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By-products and Value-added products from Cocoa Agri-waste

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Transforming lives through translational research

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1. Introduction

Cocoa, *Theobroma cacao*, popularly known as "food of gods" in Greek, is the most ancient beverage crop that is grown in tropical countries. The genus name Theobroma means "food of the gods," derived from Greek, where theos means "god" and broma means "food". Cocoa is grown for its seeds, known as beans used mainly in chocolate industry. The species name cacao comes from the indigenous reference to the seeds from which chocolate is made. Cocoa is native to lowland rainforests of Amazonian and Orinoco river basins, although its cultivation has subsequently spread to other regions like Central and South America, West Africa and South-East Asia.

Figure 1. Ripe cocoa pods and cut half cocoa pod with beans covered with pulp

2. Origin

Theobroma cacao, the primary ingredient of chocolate as we know it today, was initially domesticated in the northern Peruvian Amazon approximately 7500 years ago, and then it spread throughout Central America. The Chinchipe tribes in Peru were the first to use it, and then it was incorporated into the Chavin civilisation. Through trade with the Aztec tribes, the Spanish introduced cacao to Europe for the first time. Cocoa powder became more affordable with the beginnings of the Industrial Revolution, when steam-powered machinery made it possible to produce the powder more faster and cheaper. Currently, the world consumes more than 4.5 million tonnes of cocoa beans a year in products ranging from drinks to candy bars.

3. Taxonomy, habitat and biology

The natural habitat of cocoa predominantly lies in the warm, tropical regions of Central and South America, where a confluence of environmental factors nurtures its development. Temperatures ranging from 20°C to 30°C (68°F to 86°F) provide the requisite warmth for optimal cocoa growth, with frost-prone areas unsuitable for its successful cultivation. Moreover, high humidity levels, typically exceeding 70%, play a crucial role in sustaining the vigor of cocoa trees, ensuring the health and vitality of their leaves and fruit. One of the vital factors contributing to cocoa's prosperity is a balanced and consistent distribution of rainfall. Cocoa trees benefit from replenishing rains when there is 1,000 to 2,500 mm (40 to 100 inches) of precipitation each year. Cocoa has a recommended elevation range that lies between sea level and 1,000 meters (3,280 feet). In terms of soil, cocoa has a broad tolerance range and can grow in a variety of soil types, including volcanic, clay, and sandy loam. Diseases and pests pose a constant threat, requiring careful control techniques.

4. Varieties and Cultivation

There are a variety of cacao, but they can be broadly classified into three categories: *trinitario, criollo*, and *forastero*. While criollo types are not typically grown and are highly sensitive to disease, forastero varieties are most frequently employed in commercial production. trinitario, a forastero and criollo hybrid, yields a delicious bean that is used to make premium dark chocolate. The flowers, which are roughly 1 cm (0.4 inch) in height and width, emerge in clusters directly from the stem and limbs. Depending on the type, they might be white, rosy, pink, yellow, or vivid red, midges, tiny flies, are responsible for pollinating them. The pollinated tiny flowers grow into fruits called "cacao pods". The cacao pod turns into a vivid orange shade similar to pumpkins when it is fully ripe. There will be about 35 pulp-covered seeds (also known as "beans") in a normal pod.

During 2020, 52,42,000 t of dry beans were produced from more than 10 million hectares of land in more than 58 countries. The four West African countries of Ghana, Nigeria, Cameroon, and Cote d'Ivoire yield 74% of the world's cocoa production. Cocoa is traditionally grown on farms alongside coconut and areca nuts in the southern Indian states of Karnataka and Kerala. Its significance is growing, and it is becoming more widespread in other unconventional areas of Andhra Pradesh and Tamil Nadu. A total of 27, 072.15 t of dry beans are produced from its 97, 563 hectares of cultivation, mostly as a secondary crop in areca nut, coconut, and oil palm plantations.

Table 1: Regional cultivation data of Cocoa in Dakshina Kannada and Udupi Districts (2023-24)

	Dakshina Kannada	**Udupi**
Cultivation Area (ha)	2384.87	73.73
Production (MT)	1220.89	44.24
Yield (MT/Ha)	0.51	0.60
Value (in Lakhs)	1098.80	13.27

5. Breakdown of Cocoa Biomass Production

Age and growth conditions have an impact on cocoa's biomass production. Under areca nut and coconut, the estimated biomass generated by cocoa per hectare varies from 8450 kg to 13,000 kg due to disparity in growth patterns and population density. In cocoa, pruning is a routine procedure that yields 8–10 kg of pruned biomass per tree that constitutes recyclable garbage. Additionally, the environment, the age and kind of the plantings, and the density of shade all affect the rate of routine litter fall. The post-harvest pre-processing and processing of the cocoa pods to obtain cocoa beans generates a large part of biomass/unit pod that is often discarded as waste.

