सत्यमेव जयते

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Maharashtra Project on Climate Resilient Agriculture

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DETAILED PROJECT REPORT

(Template)

Curcumin Extraction Unit

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Between

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And

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1 Introduction: What is curcumin?

Curcumin is an orange–yellow crystalline powder essentially insoluble in water. Curcumin is yellow in color shade and is most precious constituent of turmeric. Curcumin is one of the three curcuminoids that appear in turmeric, the other two being desmethoxycurcumin and bis-desmethoxycurcumin. These curcuminoids allow turmeric its yellow color and curcumin is utilized as a yellow food colorant and additive. Curcumin is extracted from the dried rhizome of the turmeric plant, which could be a lasting herb that is cultivated majorly in south and Southeast Asia. The rhizome or the root is processed to create turmeric which contains 2% to 5% curcumin. Curcumin is the most naturally dynamic photochemical compound of Turmeric.

1.1 Market demand and Potential of Turmeric powder and Curcumin

India is the world's leading producer, consumer, and exporter of turmeric. Turmeric was grown on 1.94 lakh hectares in India in 2016-17, with a production of 10.51 lakh tonnes. Turmeric production is estimated to be over 11 lakh tonnes per year worldwide. India leads the global production scenario with 78 percent, followed by China (8 percent), Myanmar (4 percent), and Nigeria and Bangladesh, which together account for 6% of global production. With a share of around 76 percent of total worldwide output and 90 percent of global trade, India is effectively a monopolistic provider to the world. Among Indian states, Maharashtra is second top producer and contributes around 18.57% in the total turmeric production.

The increasing urbanization offers huge market for readily available Turmeric powder packaged attractively and merchandised in organized urban platforms such as departmental stores, malls, super markets. Moreover, the increasing demand for natural products as food additives makes turmeric powder an ideal candidate as a food colorant, thus increasing demand for it

Curcumin has been shown to lower blood cholesterol in studies conducted over the previous five decades. The major yellow bioactive component of turmeric, curcumin (diferuloylmethane), has been proven to have a wide range of biological activities. Its anticancer activity is primarily mediated by apoptosis induction. Curcumin's potential as a therapy for Alzheimer's disease, viral infections, inflammation, malignancies, gastrointestinal

disorders, and other conditions has prompted much research and development. It is certainly clear that the medicinal properties of curcumin generates its huge demand in the pharmaceutical industry. India is the world's largest producer of curcumin, accounting for more than 80% of global production. The worldwide curcumin showcase measure is anticipated to reach USD 99.3 million by 2024 and USD 151.9 million by 2027, growing at a CAGR of 12.7%. The pharmaceutical application segment led the market in 2020 with the highest revenue share of more than 51%. The segment is estimated to expand further at the fastest CAGR from 2020 to 2028. For many centuries, curcumin has been widely used in traditional Asian herbal medicines to treat infections and inflammation. The cosmetics application segment is estimated to have significant growth over the forecast period.

Sudden outbreak of the COVID-19 pandemic has led to the increasing utilization of curcumin in the healthcare sector based on its anti-inflammatory, anti-oxidative, anti-fungal, and anti-bacterial properties that help in treating the viral infection. Global market for curcumin was record at over USD 70 million in 2020 and will expand at more than 11% CAGR through 2027. In Europe, the application of curcumin in the pharmaceuticals sector accounted for a share of 57.2% in terms of revenue in 2019 owing to increasing focus on the marketing of capsules/tablets that offer aid to the immune system, joint, and digestive health.

Some of the major players in the global curcumin market include Arjuna Natural Pvt Ltd., Biomax Life Sciences Limited., Helmigs Prima Sehejtera, Herboveda India Pvt. Ltd., Hindustan Mint & Agro Products Pvt. Ltd., Konark Herbals & Healthcare, Rosun Natural Products Pvt. Ltd., Sabinsa Corporation, Star Hi Herbs Pvt. Ltd., SV Agrofood, Synthite Industries Ltd., and Wacker Chemie AG.

Since, PoCRA region, especially Hingoli has recently become the epicentre of turmeric trade in the state, availability of raw material for processing should be comfortable. Also, the established demand of turmeric powder and curcumin in regional, national and international markets make turmeric powder and curcumin proposition advantageous for the FPCs.

2 Techno-economic analysis

2.1 Process flow diagram

The curcumin extraction unit describes here is based on solvent extraction method. The raw materials required for the plant are dried turmeric rhizomes, solvent (ethanol) and isopropanol.

