CHAPTER - 8

TECHNO-ECONOMICS
8.1 Introduction

As stated in earlier work that total production of essential oil is 1,05,500 metric tonnes/year (Varsheny, S.C. 2001) out of which 30000 and 200 tonnes covers mint and Cymbopogon oil production (Vaze, S.V., 2000, Gupta, R., 2000). Fortunately Indian production of mint oil and Cymbopogon oil is 50% and 80% of world demand (Gupta, R., 2000). The future of this industry mainly depends on proper amendment in mint and Cymbopogon crop cultivation by which the production of oil can be increased. Besides this the chemical technique (Fig-8.1) used for driving value added components from mint and Cymbopogon oil should be changed to biotechnological process, so that both quantity and the quality of mint oil derivatives can be well managed (Schrader, J. and Berger, R. G., 2001).

Huge amount of green waste produced during mint oil processing is left without its proper use. So, suitable biotechnology means should be developed for utilizing this green waste either to produce energy to use as green manure.

Keeping the aforesaid fact in view, the present project is aimed to have comparative statement of production and expenditure budget of mint or Cymbopogon crop under variable technical amendment conditions.

8.2 Economics feasibility of mint oil production

8.2.1 Basis of Study

In the first case of study it has aim to calculate and find out proper balance sheet of mint oil production under the present method of cultivation (Fig-8.2). The following basis of study has been considered for the production of mint oil.

A) Biomass Production

1. Oil production capacity T/season – 8000 kg
2. Land for biomass production – 40 hectare.
3. Biomass production capacity – 500 T/season
4. Average biomass product – 12.5 T/ hectare.
5. Average mint oil product – 200 kg/ hectare
6. Fixed cost This includes: -
   • Amnortised establishment
   • Storage
   • Taxes & insurance
   • Land revenue
7. Variable Cost It consist of: -
   • Chemical fertilizers
   • Chemicals (Insecticide & Pesticide)
   • Daily Wages and supervision
Fig-8.1 Biomass processing technology of mint/Cymbopogon oil
Fig- 8.2 Integrated biotechnological and biochemical process for production of value added essential oil, green fertilizer and bio-fuel from processing of biomass of mint/ *Cymbopogon* crops.
8. Cost of establishing cultivar (*Mentha arvensis*). It includes:
- Land preparation
- Cost of stolons
- Broad casting of stolons
- Maintenance like first harvest

9. Cost of cultivation of *Mentha arvensis*.
- Cost of weeding
- Cost of harvesting
- Cost of irrigation

10. Working capital.
- Daily wages & supervision* - one month
- Utilities – one month
* These wages & supervision is to be shared with the steam distillation unit.

11. Daily wages & supervision
- Supervisor 1 No Rs 1000 per month
- Worker 4 Nos. Rs 4000 per month

12. Utilities
- Power – 60 KWh

13. Interest of working capital @ 14%

**B) Biomass processing of mint crop (steam distillation unit)***.

1. Plant capacity – 3 tonnes/batch
2. Batch cycle time – 8 hours
3. Material Balance
   
<table>
<thead>
<tr>
<th>Raw material</th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mint biomass</td>
<td>3.0</td>
</tr>
<tr>
<td>Mint oil produced</td>
<td>0.100</td>
</tr>
</tbody>
</table>

4. Utilities Consumption
- Electricity – 5.0 kwh
- Water – 17000 liter/day

5. Utilities
- Power – 60 p/kwh

6. Fixed cost It includes: - @ 15% of the total investment
- Depreciation
- Interest
- Taxes & insurance
- Repair & maintenance
7. Variable cost: -
   • Utilities
   • Daily wages & supervision
   • Interest of working capital
8. Working capital
   • Daily wages & supervision – 1.0 month
   • Utilities – 1.0 month
9. Daily wages & Supervision
   • Supervision – 1 Nos 1000/-
   • Daily wages – 4 Nos. 3200/-
   The wages & supervision is to be shared with biomass production.
10. Utilities
   • Power – 60 paise/ kwh
11. Interest of working capital @ 14% interest.

* The running time of the unit is 40-42 days per season.