Table 2: Summary of the breakdown of annual biomass components produced by a cocoa tree

Component	Amount per Tree per Year (kg)	Moisture (%)	Proteins (%)	Lipids (Fats) (%)	Carbohydrates (%)	Dietary Fibres (%)	Ash (Minerals) (%)
Pruned Biomass	8-10	40-50	-	-	-	50-60	-
Litter	2-3	60-70	20-25	-	-	30-40	-
Pod Husk	10-15	8-12	8-10	1-2	60-70	30-40	6-8
Pulp	2-3	80-85	1-2	-	10-15	-	1-2
Bean Shell	1-2	10-12	12-14	3-4	50-60	30-40	8-10
Beans	1-2	6-8	10-15	50-55	30-35	20-30	2-3

Among the biomass generated, pruned biomass and routine litter waste directly come from the plantation as part of tree biomass produced year-round. Both pruned waste and litter majorly constitute dietary fibre and moisture content. Cocoa begins to yield economically around the fifth year after planting, while blooms appear as early as the third year. A tree that was taken care of (irrigation and nutrient management) produced 1-2 kilogramme of pods per tree annually. It takes 140–160 days for pods to mature. Cocoa typically yields two major crops every year, from June to August and from September to January. You get to see off-season crops all year long, especially if they are watered. Harvesting must be done regularly, every ten to fifteen days. From the cocoa pod harvested, 67-76% accounts for cocoa pod husk/shell (that includes epicarp, mesocarp and endocarp), 8.7-9.9% of pulp/mucilage covering the cocoa beans, 2.1-2.3% of bean shell/husk and finally 21-23% of biomass accounts for cocoa beans (20-30 beans per pod).

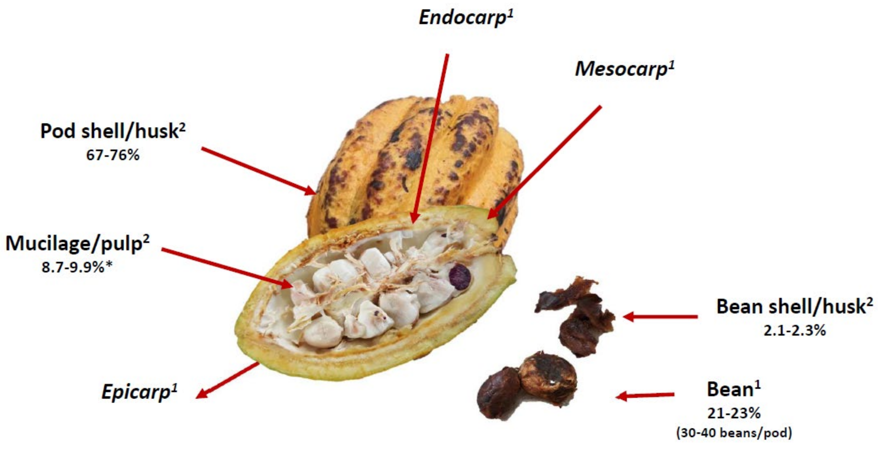

Figure 2: Breakdown of freshly harvested cocoa biomass.

6. Use of Cocoa products

Cocoa dry beans are widely used in the preparation of chocolates, confectioneries, beverages, and other edible products. Cocoa pulp juice (sweatings) may be made into a fruit drink, wine, and vinegar. Cocoa is rich in polyphenols and has several health benefits. Flavonoids, including catechin, epicatechin, and procyanidins predominate in antioxidant activity. Cocoa butter is used in the cosmetic industry. The rich, comforting scent of cocoa is used in aromatherapy. Cocoa pod husk has potential as a feed ingredient in fattening rations for sheep, goat, cattle, and poultry and in low-cost diets for fish. Pod husk is also a rich source of potassium, and hence it can be used as a manure after composting. Fallen cocoa leaves and pruned biomass can be converted to nutrient-rich manure using earthworms.