Industrial scale extraction of curcumin analyzed in this work can be represented in five steps:

1. Extraction of curcumin from turmeric using a solvent (ethanol).

2. Separation of curcumin-laden solvent from soaked rhizomes.

3. Recovery of solvent and concentration of extracted solution using evaporation.

4. Separation of curcumin from the oleoresin via crystallization.

5. Drying to obtain curcumin powder.

The primary step is to add cleaned turmeric rhizomes in a percolator tank. After the rhizomes are added, the solvent is added into the percolator chamber for almost 6 hours. This operation time of 6 hours is evaluated with regard to residence time of 4 hours. A fluid extract or curcumin loaded solvent is obtained. This liquid is then pumped and after that filtered to isolate the insoluble impurities such as skin, rootlets, rhizome particles etc. with the help of a centrifuge. This decontaminated fluid extract is at that point concentrated using an evaporator to a wanted concentration. The evaporator boils the ethanol solvent and water from the blend, taking off an oily residue with high curcumin concentration called oleoresin. The oleoresin contains fixed oil, curcuminoids (generally from 20-60%), together with some amounts of ethanol and water.

The oleoresin is cooled to room temperature using a heat exchanger. Within the base-case design, half of the oleoresin is collected as a product, and the curcumin from the remaining oleoresin is crystallized utilizing isopropanol as solvent at low temperatures for higher yields. Amid centrifugation, settled oils alongside isopropanol clears out as mother alcohol, and the precipitate is collected. At last, the solids from the centrifuge are dried in a vacuum tray dryer to get dried curcumin which can be powdered and packed. The process flow diagram in shown in Figure 2.1

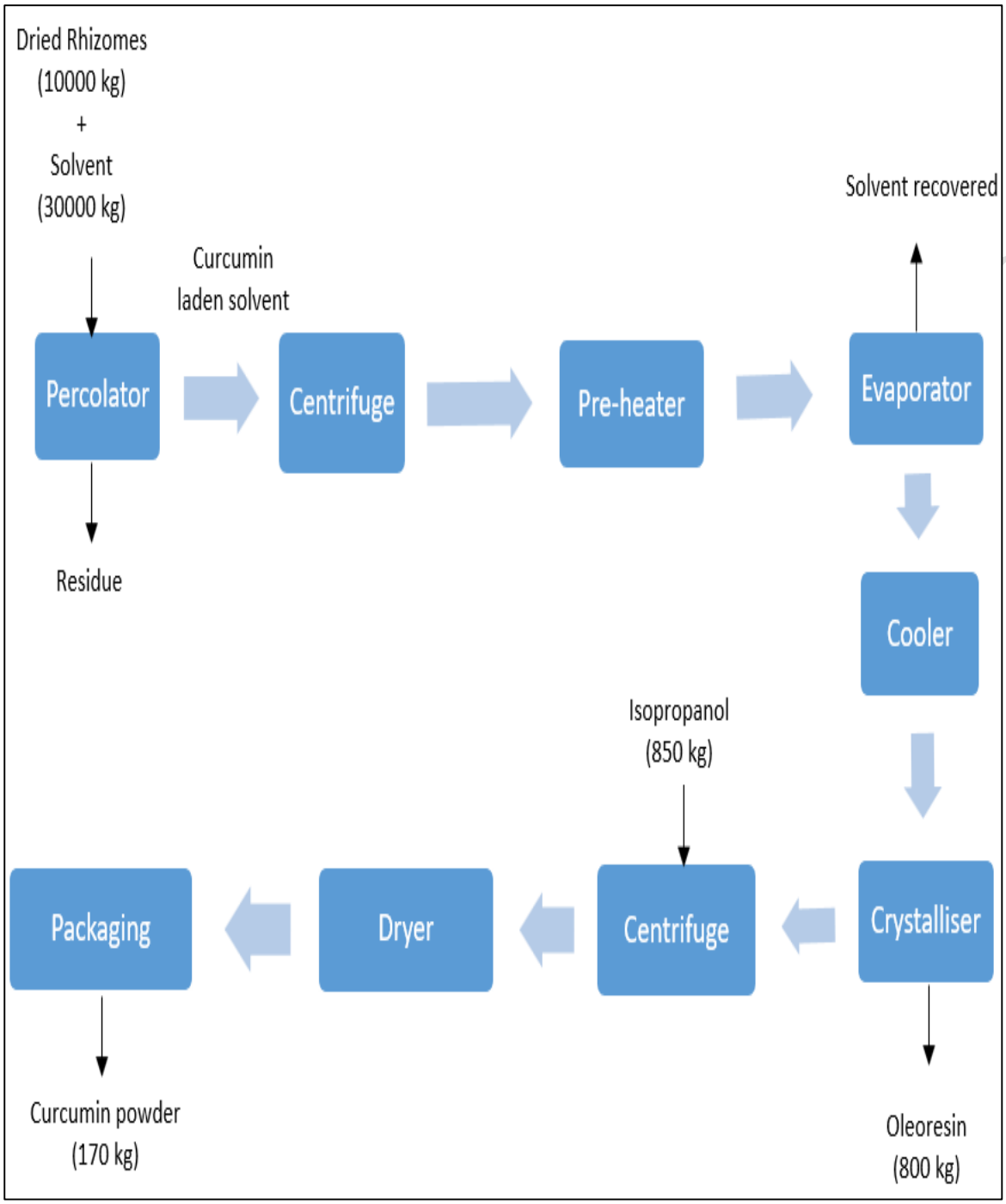

Figure 2.1 Process flow diagram of Curcumin

2.2 Plant layout

Figure 2.2presents the layout of curcumin extraction plant.

