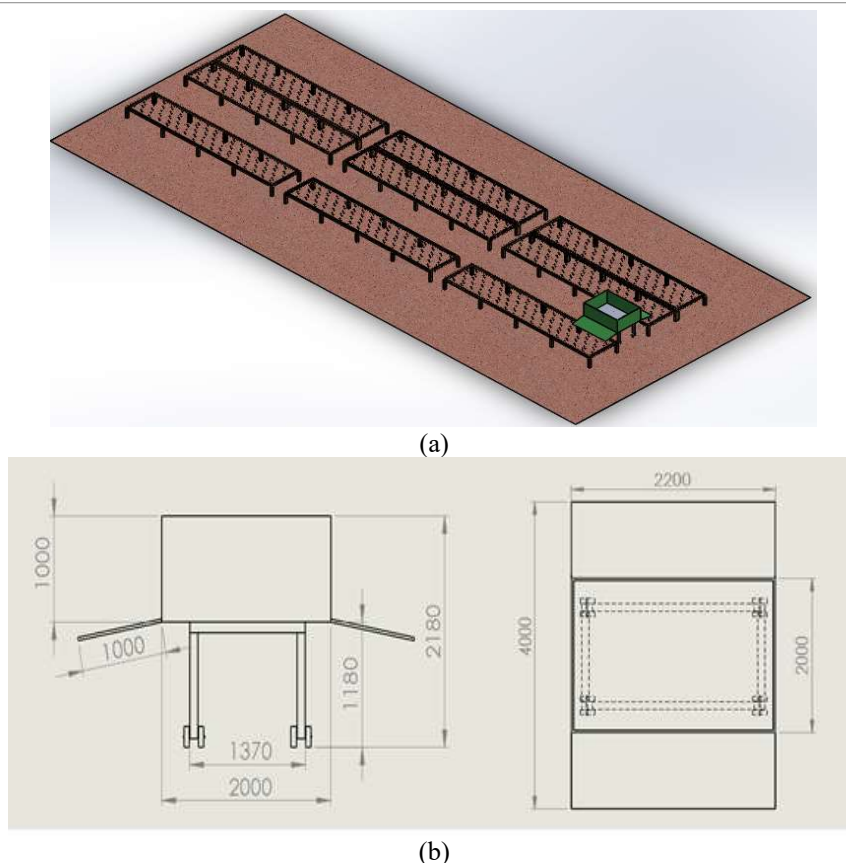
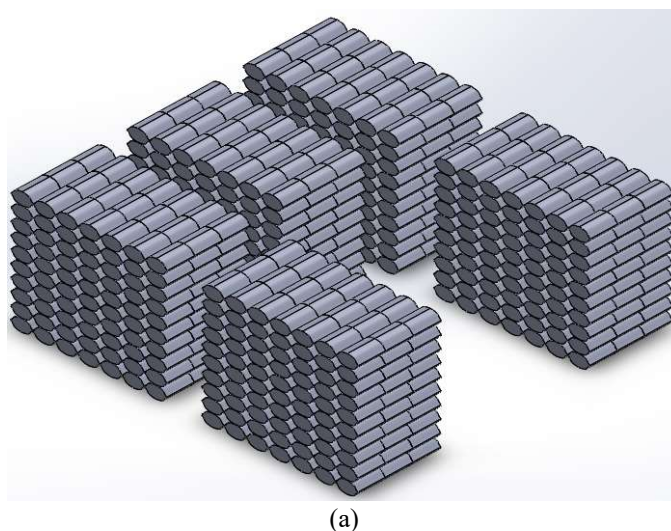


FIGURE 10. Optimized layout for the drying plant. (a) Isometric drawing of the drying plant. (b) Front and top views of the agricultural drying trailer (mm).