7. Cocoa agro-waste – Potential source for revenue generation and sustainability

Cocoa adds nutrient to the soil through the litter fall, through fall and stem flow. The tree shed about 818 kg and 1785 kg of litter ha-1 year-1 (dry weight), respectively under single and double hedge systems of cocoa mixed cropped with coconut. Based on the nutrient composition of the cocoa leaves and pruned waste, a large quantity of macro and micronutrients such as 20.1 kg N, 2.8 kg P, 74.7 kg K, 38.9 kg Ca, 9.6 kg Mg, 2.3 kg Fe, 1.0 kg Cu and 0.7 kg Zn per ha goes as waste every year. The available recyclable biomass from cocoa (which includes pruned biomass, leaf litter and pod husk) is quantified at 0.7–0.8 million tonnes in India. Thus, the recyclable biomass in cocoa has potential to supply considerable nutrients as converted to nutrient rich manure using earthworms. Apart from the waste generated from plantation itself, Cocoa husk is the first and main residue of the cocoa production, representing about 80% of the fruit in dry weight (d.w.). This by-product has a composition rich in lignin and non-starch polysaccharides (cellulose, hemicelluloses and pectin). Cocoa pulp, also known as mucilage, is a white mass that surrounds the cocoa beans. Approximately 100–150 L of cocoa pulp juice per ton of wet cocoa beans are produced during the fermentation process. Its composition is rich in sugars and minerals, without alkaloids and other toxic substances which can be converted and used in culinary industry as a flavouring agent, fruit concentrate or jam.

8. By-products from Cocoa agro-waste

Following are the few cocoa-based value-added and by-products developed from the waste generated from cocoa farming.

A. Vermicompost from Cocoa litter and pruned waste

I. Raw material

The major raw material that comes from cocoa farming is the plant waste generated during periodic pruning and routine litters that added to soil directly if not collected. When cocoa trees are pruned, they yield approximately 21 kg of dry organic matter annually/tree, or roughly 25 tonnes/ha/year that is roughly 8–10 kg of trimmed biomass and 2-3 kilogramme of litter fall per tree per year in the cocoa farms. Even though the biomass available in the form of leaf litter and pruned plant parts is quite high, their direct usage is not advisable because of slow rate of decomposition due to their high carbon, lignin, polyphenol and cellulose concentrations. However, the cocoa leaves can be converted into compost using earthworms. The composted cocoa leaves were found rich in macro and micronutrients, which was more than the normal compost. A recovery percentage of 74 percent was obtained and about 6.0–9.0 t of vermicompost can be obtained by recycling the biomass produced in one hectare. From 100 kg of litter and pruned waste, 74.65 kg of vermicompost can be recovered using 1 kg of worms

II. Production method

Vermicomposting can be done in a pit or on a tank. Composting is done using the tank method, which involves creating a bed of organic material in the cement or plastic tank (1 m x 1 m x 1 m), and the pit method, which involves using cement or earthen pits however, tanks are more preferred compared to pits. Approximately 10 tanks can be constructed in an area of 150 sq. ft.

- A cold, humid and shaded location is ideal for the vermicomposting unit.

- For 15 to 20 days, cow dung and chopped and shredded leaf and pruned waste are combined in a 2:3 ratio, covered with layer of soil (in ratio 1) and allowed to partially decompose with frequent watering.
- About 1 Kg of earth worms of any suitable species such as African night crawler (Eudrilus eugeniae) were evenly distributed into beds.
- As soon as the worms are released, water should be sprayed with can.
- Beds should be covered with polythene or gunny sacks and sprayed with water every day to keep them moist.
- After 7 days, the bed should be mixed once to ensure adequate decomposition and aeration.
- An incubation period up to 90 days is required to convert the agro-wastes to manure and is separated from worms by sieving through 2 mm sieves.
- The excess water run through the vermicompost bed can be collected and used fertilizer separately
- The dry vermicompost sieved is packed and marketed in unit quantity.

III. Expenses required

A. Capital Cost

Particulars	**Price/unit**	**Minimum quantity/capacity**	**Expenditure (Rs)**
1. Land			
Earthen work & Site development			10,000
2. Building			
Shed construction	200/sq.ft	150 sq.ft	50,000
Additional space, godowns	250/sq.ft	200 sq.ft	50,000
Water tank		1000 Lts	10,000
3. Equipment and Machinery			
Plumbing and fitting			15,000
Horticulture Waste Shredder	50,000/Nos	One	50,000
Weighing scale/machine	20000/Nos	One	20,000
pump set	10000/Nos	One	10,000
Sieving machine	30000/Nos	One	30,000
Carry baskets	250/Nos		2,500
Shovels, Spades, Crowbars and others			10,000
Trolley with handle	8000/Nos	One	8,000
Misc. construction cost incl. electrification, cabling etc			10,000
Furnitures & fixtures			25,000
Total			**3,00,500**