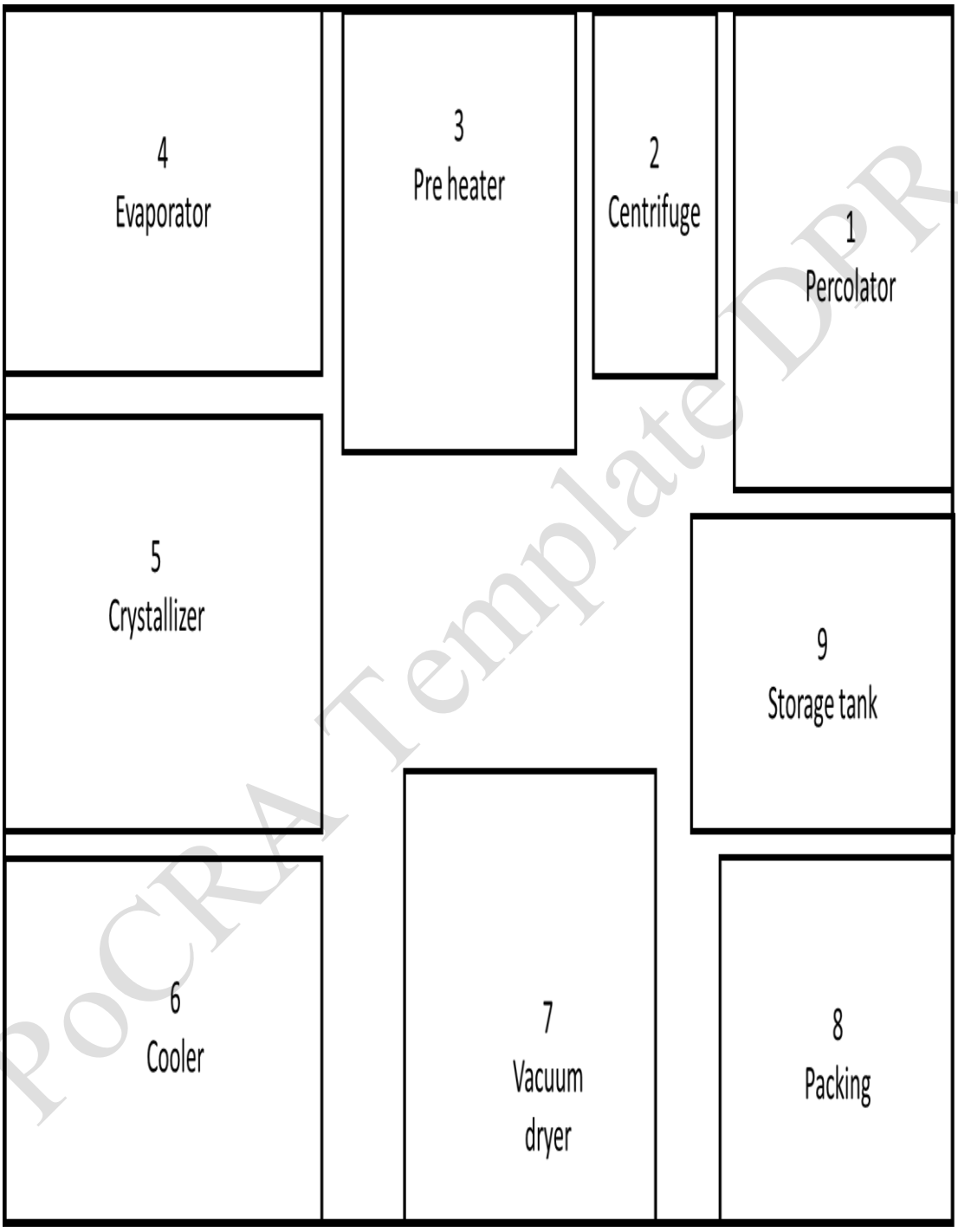

Figure 2.2Plant layout of Curcumin extraction plant

2.3 Financial analysis

Table 2-1 presents the financial analysis for a curcumin processing unit of 10 tonnes per day capacity. The assumptions and costs are considered after through study of literature and contact with manufacturers/vendors. The analysis has been done considering the 300 days of operations. Based on these considerations, the annual raw material requirement (dried rhizomes) is estimated to be around 3000 tonnes. The fixed cost (capital investment) include the cost of machinery, land, civil construction, taxes and pre-operative expenses. The operating or variable cost include the salaries of staff, cost of raw material, power/electricity, fuel, maintenance and contingency. The costs of individual items is mentioned in Table 2-1.