To optimize storage capacity for cocoa beans, a new warehouse design was based on the dimensions of a standard cocoa bean sack filled in a horizontal position. The warehouse will accommodate 1,050 bags stacked efficiently. The planned layout consists of five stacks, each 10 bags high, seven bags long, and three bags wide. Based

on these parameters, the warehouse will measure 12.75 meters long by 11.02 meters wide, with a height of 5.15 meters. A gate suitable for vehicle access will be incorporated to facilitate the loading and unloading of the bags. Figure 11 illustrates the proposed layout for stacking the bags within the warehouse.



(a)

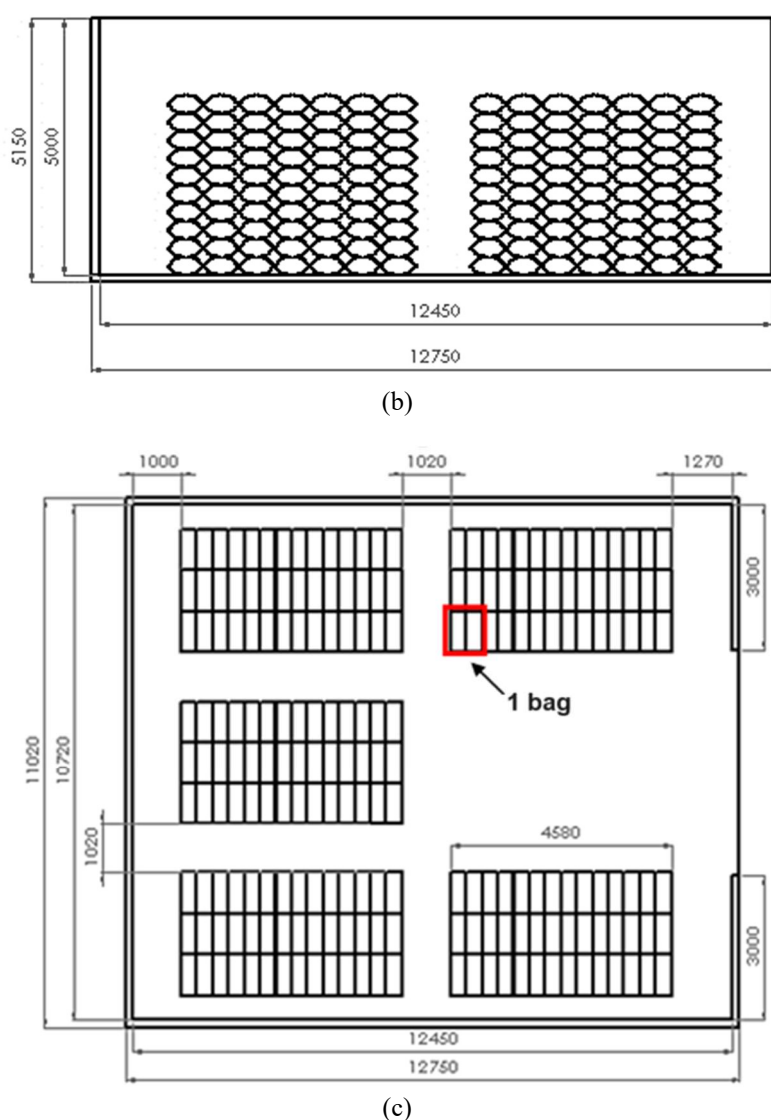


FIGURE 11. Proposed layout for sack stacking within the warehouse. (a) Isometric drawing of the sack stacking; (b) side and (c) top views of the warehouse (in mm).

Dimensional Calculation and Production

The farm's existing cocoa plantings are planned for harvest over the next three years, with an expected yield of 15 tons per year. This, combined with the current annual production of 55 tons of fine cocoa, projects an increase in production to 70, 85, and 100 tons per year over the next three years. To accommodate this growth, the processing plant is designed for a maximum capacity of 100 tons per year.

Following economic principles, the plant's design prioritizes minimizing initial investment to prevent overcapacity. This ensures the processing plant's growth aligns with the projected increase in cocoa production. Equations 1 to 8 were used to determine equipment sizing based on the farm's production data. Equations 9 to 13 were used to estimate annual production costs and revenue.