B. Running cost (Operational cost for one cycle of 90 days)

Particulars	Price/unit	Minimum quantity/capacity		Expenditure (Rs)
pruning waste + litter	5/kg		3000	15000
Cow dung	5/kg		2000	10000
Mother earthworms	50/kg		10	500
Packaging				1,000
Electricity and Water				1,000
Skilled technician	10,000/month	3 months		30,000
Unskilled workers (2 Nos)	5,000/ month	3 months		30,000
Total				**87,500**

IV. Market potential

	Price/quantity	Quantity produced	Income (Rs)
Production of vermicompost per cycle	60/kg	4500 kg (75% of starting material)	2,70,000
Production of worms per cycle	50/kg	60 kg	3000
Annual production of vermicompost	60/kg	4 cycles X 300 kg	10,80,000
Annual production of worms	50/kg	4 cycles X 6 kg	12,000

Farmers have high demand for vermicompost since it is less expensive and when used, improves the quality of agricultural products. It's also commonly utilized in home gardens and pot culture. Furthermore, it is purchased in bulk quantity by numerous government sectors, such as horticulture, forestry, and agriculture. The highlight of vermicompost is that the process involved is simple, less expensive and results in nutritiously rich manure that supports sustainable agriculture.

B. Pectin from Cocoa pods

Pectin is a plant-based soluble fibre component that is produced as a light brown powder and utilised in food products. It is a polysaccharide starch that is taken out of the cell walls of a variety of fruits and vegetables. It is used to make solid jams, marmalades, and jellies by stabilising and gelling fruit liquids and milk-based drinks. Moreover, it is used in the production of pharmaceutical products including adhesives for wound healing and specialised medication preparations. The increased demand for functional foods is predicted to drive growth in the pectin powder market. The pectin market is projected to increase at a compound annual growth rate (CAGR) of 7.95% from 2023 to 2032, valued at USD 1.63 billion. The sector is expected to reach USD 3.50 billion by 2032.

I. Raw material

The cocoa pod has been described as a natural laminated material consisting of three distinctly different layers: epicarp, mesocarp and endocarp. The endocarp is a soft whitish tissue protecting the delicate cocoa beans in a well-lubricated inner chamber; the mesocarp displays a hard-composite structure able to hold the cocoa beans in place even under high impact; and the outermost relatively soft layer is the yellow cover (when ripe) that is directly exposed to sunshine, after which it turns black indicating rot due to degradation. The pod constitutes 80% of the riped cocoa fruit (dry weight), and is the major waste produced in cocoa farming. This waste generated contains lignin and non-starch polysaccharides (cellulose, hemicelluloses and pectin). It is experimentally proven that 8-11% (dry weight) of cocoa pod husk is comprised of pectin and is one of the rich sources of pectin.

Table 3: Structural composition of cocoa pods.

Component (in %)	**CPH**	**Epicarp**	**Mesocarp**	**Endocarp**
Moisture	80.2	82.8	64.0	87.1
Ash	9.1	10.1	4.6	6.7
Protein	5.9	5.0	1.9	6.9
Crude Fiber	22.6	17.3	29.5	15.3
NDF	61.0	62.0	80.0	41.0
ADF	50.0	45.0	70.0	34.0
Nitrogen-free	62.2	66.8	63.7	70.0
Crude fat (ether extract)	1.2	0.8	0.3	1.1
Cellulose	35.0	30.0	57.5	20.8
Hemicellulose	11.0	17.0	10.0	7.0
Lignin	14.6	15.0	12.0	13.2
Pectin	6.1	5.1	2.1	10.5
Ca	0.32	0.58	0.19	0.13
K	3.18	4.61	1.56	2.66
P	0.15	0.16	0.06	0.09
Mg	0.22	0.39	0.10	0.15
Component (in mg/kg)				
Na	3.1	9.1	6.0	7.2
Zn	40.4	64.9	23.5	30.8
Fe	90.1	197.1	106.3	112.4
Cu	7.2	13.2	5.6	7.1
Mn	33.6	103.2	21.3	31.9

Adapted from Sobamiwa & Longe (1994).