It is considered that of the total curcumin content present, 50 % is in curcumin powder and 50% is in oleoresin. As mentioned in the process flow diagram, 1 kg dried turmeric rhizomes will yield 85g oleoresin while 17.7 g curcumin powder. The annual production of the plant at full capacity is 34 tons curcumin powder and 160 tons oleoresin. Assuming the wholesale price of curcumin powder as Rs.5000/kg, that of oleoresin as Rs.200/kg, the annual income of the plant is estimated to be Rs. 30,30,00,000. Considering the life of plant as 10 years, the Net Present Value (NPV) is calculated to be Rs 6,55,92,949 at a discount rate of 10%.

The calculation indicate an internal rate of return (IRR), benefit to cost ratio (BCR) and discounted payback period (DPBP) as 48.77%, 2.72 and 2.58 years respectively. Since, the value of IRR is in the acceptable range while BCR is more than one, it could be inferred that the curcumin processing unit of the proposed capacity is convincingly profitable.

Table 2-1 Financial Summary of curcumin extraction unit (10 TPD)

Value addition intervention- Curcumin extraction unit			**Details**	**Values**
A. Plant capacity per day (MT)				10
A.1	*Number of operating days*			300
A.2	*Raw material input per batch*			
	A.2.1	*Dried Turmeric rhizomes*	*in kg*	10,000

	A.2.2	*Solvent (Ethanol)*	*in kg*	1,00,000
	A.2.3	*Isopropanol*	*in kg*	6,000
B. Capital Investment				
B.1	*Cost of Machine excluding taxes & duties (Grinder, Percolator, Centrifuge, Pre-heater, Evaporator, Cooler, Crystallizer, Dryer)*			86,15,000
B.2	*Solvents*			
	B.2.1	*Solvent (Ethanol)*	*Rs. 60/kg*	60,00,000
	B.2.2	*Isopropanol*	*Rs. 130/kg*	7,80,000
B.3	*Land (plant area)*		*In sqft (square feet)*	2,000
	B.3.1	Land cost (ownership/leased)	*2000/- sqft including taxes*	30,00,000
	B.3.2	Civil Work including water tank and electrical work	*Construction cost 200/sqft + utility cost 300/sqft (Electrical)*	10,00,000
B.4	*Pre-Operational Expenses*			
	B.4.1	GST on machines	*18 %*	27,71,100
	B.4.2	Licencing, registration, documentation, accountant fees		3,00,000

	B.4.3	Training, Installation and delivery charges	*10% of equipment cost*	15,39,500
	B.4.4	iii. Office Furniture & Equipments		50,000
	B.4.5	iv. Miscellaneous		50,000
B.5	*Total Capital Investment (B.l+B.2+B.3+B.4)*			2,41,05,600
C. Annual Expenses				
C.1	*Interest on Loan@ 10%pa*		*Considering 40% of capital cost is loaned by FPC*	9,64,224
C.2	*Manpower Cost 3 Workers @ 10000/- per month and 1 supervisor @ 30000/- per month and*		200000/- marketing expenditure per annum	9,20,000
C.3	C.3.1	Raw Turmeric cost	*Rs. 75/kg*	22,50,00,000
	C.3.2	Solvent (Ethanol)	*2% losses per batch*	3,60,00,000
	C.3.3	Isopropanol	*2% losses per batch*	46,80,000
	C.3.4	Packaging material	*20/- per kg of produce*	58,20,000
C.4	*Power Consumption*			
	C.4.1	Unit consumed per annum		1000372
	C.4.2	Cost of Electricity @ Rs. 10/KW		1,00,03,729
C.5	*Cost of water*		*1 kg rhizome = 10 litre water*	12,00,000
C.6	*Maintenance*			20,000
C.7	*Contingency*		*5% of total fixed cost*	12,05,280