- Number of pods = weekly production (t) x number of pods per ton (1)
- Volume occupied by pods (weekly) = Number of pods / Volume occupied (whole pods) (2)
- Weight of whole pods (weekly) = Number of pods x average weight of pods (3)
- Fresh mass weight = Dry cocoa weight / Cocoa dry matter content in seeds (4)
- Fresh mass volume = Fresh mass weight / Apparent specific mass (5)
- Number of required boxes = (Fresh mass volume / Box volume) + 1 (6)
- Platforms' total area = [fresh mass volume x (platform area per cubic meter)] (7)
- Number of platforms required $\cong$ Platforms' total area / Each platform area (8)
- Processing unit construction budget = area x CUB m² (9)
- Input cost = cost per input x quantity (10)
- Required workdays = Σ (workdays per hectare x number of hectares) (11)
- Number of workers = required workdays/number of working days (12)
- Monthly revenue = monthly production (kg) x cocoa kg price (13)

RESULTS AND DISCUSSION

Key design decisions included automating cocoa pod breaking and rearranging the physical layout for the fermentation and drying stages. The project was sized to handle the farm's maximum production potential. Table 3 shows the farm data used as input for the calculations.

TABLE 3. Farm data used as input data for sizing.

Variable	Value
Harvest and off-season periods	6 months
Annual production percentage during harvest season	85%
Annual production percentage during off-season	15%
Apparent density of cocoa pod	1.110 kg m ⁻³
Percentage yield of dry cocoa beans from a cocoa pod	40%
Number of pods per volume	950 fruits m ⁻³
Number of whole pods per ton	25.000 fruits t ⁻¹
Average weight of a whole pod	0,40 kg
Box volume	0,8 m ³
Drying platform area required per fresh mass volume of cocoa beans	42 m ² m ³

To select the appropriate agricultural trailer for transporting fruit from the plantation to the fermentation shed, the weight of the fruit harvested each week was calculated (Equations 1-3). The farm has 55 hectares of planted area, with 30 hectares currently in production. An additional 25-hectare area is under cultivation for short-term production. The farm's annual yield is 55 tons, translating to approximately 1.8 tons per hectare (t/ha). This is considered high for the Transamazon region, where the average yield is 1 t/ha. However, some farms in Bahia

achieve yields closer to 3 t/ha. Based on this productivity rate, the farm expects to produce 100 tons of fruit over the next 3 years from the existing 55 hectares.

Calculations using equations 4, 5, and 6 determined the number of boxes required to handle the weekly cocoa production. Similarly, equations 7 and 8 were used to calculate the number of platforms needed to accommodate the weekly production for each year. Table 4 presents the initial project results.

TABLE 4. Boxes and platforms demanded by the farm.

Year	Production (t)	Weight of pods (kg/breaking)	Box number (un)	Platform number (un)
1	70	12395	10	9
2	85	15052	12	10
3	100	15052	12	12

Fresh mass volume per fermentation cycle each year was 2.8 m³, 3.4 m³, and 4 m³, respectively. Dividing these volumes by the capacity of each fermentation box results in the need for 4, 4.28, and 5 boxes, respectively. These values indicate the mass required for each fermentation cycle. With two fermentation cycles per week, each week will require two rows of boxes containing the specified quantities, plus one additional empty box for turning. For platforms, the weekly quantities for years 1, 2, and 3 are 8.2, 10, and 11.2, respectively. To accommodate all production, these values

were rounded up to match standardized box and platform dimensions.

Table 5 details the budget allocation for the farm's physical rearrangement. The shed construction cost was based on the Industrial Shed (IS) classification from the Basic Unit Cost Table (CUB m-2), which provides reference values per square meter for different project types. This index fluctuates by month and location (SINDUSCONPA, 2022). Therefore, the January 2022 value of US\$188.36 per square meter (determined using [eq. (9)]) was used to calculate the shed's dimensions.