II. Production method

Pectin extraction can be carried out by different methods including physical, chemical and enzymatic methods. However, the running cost, duration of extraction process, quality and quantity of the pectin yield varies from process to process. Figure XX describes the overview of process involved in pectin extraction from cocoa pod husk. Based on literature survey, it is observed that the high quality and quantity of pectin yield are obtained in physical methods such as micro-wave assisted and ultra-sound assisted extraction methods where the initial investment and running costs are relatively high compared to conventional or chemical extraction process which yields low quality and quantity of pectin.

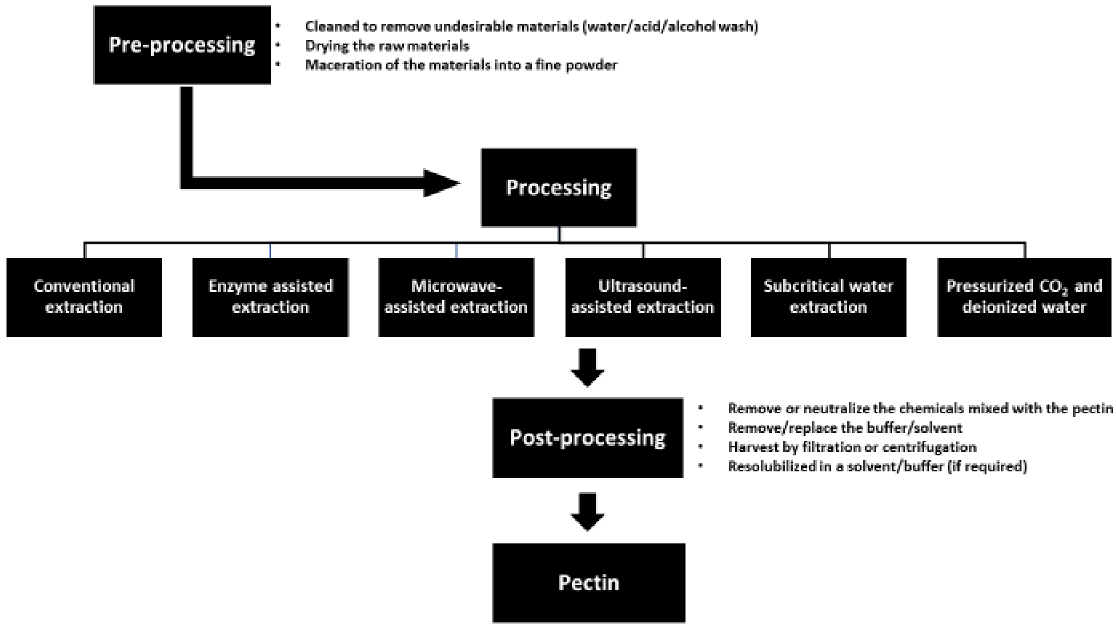

Figure XX: General Overview of the different techniques used in Pectin extraction

Microwave assisted extraction

a. Raw Material Preparation

Material: Cocoa pod husk (CPH) from cocoa farms or collected from local suppliers.

Cleaning: Wash the cocoa pod husks to remove dirt, soil, and other impurities. Let them dry under sunlight or in an oven at low heat (40°C–50°C) for a day or two to reduce the moisture content.

Grinding: Once dried, cut the husks into smaller pieces or grind them into coarse powder using a blender or grinder.

b. Preparation of Citric Acid Solution

Citric Acid Solution: Prepare a 10% (w/v) citric acid solution using food-grade citric acid in deionized water. Heat the solution to 60°C–70°C before use to improve the extraction process.

c. Microwave-Assisted Extraction (MAE)

Microwave System: Use a microwave extractor designed for medium-scale production with a capacity of processing 10–50 kg of raw material per batch. Adjustable power setting (1000–2000 W).

Temperature Control: The system should allow for precise temperature control (60°C–90°C).

Batch or Continuous System: Depending on production needs, choose between a batch process (for more control) or a continuous microwave extraction system (for higher throughput).

Ratio of Cocoa Husk to Citric Acid Solution: Use a 1:10 ratio of husk to citric acid solution. For example, for 10 kg of cocoa pod husk powder, use 100 L of citric acid solution.

Microwave-Assisted Extraction: Place the husk powder into the microwave extraction vessel. Ensure even distribution of the material for uniform heating. Set the microwave power to 450 - 1000 W. Heat the mixture to 70°C–80°C and maintain it at this temperature for 20–30 minutes.