C.8	*Depreciation*			
	C.8.1	Depreciation on Furniture	*at 10%*	5,000
	C.8.2	Depreciation on Machines	*at 10%*	5,66,500
	C.8.3	Depreciation on Civil work	*at 10%*	1,00,000
C.9	*Total Expenses (C.3 + C.12)*			19,15,81,004
D. Total production per annum				
D.1	*Curcumin Powder*		*in kg*	51000
D.2	*Turmeric oleoresin*		*in kg*	240000
F. Annual Income (Full capacity)			*Selling price of curcumin : Rs. 5000/kg* *Selling price of oleoresin : Rs. 200/kg*	30,30,00,000
G. Economic Indices			Plant life: 10 years. Capacity Utilization : Year 1- 50% , Year 2 – 65%, Year 3 – 80%, Year 4 onwards 100%	
G.1	*Net present value (NPV)*		IN Rs.	6,55,92,949.78
G.2	*Internal rate of return (IRR)*		%	48.77%
G.3	*Benefit to cost ratio (BCR)*			2.72
G.4	*Discounted payback period*		In years	2.58

It was observed during the financial analysis that the minimum threshold capacity for viable curcumin extraction plant was 10MT/day. A plant below 10MT/day capacity produced negative NPV and therefore is not recommended based on the considerations in Table 2-1.

2.4 Sensitivity analysis

A sensitivity analysis is done by creating scenarios of the dried turmeric rhizome cost, curcumin powder selling price and oleoresin selling price. The sensitivity of NPV and BCR is studied under three different scenarios. Following are the three scenarios.

Base case Scenario: Dried turmeric rhizomes cost- Rs. 75/kg, Curcumin powder selling price- Rs. 5000/kg and Oleoresin selling price - Rs.200/kg

Low price: Dried turmeric rhizomes cost- Rs. 70/kg, Curcumin powder selling price- Rs. 4000/kg and Oleoresin selling price - Rs.150/kg

High price: Dried turmeric rhizomes cost- Rs. 80/kg, Curcumin powder selling price- Rs. 6000/kg and Oleoresin selling price - Rs.250/kg

It is clearly visit in Figure 2.3, that the scenarios drastically affect the overall economics of the curcumin extraction unit. A high raw material cost negatively affects the economics while in case of high price scenario, along with a high raw material cost, the selling price of curcumin powder and oleoresin as also kept high and it could be observed that the NPV is almost seven times higher than the case. The high volatility of curcumin plant for raw material cost and selling price is evident through this analysis.

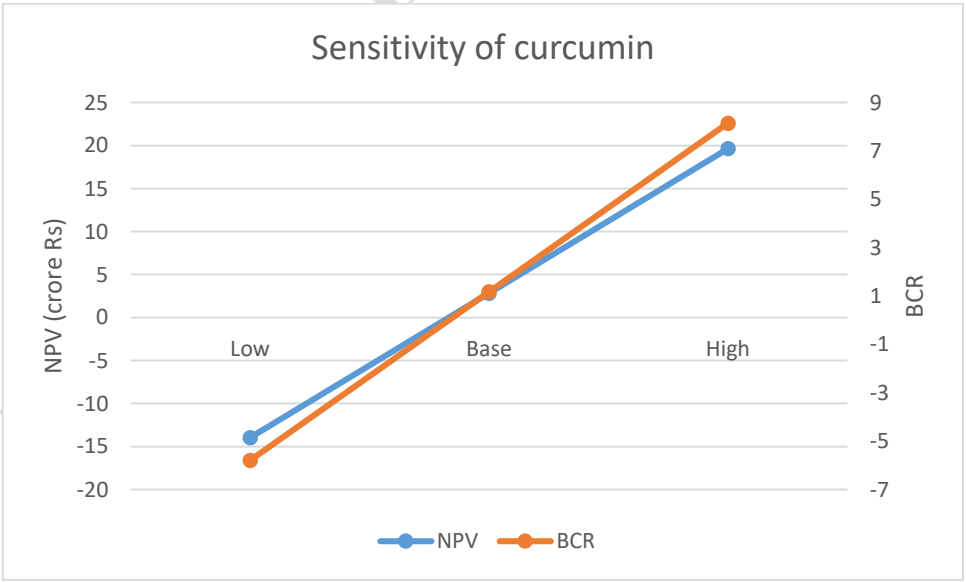

Figure 2.3 Sensitivity of NPV and BCR with different cases of raw material cost and selling prices

2.5 Conjoint analysis

Three cases of raw material prices (Dry rhizome, Ethanol, isopropanol) are developed for conjoint analysis.

Low – Dry rhizome: Rs. 67.5/kg, Ethanol: Rs. 54/kg, Isopropanol: Rs. 117/kg

Baseline – Dry rhizome: Rs. 75/kg, Ethanol: Rs. 60/kg, Isopropanol: Rs. 130/kg

High - Dry rhizome: Rs. 82.5/kg, Ethanol: Rs. 66/kg, Isopropanol: Rs. 143/kg

The effect on NPV of variation in raw material price and turmeric powder selling price is shown in Figure 2.4. Similarly, the effect of variation in raw material price and operating days in shown in Figure 2.5. The project viability is negative (NPV<0) in high case with low milk selling price and less operating days. Therefore these scenarios should be avoided for profit viability.