TABLE 5. New processing plant investment costs.

Item	Quantity	Price (US\$)
Processing area renovation	167,2 m ²	31493.27
Storage area renovation	140,51 m ²	26466.02
Platforms	1 unit	177.22
Cocoa pod-breaking machine	1 unit	36784.39
Drying cart	1 unit	278.81
Agricultural cart	1 unit	3066.91

The cost of each item was determined as follows: 1) platform costs were estimated based on the project's specifications and dimensions of the existing platforms; 2) cocoa pod breaking machine was quoted directly from a specialized manufacturer; 3) agricultural drying cart was quoted from a local metalworking shop; and 4) agricultural

cart was sourced online from a retailer that offered a 4-ton capacity trailer with a 6 m³ volume, which is expandable by adding side panels to increase its volume capacity.

Tables 6 and 7 provide detailed information on the values of inputs consumed on the farm and the number of workdays required for farm tasks, respectively.

TABLE 6. Values of inputs consumed on the farm.

Input	Unit	Price (US\$)
Limestone	50-kg bags	9.29
Pesticides	Liters	11.15
NPK fertilizer	Kilograms	1.67
Urea	Kilograms	4.65

TABLE 7. Workdays per hectare for farming activities.

Activity	Workdays per hectare
Shade correction	1
Tree pruning	2.5
Tree cleaning	6
Liming	0.87
Pest control	1,15
Basal fertilization	2.2
Nitrogen fertilization	2

Table 8 presents the farm input consumption and hectares per activity for each month.

TABLE 8. Quantity of inputs and activities by month.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Liming	150	-	-	-	-	-	-	-	-	-	-	450
Insecticide application	-	1.2	2	-	-	-	-	-	-	2	-	2
NPK fertilization	-	-	-	1875	-	1875	937.5	-	-	1875	-	3750
Urea fertilization	-	-	-	-	-	360	180	-	-	360	360	720
Shading	10	15	15	-	-	-	-	-	-	-	-	15
Pruning	15	-	-	-	20	-	-	-	-	-	10	10
Cleaning	10	10	10	5	10	-	-	-	-	-	-	10
Liming	5	-	-	-	-	-	-	-	-	-	-	15
Pest control	-	3	5	-	-	-	-	-	-	5	-	5
Basal fertilization	-	-	-	10	-	10	5	-	-	10	-	20
Nitrogen fertilization	-	-	-	-	-	10	5	-	-	10	10	20

Monthly input costs are calculated using [eq. (10)]. For agricultural limestone, sold in 50 kg bags, the result needs to be divided by 50 kg to determine the number of bags required. Implementing the machine at the beginning

of Year 1 will incur additional monthly costs: US\$167.29 for fuel and maintenance, and US\$46.47 for machine energy consumption. Table 9 displays the breakdown of input costs for the current year and the projected years.

TABLE 9. Breakdown of input costs for the current and projected years.

Month	Current year (US\$)	Year 1, 2, and 3 (US\$)
Jan	1394.05	1607.81
Feb	13.38	227.14
Mar	22.30	236.06
Apr	3136.62	3350.37
May	0	213.75
Jun	4809.48	5023.23
Jul	2404.74	2618.49
Aug	0	213.75
Sep	0	213.75
Oct	4831.78	5045.54
Nov	1672.86	1886.62
Dec	13823.42	14037.17

Input consumption will remain consistent from the first year onwards, as the crop size does not increase, only the younger plants grow. Therefore, the price base for these inputs remains unchanged from the previous year, with only the inputs resulting from machine implementation being added.

To calculate labor costs, monthly working hours were determined using [eq. (11)]. Equation 12 was then

used to determine the number of workers required on the farm. The result is the sum of the number of workers employed each month, multiplied by the monthly salary of US\$ 241.64 plus 33.77% for the company's social charges under the simple taxation system. Table 10 shows the labor costs for the four-year production plan.

TABLE 10. Labor costs for the current year and projected years.