C) Process Economics
1. Biomass production economics

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Fixed cost</td>
<td>113600.00</td>
</tr>
<tr>
<td>B) Variable cost</td>
<td>3,09,600.00</td>
</tr>
<tr>
<td>C) Cost of Establishing of cultivar</td>
<td>2,00,580.00</td>
</tr>
<tr>
<td>D) Cost of cultivation of mint crop</td>
<td>3,19,320.00</td>
</tr>
</tbody>
</table>

Total cost 943100.00

2. Biomass processing (steam distillation) Economics

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Fixed cost</td>
<td>23250.00</td>
</tr>
<tr>
<td>C) Variable cost – Labour cost</td>
<td>44000.00</td>
</tr>
<tr>
<td>Fuel cost</td>
<td>35200.00</td>
</tr>
<tr>
<td>Total variable cost</td>
<td>79200.00</td>
</tr>
</tbody>
</table>

Total cost 1,02450.00

8.2.2 Result Summary
Following results summary has been obtained based on biomass production/ biomass processing (steam distillation) for the production of mint oil.

256
S.N. | Item Biomass production | Biomass processing (steam distillation)
---|---|---
1. | Capacity | 500 | 500
2. | Fixed cost (Rs) | 1,13600 | 23250.00
3. | Variable cost (Rs) | 3,09600 | 79200.00
4. | Cultivar establishing cost (Rs) | 2,00580 | -
5. | Cultivation cost (Rs) | 319320 | -
6. | Total cost (Rs) | 943100 | 1,02450

8.2.3 Sensitivity Analysis for mint oil production

Sensitivity analysis for biomass production / biomass processing (steam distillation) to mint oil is tabulated below.

A) For biomass production

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Figure in Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Land under cultivation (hectare)</td>
<td>13.3</td>
</tr>
<tr>
<td>2.</td>
<td>Biomass production capacity T/season</td>
<td>166.6</td>
</tr>
<tr>
<td>3.</td>
<td>Mint oil production capacity kg/season</td>
<td>2666.6</td>
</tr>
<tr>
<td>4.</td>
<td>Total prod. Cost</td>
<td></td>
</tr>
<tr>
<td>A)</td>
<td>Fixed cost</td>
<td>41,600</td>
</tr>
<tr>
<td>B)</td>
<td>Variable cost</td>
<td>125000</td>
</tr>
<tr>
<td>C)</td>
<td>Establishing cost of cultivar</td>
<td>66860</td>
</tr>
<tr>
<td>D)</td>
<td>Cultivation cost</td>
<td>106440</td>
</tr>
<tr>
<td>E)</td>
<td>Total cost</td>
<td>339900</td>
</tr>
<tr>
<td>5.</td>
<td>Production cost Rs/kg mint oil</td>
<td>127.46</td>
</tr>
</tbody>
</table>

Table 8.1 The biomass production economics of mint.

The variation of production cost (Rs/kg), total production cost with respect to biomass production in the above table has also been represented graphically in Fig 8.3. The following observation is made.

By varying the production capacity from 100 T/season to 500 tonnes/season the cost of per kg mint oil goes down from 127.46 to 113.03 Rs/kg and investment goes up from Rs 319900 to 1507100. In production of 500 T biomass per season to cost of per kg mint oil will be Rs 113.03.
Figure-8.3 Techno-economics of mint biomass production
B) For Biomass processing

Biomass processing to mint oil (steam distillation unit). In a season the running time for a steam distilling plant is about 50-60 days during harvesting period.

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Item</th>
<th>Figure in Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Plant capacity/ Batch</td>
<td>1.0 competency</td>
</tr>
<tr>
<td>2.</td>
<td>Mint oil quantity</td>
<td>2666.6</td>
</tr>
<tr>
<td>3.</td>
<td>Total proc. Cost</td>
<td>A) Fixed cost</td>
</tr>
<tr>
<td></td>
<td>B) Variable cost</td>
<td>20150 72120</td>
</tr>
<tr>
<td></td>
<td>C) Total cost</td>
<td>80540 92270</td>
</tr>
<tr>
<td>4.</td>
<td>Processing cost Rs/kg oil/season</td>
<td>30.20 17.300 12.806 10.183 8.474</td>
</tr>
</tbody>
</table>

Table 8.2 The biomass processing economics of mint.

Variation of processing cost and total investment with respect to plant capacity as indicated in the above table has been further graphically represented in Fig 8.4. Based on these variations it has been observed that-

Total investment goes from Rs 80540 to 112990 while the processing cost of per kg mint oil goes down from 30.20 to 8.47 of the plant capacity is increased from 1.0 to 50 tonnes / batch. For a plant capacity of 5.0 tonnes/ batch the processing cost is likely to go down to Rs 8.47/kg mint oil.