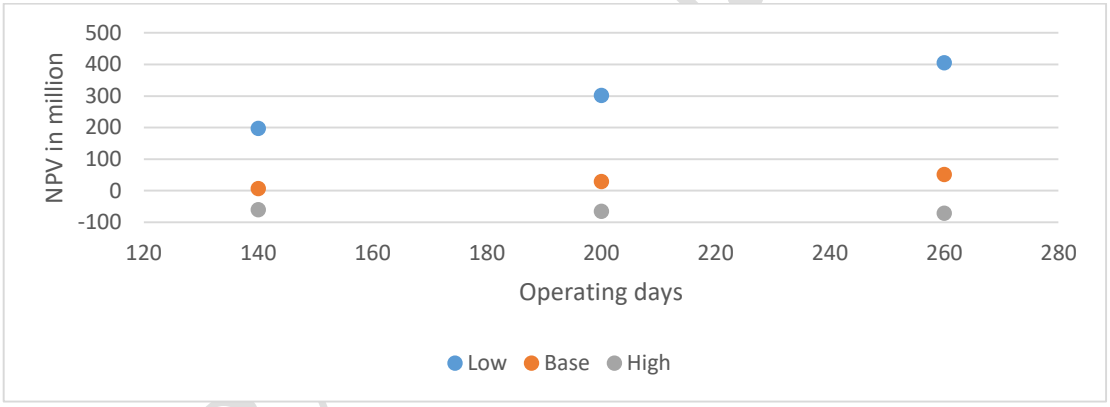

Figure 2.4 Effect of operating days and raw material price on NPV in Curcumin extraction plant

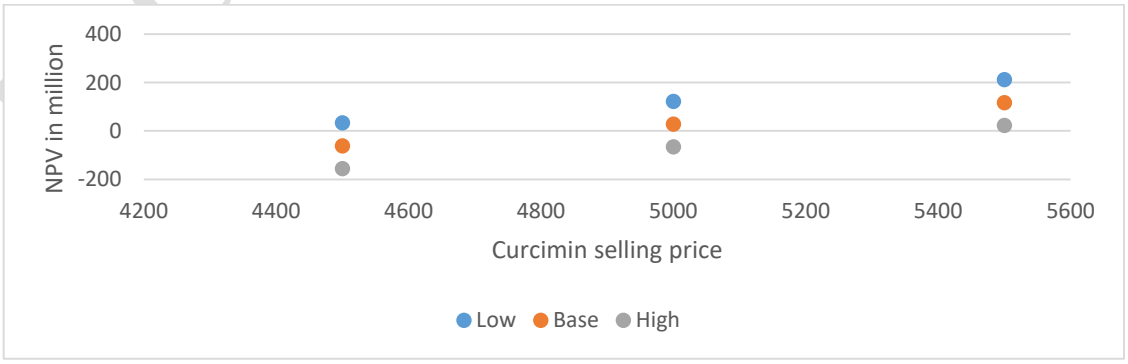

Figure 2.5 Effect of curcumin selling price and raw material price on NPV

2.6 Breakeven points

The project is viable when the cost of dried rhizomes is at least ₹ 75, selling price of curcumin is at least ₹5000/kg and selling price of oleoresin is at least ₹200/kg. The project is viable when the selling price is at least ₹4300/kg considering low case scenario, ₹4900 in case of base case scenario and ₹5400 in case of high case scenario as mentioned.

2.7 Monte carlo simulation (Uncertainty analysis)

A monte-carlo simulation has advantages over sensitivity analysis to estimate the uncertainty in a project. The parameters that may vary in soymilk processing plant simultaneously are as mentioned in Table 2-2.

Table 2-2 Range of uncertain parameters considered for Monte Carlo simulation of soy milk/tofu processing unit

Parameter	Min	Max
Turmeric rhizomes cost per kg	60	80
Curcumin powder selling price per kg	4000	6000
Turmeric oleoresin selling price	150	250

The simulation results in terms of NPV and BCR are shown in Figure 2.6and Figure 2.7 respectively. Ten thousand scenarios are generated using the range of uncertain parameter to capture every possible real life scenario. The blue bars indicate a favourable scenario while a red bar is an unfavourable scenario. A probability that among all the scenarios, the plant would have a positive NPV is 38.3% while that the plant will have a BCR greater than one is 31.2%.