Month	Current year (US\$)	Year 1 (US\$)	Year 2 (US\$)	Year 3 (US\$)
Jan	1574.16	1347.89	1376.18	1404.46
Feb	1203.52	977.25	1005.53	1033.82
Mar	1228.30	1002.03	1030.31	1058.60
Apr	918.53	692.26	720.55	748.83
May	1543.45	1317.19	1345.47	1373.75
Jun	2482.63	1200.46	1360.73	1521.01
Jul	2256.36	974.20	1134.47	1294.74
Aug	2030.10	747.93	908.20	1068.47
Sep	2030.10	747.93	908.20	1068.47
Oct	2544.58	1262.42	1422.69	1582.96
Nov	2514.95	1232.79	1393.06	1553.33
Dec	2543.33	2317.06	2345.35	2373.63

The implementation of the cocoa machine is expected to significantly reduce working hours by 70% in the first year compared to the current year. However, labor costs will increase gradually from year 1 to year 3. This is because new trees will reach maturity and contribute to fruit production, requiring more labor per hectare to harvest.

Table 11 shows the current year's production alongside projected production for the following years.

These figures represent monthly production during both the harvest season (June to November) and the off-season (December to May).

Monthly revenue was calculated using Equation 13 based on the average cocoa price of US\$2.01 per kilogram provided by the International Cocoa Organization (ICCO) for 2022. The results are presented in Table 12.

TABLE 11. Monthly production for the current and projected years.

Period	Current year (kg)	Year 1 (kg)	Year 2 (kg)	Year 3 (kg)
Off-season	8075	9916.67	12041.67	14166.67
Harvest season	1425	1750.00	2125	2500

TABLE 12. Monthly revenue for the current and projected years.

Period	Current year (US\$)	Year 1 (US\$)	Year 2 (US\$)	Year 3 (US\$)
Off-season	16210.04	19907.06	24172.86	28438.66
Harvest season	2860.59	3513.01	4265.80	5018.59

Monthly accumulated revenue is calculated by subtracting expenses from monthly revenue. In December of each year, the farm's annual balance is determined by

summing the monthly balances. Table 13 displays the farm's annual profit for each year, which is calculated by subtracting annual expenses from annual revenue.

TABLE 13. Annual profit of the farm for the current and projected years.

Month	Current year (US\$)	Year 1 (US\$)	Year 2 (US\$)	Year 3 (US\$)
Jan	-107.62	557.31	1281.81	2006.32
Feb	1536.08	2865.93	4314.94	5763.95
Mar	3146.07	5140.85	7314.37	9487.88
Apr	1951.52	4611.23	7509.25	10407.27
May	3268.67	6593.30	10215.82	13838.35
Jun	12186.59	20276.66	28004.72	35732.77
Jul	23735.53	36591.04	48424.62	60258.20
Aug	37915.46	55536.41	71475.52	87414.63
Sep	52095.40	74481.79	94526.43	114571.06
Oct	60929.07	88080.90	112231.06	136381.23
Nov	72951.29	104868.56	133124.25	161379.94
Dec	59445.14	92027.33	121007.53	149987.72

Implementing the cocoa processing machine, along with a projected 15-ton increase in cocoa production in the first year, is expected to generate a 54.81% increase in revenue for the farm. By the third year, when production reaches 100 tons, accumulated revenue will be 152.31% higher compared to the current year, indicating substantial profit potential.

This positive outcome aligns with the economic benefits of implementing Cocoa Agroforestry Systems as analyzed by Andrade et al. (2021). Their study found that investing in cocoa plantations yields positive environmental and economic results, making it an attractive option for both farmers and credit institutions.

Payback period

A crucial factor in analyzing project viability is the payback period, which indicates how long it will take to

recover the initial investment in physical structures and machinery. This break-even point is estimated through a return-on-investment (ROI) analysis, as suggested by Dobbs (1988). Such analysis typically considers factors like cost estimates, market assessments, product pricing strategies, and profit forecasts, which are all addressed in this study.