8.2.4 Conclusion

Following conclusion are drawn based on the result summary, that when the plant capacity is low the production and processing cost of per kg mint oil is high but when plant capacity increases the processing cost of per kg mint oil decreases. But the total investment increases as the plant capacity increases, so it is advisable for ago-industry for the optimum production and processing of biomass the capacity of 300T/season is advisable for the project viability.
Figure-8.4 Techno-economics of mint biomass processing to obtain mint oil
8.2.5 Project Viability

The present market rate of crude mentha oil is Rs 274/Kg as stated earlier.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Figure in Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Production capacity mint oil (kg)</td>
<td>2666.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5333.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7999.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10666.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13333.3</td>
</tr>
<tr>
<td>2</td>
<td>Biomass production capacity T/season</td>
<td>166.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>333</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>666.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>833</td>
</tr>
<tr>
<td>3</td>
<td>Steam distillation unit (capacity) T/Batch</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>4</td>
<td>Total processing Cost per kg oil (mint oil)</td>
<td>150.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>136.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>130.686</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125.663</td>
</tr>
<tr>
<td></td>
<td></td>
<td>121.504</td>
</tr>
<tr>
<td>5</td>
<td>Net profit/ kg mint oil</td>
<td>123.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>137.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>143.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>148.34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>152.5</td>
</tr>
<tr>
<td>6</td>
<td>Total Profit</td>
<td>3,30,231</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7,31,088</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11,46,545</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,82,283</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20,33,328</td>
</tr>
</tbody>
</table>

Table 8.3 Total Economic of per kg mint oil and net profit per annum when the crude mint oil is sold as such. *

*The data obtained are on the basis of farmer having own land.

8.3 Techno – Economic feasibility of crude mint oil processing

8.3.1 Executive Summary

The present techano-economic feasibility study is based on a plant capacity of 25 T/A of crude mint oil to high value added chemicals. A summary of the process economics is given below:

1. Basic data available from pilot scale plant for this study is given under “Basis of study”
2. From the pilot scale plant data, it can be seen that yield of the different constituents from crude mentha oil processing is 95% (by wt. Basis). The cost of per kg mint oil is about Rs 274.
3. The process is heavy investment oriented of the order of Rs. 1106500 mainly due to column, reactors and Gas liquid chromatography (instrument) cost.
4. So, for economic it is necessary to run the plant through out the year and raw material should be provided through capital investment.

8.3.2 Introduction

It has been reported that crude mint oil contain different high value added chemical constituents like menthol, menthone, cis-3-hexanol, 3- octanol, l-limonene, α-pinene, β-pinene, 1,8 cineol etc (Pandey,
A. K. and Chowdhury, A. R., 2000). It is possible to separate these chemicals through different rectification and chemical reactions (Varsheny S. C., 2001d). So the aim of the present project is to see the economic viability at different plant capacity.

### 8.3.3 Basis of study

The following basis of study has been considered for the separation of different value added chemicals from crude mint oil.

- **Plant Capacity** – 25 T/ A
- **Stream factor** – 8000 hr
- **Batch cycle time** – 15 days /tonne / batch

#### Material Balance

- **Raw material** – crude mint oil
- **Products**
  - Menthol crystal (bold)
  - Menthol crystal (rice)
  - Menthol crystal (flake)
  - Liquid peppermint
  - \{menthone (50%) + menthol (50%)\}
  - Cis-3-hexanol
  - 3-octanol
  - l-limonene
  - 1,8-cineole
  - α-pinene
  - β-pinene
  - other mixture

#### Chemicals consumed / Batch

- Boric acid – 15 kg
- Sodium hydroxide – 20 kg
- Polyethylene -- 15 kg

#### Utilities consumption / Batch

- Electricity –2250 units
- Water – 75 m$^3$

#### Chemical cost

- Boric acid -- Rs. 50 / kg
- Sodium hydroxide – Rs. 20 / kg
- Polyethylene -- Rs 74 / kg

#### Utilities cost

- Power @ 350 paise / unit
- Water @ 30 paise / m$^3$

#### Wages & Supervision

- Manager 01 – Rs 2500.00
- Supervisor 01 – Rs 1500.00
- Operator 02 – Rs 1000.00
j. Plant investment
   - Plant and machinery cost
   - Add 15% extra for erection, piping, electric fitting, contingency, Generator, etc.

k. Fixed cost @ 15% of plant investment that includes
   - depreciation
   - interest
   - taxes and insurance
   - repair and maintenance
   - Generator repair & maintenance

l. Variable cost
   - Chemicals
   - Utilities
   - Wages & Supervision
   - Diesel for generator
   - Hi thermic oil (0-600°C)
   - Interest of working capital
   - Maintenance of lab equipment

m. Working Capital
   - Raw material – 30 days
   - Chemicals – 30 days
   - Wages & supervision – 3 months

n. Interest on working capital @ 14%

8.3.4 Mint Oil Processing
   The yield of different product during mint oil process is 95% of the total (on wt. Basis). There is 5% loss of the mint oil during operator. The processing of mint oil is already discussed in chapter-5 and Fig 5.3