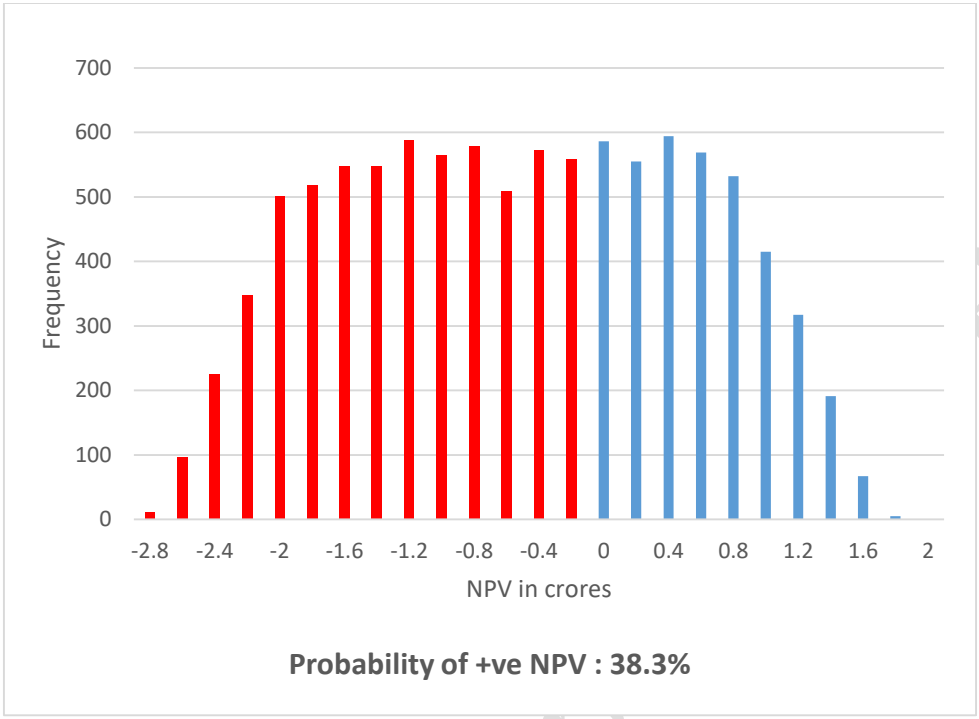

Figure 2.6 Histogram showing Monte Carlo simulation wrt to NPV for curcumin plant

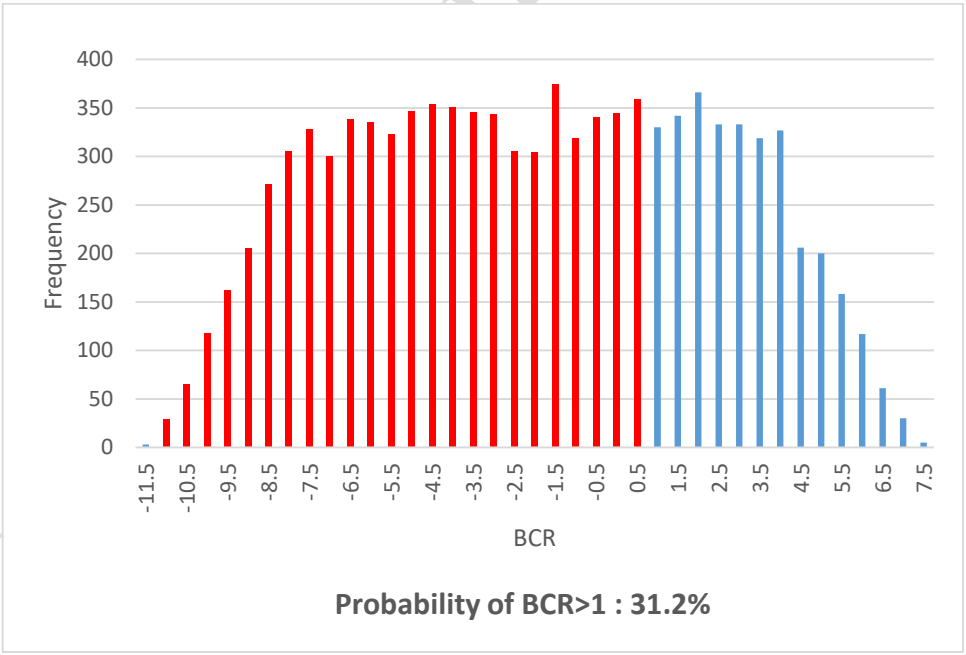

Figure 2.7 Histogram showing Monte Carlo simulation wrt to BCR for curcumin plant

3 SWOT analysis

Strengths	Opportunities
• High value of final product • With more research, rising demand for use in treatment of various diseases such as cancer, heart diseases etc	• Rising awareness of Neutraceuticals pharmaceutical use of curcumin after covid outbreak • Good market value for by-products such as oleoresin, volatile oil
Weakness	**Threats**
• Cost intensive extraction process • Have niche market • Percent extraction of main product is very low • Price volatility	• Extraction rate is dependent on variety of raw material • Extraction process involves handling of inflammable substances such as solvents