For this project, the total cost of physical structures, machinery acquisition, and implementation is US\$98,089.41. The ROI calculation will use January of Year 1 as the base date, signifying the moment the new processing facility becomes operational. Figure 12 illustrates the payback period for the invested amount, calculated by factoring in monthly profits earned throughout Year 1.

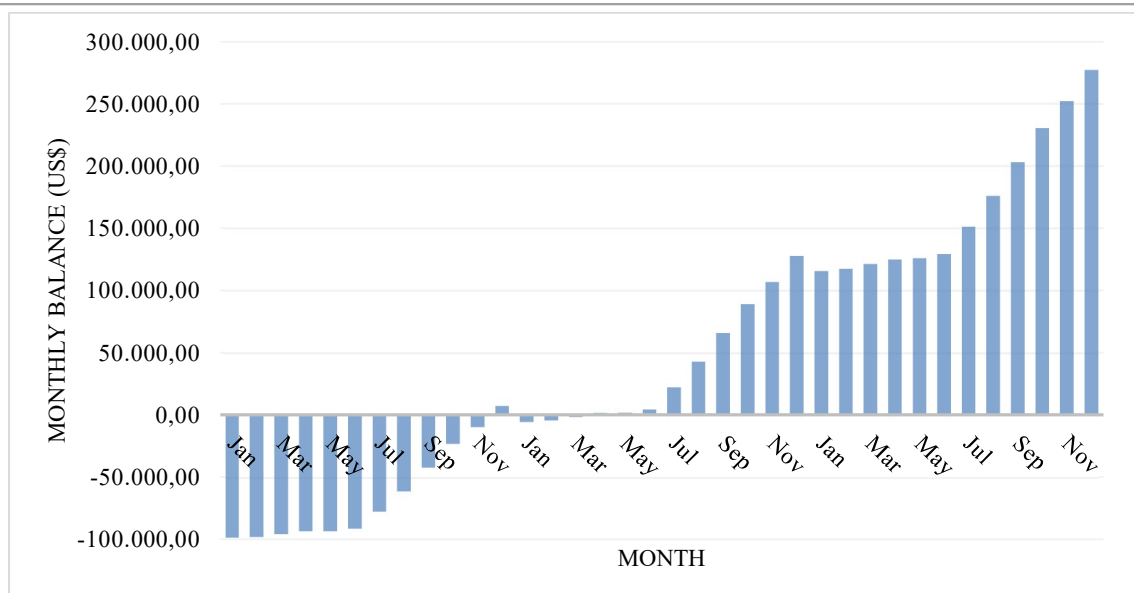


FIGURE 12. Payback period.

An analysis of projected revenues and expenses for the new cocoa processing plant shows a positive balance by December of Year 1. However, during the off-season, when cocoa production dips to around 15%, the farm is expected to experience negative cash flow.

As all revenue in the first year will be dedicated to recouping the initial investment, there will be no positive balance in the early months of Year 2. However, a significant recovery is projected once the harvest season begins in June. By the beginning of Year 3, coinciding with peak production, a substantial positive balance of approximately US\$120,000.00 is expected.

CONCLUSIONS

This technical and economic feasibility study was conducted to evaluate potential improvements in the cocoa pod breaking, fermentation, and drying stages at a cocoa farm in Novo Repartimento, Pará State, Brazil. The goal was to increase farm productivity and profitability.

The study explored modifications to the fermentation area and the introduction of a cocoa pod-breaking machine. The payback period calculations demonstrated the project's feasibility, particularly considering two key factors. First, the studied cocoa plantation is just entering full production, and according to CEPLAC (Brazilian Executive Commission for the Cocoa Plantation Plan), cocoa plantations have a lifespan exceeding 50 years. Second, the payback period is projected to be short-term, achievable within the first year. This rapid return on investment makes the project highly attractive, as it will lead to increased production, reduced costs, and ultimately, higher profits for the farm.

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