Monitoring: Use sensors to monitor the temperature and prevent overheating, which could degrade the pectin.

d. Filtration and Clarification

Filtration: After the extraction, separate the liquid (pectin extract) from the solid husk residue. Use an industrial filtration system, such as a rotary vacuum filter to remove the solid particles.

Clarification: To remove fine particulates, use a centrifuge or let the extract settle for 1–2 hours, then decant the clear solution. Optionally, use activated carbon to decolorize the extract if necessary.

e. Concentration and precipitation of Pectin Extract

Concentration: The pectin-rich extract contains a large amount of water. Use vacuum evaporation to concentrate the extract without degrading the pectin. Set the evaporator to 50°C–60°C and reduce the liquid volume by 50%–70% to obtain a more concentrated pectin solution.

Precipitation: To precipitate pectin, add food-grade ethanol (95%) in a 1:2 ratio (pectin extract to ethanol). Stir the mixture thoroughly to ensure uniform precipitation of pectin. Allow the pectin to settle for 1–2 hours. After settling, filter the precipitated pectin using a filter press.

f. Washing, Drying and powdering

Washing: Wash the precipitated pectin with additional ethanol (1:1 ratio) to remove impurities.

Drying: Dry the wet pectin in an industrial tray dryer at 50°C–60°C for 12–24 hours until the moisture content is reduced to below 10%. Alternatively, use a vacuum dryer for faster drying times and better preservation of pectin quality.

Grinding and Powdering: Once dried, grind the pectin into a fine powder using a medium-scale industrial grinder. Use a fine mesh sieve to ensure a uniform particle size of the pectin powder (typically 100–150 microns).

g. Packaging and Storage

Packaging: Package the pectin powder in moisture-proof, airtight bags or containers. Ensure that the packaging is food-grade and complies with relevant food safety standards.

Storage: Store in a cool, dry place at 15°C–25°C. Properly stored pectin can have a shelf life of up to 2 years.

III. Expenses required

A. Capital cost

Component	Description	Potential suppliers	Estimated Cost (INR)
Land & Building	Land acquisition and factory building (around 2500-3000 sq. ft.)	NA	₹15,00,000 - ₹20,00,000
Crushing and Pre-treatment Equipment	Crushers and grinders to crush the cocoa pod husks before processing	Wayal Industries Private Limited, Talwade, Pune	₹ 50,000 - ₹1,50,000
Citric Acid Handling & Storage	Tanks and dosing systems for citric acid use	Shakti Engineering, Vatva, Ahmedabad, Gujarat	₹50,00,000 - ₹1,00,000
Microwave assisted Extraction Tanks/Reactors	Small to medium-sized extraction tanks with temperature control	Rufouz Hitek Engineers Pvt. Ltd. Mumbai	₹2,50,000 - ₹5,00,000
Filtration Units	Filtration units (vacuum filtration) to separate pectin	Global Marketing And Services, Kothrud, Pune, Maharashtra	₹1,00,000 - ₹2,00,000
Separation Units	Centrifuge unit	Maruti Engineers, Amraiwadi, Ahmedabad, Gujarat	₹1,00,000 - ₹2,00,000
Concentrator	Industry scale Rotary Evaporator (20L)	TopLab, Kharghar, Navi Mumbai	₹4,00,000 - ₹5,00,000
Stainless Steel Slurry Mixer Machine	For mixing of the pectin slurry and ethenol	Bharath process Equipment, Bhosari, Pune	₹1,00,000 - ₹2,00,000
Precipitation Units	Filter Press Hydraulic, Filtration Capacity: 1000 litres/hr	Om Sai Filter Press, Vatva GIDC, Ahmedabad, Gujarath	₹1,00,000 - ₹2,00,000
Drying Equipment	Industrial Tray Dryer	Ambesh Fabricators, Vatva, Ahmedabad	₹ 50,000 - ₹ 75,000
Grinding unit	500 W Industrial Grinder Machine	Durgesh Engineering, Moshi, Pune	₹1,00,000 - ₹1,50,000
Weighing balance	External Weighing Scale Balances	Swastik Systems and Servives, New Delhi	₹ 5,000 - ₹ 10,000