4 Forward and Backward linkages

The entrepreneur must provide tentative supplier list and quotations with respect to his project. However, there are many machinery suppliers available within India for curcumin processing machineries and equipment. Some of the suppliers are:

Machine suppliers

1. Dolphin Engineers, Uttam Patil, Plot No. 222, Sector No. 4, Sant Nagar, Moshi Pune - 412105, Maharashtra, India
2. Ved Engineering, Sagar Chadha, B-38, Sector 60, Noida - 201301, Gautam Budh Nagar, Uttar Pradesh, India
3. Excel Plants & Equipment Private Limited, Vishal Dange, Gat No. 611, Mouje Kuruli, M. I. D. C. Chakan, Pune - 410501, Maharashtra, India
4. Himanshu Shah No. 506, World Trade Center, Sayajigunj Vadodara - 390005, Gujarat, India
5. Swaraj Process And Systems Yogesh Patil, Gat No. 183, Ganesh Nagar, Talwade, Pune - 411062, Maharashtra, India

6. Avalon Separation Jitendra Patel, A-32 Akshardham Industrial Estate, Vatva GIDC Ahmedabad - 382445, Gujarat, India
7. Nikul Pharma Equipment, Mahendra Jadeja, Sr. No.257, Abdullah And Rasid Compound, Bhavkal, Virar East, Vasai Virar - 401202, Mumbai, Maharashtra, India
8. Omkar Industries, Mahadeo Patil, S. R. No. 52/3, Maruti Nagar, Wadgaon Sheri Vadgaon Sheri Pune - 411014, Maharashtra, India

5 Risk mitigation in curcumin extraction plant

Sources of Ignition

- Electrical installations shall conform to the requirements of NFPA 70, National Electrical Code®, as hereinafter specified.
- There shall be no smoking or other sources of ignition within the restricted and controlled areas.

Housekeeping

- Waste materials such as oily rags, other wastes, and absorbents used to wipe up solvent, paints, and oils, shall be deposited in approved waste cans and removed from the premises not less than once each day.
- The space within the restricted and controlled areas shall be kept free of dry grass, weeds, trash, and all combustible materials.
- Any spills of oil, solvent, or deposits of solvent bearing material shall be cleaned up immediately and removed to a safe place.

Emergency Procedures

- Personnel shall be thoroughly indoctrinated as to the location of exits.
- All personnel shall be thoroughly trained in the use and limitations of each type of fire-fighting equipment on the premises, including control valves for the water spray system.

Solvent Transfer Equipment

- Pumps shall be designed for the solvent, the working pressures, and the structural stresses to which they will be subjected.
- The use of air pressure as the solvent transferring medium shall be prohibited.

Piping, Valves, and Fittings

- Pipe systems shall be substantially supported and protected against physical damage caused by expansion, contraction, and vibration.
- Drain valves shall be provided with plugs to prevent leakage.

Exits

- A building shall be provided with at least two remotely located means of egress, one of which shall be enclosed or separated from the process by a wall that is blank except for doors.
- Self-closing, non-combustible doors, normally kept closed, shall be provided for access to the protected stairway.

Fire Protection

- An approved system of automatic sprinklers shall be provided in the preparation area.
- Fire alarm signals shall be relayed or sent to a constantly supervised point on or off the premises.
- An approved system of automatic sprinklers shall be provided in the preparation area.

Location

- Bulk solvent storage tanks shall be located outside of any building.
- The arrangement shall be such that all portions of solid floor areas will be subjected to continuous positive movement of air.

6 List of Statutory Clearances Required

The following table mentions the list of statutory clearances required to set up the processing unit of soy milk/tofu.

S.NO.	Approval and Clearances required	Departments/Offices to be consented
1	State Investment Promotion Board, Stage – I clearance	Department of Industries
2	Environmental clearance	Maharashtra State Pollution Control Board
3	GST registration	Commercial Taxes
4	Change in land use	Land revenue department
5	Sanction and supply of power	DISCOM
6	Sanction and supply of water	

7 Conclusion

In this section, turmeric powder and curcumin extraction unit is introduced and its market potential is discussed. Based on the techno-economic analysis, it is understood that the turmeric powder and curcumin extraction plant of the proposed capacity is profitable with a quantum requirement of around 380 MT/annum and 3000 MT/annum respectively. Based on the field visit experience, majority of the FPCs have sufficient quantum to venture into both turmeric powder and curcumin business. The monte-carlo simulation suggest the volatility of the proposed interventions of turmeric. It is observed that turmeric powder unit has a higher probability of positive NPV and BCR <1 as compared curcumin plant. The monte carlo simulations also suggest that the curcumin extraction business is risky since, the probability of achieving a BCR>1 is mere 31% which is very less as compared to other products discussed in this report.