Package sealer	Vertical Band Sealer for Pouch Sealing	Thekkanath Technologies Pvt Ltd, Kizhakkambalam, Ernakulam, Kerala	₹ 15,000 - ₹ 20,000
Laboratory Equipment	pH meters, spectrophotometers	Any suppliers	₹1,00,000 - ₹2,50,000
Waste Management System	Waste handling and treatment systems for solid and liquid waste	NA	₹1,00,000 - ₹2,00,000
Installation and Commissioning Costs	Engineering, installation, and commissioning of equipment	NA	₹8,00,000 - ₹12,00,000
Licensing & Regulatory Approvals	Environmental, industrial, and food safety approvals	NA	₹1,00,000 - ₹3,00,000
Contingency Costs	15% of total cost for unforeseen expenses		₹6,57,000 - ₹9,40,500
Total Fixed cost			**₹50,32,000 - ₹72,00,000**

B. Running Cost (Per Cycle)

Description	**Potential suppliers**	**Estimated Cost (INR)**
Raw material	Directly from farmers or suppliers	₹ 500 - ₹1,000
Citric acid - 100kg per cycle (to prepare 1000L of 10% conc.)	Lalko Minerals, Ramol, Ahmedabad	₹ 5,000 - ₹10,000
Essential utilities, water supply and electricity supply	NA	₹ 10,000 - ₹15,000
Food grade Ethanol - 100 L per cycle	Alpana Enterprise, PANSKURA, Bahirgram, West Bengal	₹ 10,000 - ₹15,000
LDPE bags (1 kg) supplied 300 unit/pack	Sachdeva Enterprises, New Delhi	₹ 1,500 - ₹ 2,500
contingency for unforeseen expenses	NA	₹ 2,000 - ₹ 3,000
Total running cost per cycle		**₹ 28,000 - ₹ 45,000**

IV. Market analysis

Estimation per cycle

Factor	**Low Estimate (INR)**	**High Estimate (INR)**
Raw Material (500 kg)	₹500 - ₹1,500	₹500 - ₹1,500
Pectin Yield per Cycle	15 kg	20 kg
Market Price (Approximate)	Medium to high quality yield @ ₹1,500 - ₹3,000/kg	
Revenue (per yield)	₹22,500 - ₹45,000	₹30,000 - ₹60,000

Operating Cost per Cycle	₹ 28,000	₹ 45,000

Annual Estimation (for 250 cycles)

Factor	Low Estimate (INR)	High Estimate (INR)
Pectin Yield per Year	3,750 kg	5,000 kg
Operating Cost per Year	₹ 70,00,000	₹ 1,12,50,000
Salary for skilled technician (X1)	@ ₹ 15,000/month = ₹ 1,80,000/year	
Salary for unskilled workers (X2)	@ ₹ 8,000/month = ₹ 1,92,000/year	
Revenue (Market Price)	₹56,25,000 - ₹ 1,12,50,000	₹75,00,000 - ₹1,50,00,000

C. Sweetening agent (Concentrate) from Cocoa pulp

During the post-harvest processing of cocoa, a mucilaginous white pulp mass releases a turbid liquid called cocoa pulp juice or "sweating" (CS). In general practices, farmers ferment the seeds with pulp to remove the mucilaginous pulp and develop chocolate flavour precursors (seeds). During the fermentation process, approximately 100–150 L of CS per ton of wet cocoa almonds is generated. The inappropriate disposal of this material contaminates the soil and waterways, becoming a threat to the cocoa crop due to the high risk of infestation by plagues. There are several species of microorganisms that play an important role in the hydrolysis and solubilization of cocoa pulp mucilage. CS has also been tested to produce alcoholic beverages with standard levels of volatile compounds (i.e., higher alcohols, esters and aldehydes), low concentration of methanol and high acceptability concerning aroma and general acceptability compared to that of other fruit wines.

I. Raw material

Cocoa fruits (pods) have a thick shell filled with seeds (beans) embedded in a mucilaginous white pulp. After harvesting, the fruits (pods) are opened or broken, still in the field, and the beans are removed along with the pulp. Visually, pulp or mucilage is characterized by a white mass that surrounds the cocoa beans. This white pulp is the base material for producing sweetening agent.

II. Production method

The process is traditionally carried out using wood presses, but stain less steel equipment has already been introduced in some farms, with the advantage of reducing contamination by microorganisms and increasing the volume of juice obtained, without influencing the product characteristics.

Harvesting Cocoa mucilage: Collect ripe cocoa pods from the plantation. Cut pods open to remove cocoa beans and surrounding pulp.

Fermentation of Cocoa Pulp: Place cocoa pulp in fermentation containers. Cover containers with a breathable material to allow airflow. Ferment for 3-7 days at a temperature of 25-35°C (77-95°F). Monitor daily for consistency; the pulp should become fluid and develop a distinct aroma.

Fermentation Aids (Optional):

Yeast (if used @ 1:100): Some producers add specific yeast strains to optimize the fermentation process. Wild fermentation can occur naturally without additional yeast, but controlled fermentation may require Saccharomyces cerevisiae or other strains suitable for fermenting fruit pulp (To speed up fermentation and improve yield or flavour consistency).

Water: While the pulp naturally contains moisture, some processes may require the addition of a small amount of water to control the fermentation process.

Extraction of Cocoa Honey: After fermentation, place the fermented pulp in the extractor. Apply pressure to separate the liquid honey from the solids. Collect the liquid in a clean container.

Filtration: Filter the liquid through a fine mesh or cheesecloth to remove any solid particles. Optionally, measure the pH to ensure it's in the desired range (typically around 4.5 to 5.5).

Packing: Pour the filtered cocoa honey into sterilized bottles. Seal the bottles tightly and label them with product information.

Storage: Store bottles in a cool, dark place to prolong shelf life.

III. Expenses required

A. Fixed cost

Component	Description	Potential suppliers	Estimated Cost (INR)
Land & Building (with air condition)	Land acquisition and factory building (around 2500-3000 sq. ft.)	NA	₹2,00,000 - ₹4,00,000
Plastic cart	For carrying cocoa pods from farm to processing	Anmol Machine Tools, Kolkata, West Bengal	₹ 5,000 - ₹ 8,000
Stain less steel table	For cutting and processing cocoa pods	Maxx Furniture, Siliguri, West Bengal	₹ 10,000 - ₹15,000
Knifes (@₹ 150 / Piece)	Cutting pods	Sakshi Kitchenware, Rajkot, Gujarat	₹ 1,000 - ₹ 1,500
Chopping boards (@₹ 50/piece)	Cutting pods	Kartavya Enterprise, Rajkot, Gujarat	₹ 500 - ₹ 1,000
Plasticwares	Carry the pulp with seeds	IB Monotaro Private Limited, New Delhi,	₹ 2,000 - ₹ 2,500
Stainless steel fermentors	Fermentation of the pulp with seeds	Real Ions Technologies, Pune, Maharashtra	₹ 25,000 - ₹ 50,000
White Cotton cheese strainer Cloth	Filtration of the fermented liquid	Sarfii, Dholka, Gujarat	₹ 1,000 - ₹2,000

Automatic Stainless Steel Fruit Juice Pasteurizer	For sterilization of filtered pulp juice	Packaging Solution (A Unit Of Woxn Packaging Solution Pvt .Ltd.), Ghaziabad, Uttar Pradesh	₹ 2,00,000 - ₹ 2,50,000
Fruit Juice Bottle Packing Machine	For packing and sealing bottles	S K Machine, Mumbai, Maharashtra	₹ 1,00,000 - ₹ 2,00,000
Total Fixed cost			**₹5,44,500 - ₹9,30,000**

B. Running cost (per cycle)

Description	**Potential suppliers**	**Estimated Cost (INR)**
Raw material (100 kg)	Farmers themselves grow the pods	NA
Glass bottles with lid (400 bottles)	AL Nabi Glass Bottle, New Delhi	₹ 2,000 - ₹4,000
Essential utilities, water supply and electricity supply	NA	₹ 1,000 - ₹3,000
Yeast powder (@ ₹700 / Kg)	Shree Sai Biotech, Indore, Madhya Pradesh	₹ 700 - ₹1,000
contingency for unforeseen expenses	NA	₹ 2,000 - ₹ 3,000
Total running cost per cycle		**₹ 5,700 - ₹ 11,000**

IV. Market analysis

Estimation per cycle

Factor	**Low Estimate (INR)**	**High Estimate (INR)**
Raw Material (100 kg)	NA	NA
Yield per Cycle	40 kg	60 kg
Market Price (Approximate)	@ ₹ 200 - ₹ 350/kg	
Revenue (per yield)	₹ 8,000 - ₹ 14,000	₹12,000 - ₹21,000
Operating Cost per Cycle	₹ 5,700	₹ 11,000

Annual Estimation (for 6 cycles)

Factor	Low Estimate (INR)	High Estimate (INR)
Yield per Year	240 kg	360 kg
Operating Cost per Year	₹ 22,800	₹ 44,000
Revenue (Market Price)	₹ 48,000 - ₹ 84,000	₹ 72,000 - ₹ 1,26,000