8.3.5 Process Economics
   The process economics is based on the plant capacity of 25 tonnes/annual of crude mint oil to its different constituents. The details of the economics are given below:
   a) Plant Investment
   A) Plant and Machinery cost.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Numbers</th>
<th>Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column</td>
<td>2</td>
<td>2,40,000</td>
</tr>
<tr>
<td>Reboiler</td>
<td>2</td>
<td>1,20,000</td>
</tr>
<tr>
<td>Thermic oil tank</td>
<td>1</td>
<td>30,000</td>
</tr>
<tr>
<td>Reactors</td>
<td>2</td>
<td>1,40,000</td>
</tr>
<tr>
<td>Condenser</td>
<td>3</td>
<td>70,000</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>1</td>
<td>30,000</td>
</tr>
<tr>
<td>Total cost</td>
<td></td>
<td>6,30,000.00</td>
</tr>
</tbody>
</table>
B) Add 15% extra for installation, electric fitting, piping etc 94,500
C) Laboratory cost 3,00,000
D) Generator cost (40 kVA) 82,000

Total plant investment 11,06,500.00

2) Processing Cost
   1. Fixed cost @ 15% of total Investment 1,65975
   2. Variable cost
      • Boric acid = 18750
      • PEG = 27,750
      • NaOH = 10,000
      • Wages & supervision = 72,000
      • Interest of working capital = 12338
      • Diesel of Generator = 79200
      • Utilities cost = 189562
      Total Variable cost = 409600

Total processing cost = 575575
So, processing cost of per kg oil / annual = 23.023

8.3.6 Project Economics of Mentha Oil Processing
   The project economics
   is based on the plant capacity of 25 T/ A of mint oil to different value added chemicals. The details of the economics are given below.
   A) Raw material used for processing = 1 tonne/ batch
   B) Cost of raw material Rs/kg =274
   C) Products obtained: -

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Rs /kg</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Menthol crystal (bold)</td>
<td>500</td>
<td>374</td>
<td>18700</td>
</tr>
<tr>
<td>2) Menthol crystal rice</td>
<td>50</td>
<td>365</td>
<td>18250</td>
</tr>
<tr>
<td>2) Menthol crystal (flake)</td>
<td>150</td>
<td>335</td>
<td>50250</td>
</tr>
<tr>
<td>3) Liquid peppermint oil</td>
<td>160</td>
<td>225</td>
<td>36000</td>
</tr>
<tr>
<td>4) Cis- 3 hexanol</td>
<td>0.5</td>
<td>15,000</td>
<td>7500</td>
</tr>
<tr>
<td>5) 3- Octanol</td>
<td>12</td>
<td>470</td>
<td>5640</td>
</tr>
<tr>
<td>6) l-limonene</td>
<td>32</td>
<td>150</td>
<td>4800</td>
</tr>
<tr>
<td>7) α- pinene</td>
<td>12</td>
<td>120</td>
<td>1440</td>
</tr>
<tr>
<td>8) β- pinene</td>
<td>20</td>
<td>160</td>
<td>3200</td>
</tr>
<tr>
<td>9) 1,8 cineol</td>
<td>8</td>
<td>250</td>
<td>2000</td>
</tr>
<tr>
<td>10) others (myrcene, sabinene, γ- terpinene)</td>
<td>10.5</td>
<td>20</td>
<td>210</td>
</tr>
</tbody>
</table>

Total 316290
D) Raw material cost (Rs/tonne) = 274000
E) Processing cost = 23.023
F) Average cost of product = 332.9
G) Loss during processing = 5%
H) Total loss (/kg) = 50 gm
I) Cost of loss (Rs/ kg) = 19.15
J) Total expenditure cost (Raw material + processing cost + losses) per kg oil = 316.17
K) Net profit / kg oil = 16.76
L) Profit per annual = 419171

8.3.7 Result Summary

Following result summary table has been prepared based on mint oil processing through rectification & crystallization.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw material cost Rs / kg</td>
<td>274</td>
</tr>
<tr>
<td>2</td>
<td>Plant Capacity (T/A)</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Plant investment</td>
<td>1106500</td>
</tr>
<tr>
<td>4</td>
<td>Fixed cost</td>
<td>165975</td>
</tr>
<tr>
<td>5</td>
<td>Variable cost</td>
<td>409600</td>
</tr>
<tr>
<td>6</td>
<td>Total processing cost</td>
<td>375575</td>
</tr>
<tr>
<td>7</td>
<td>Processing cost Rs /kg</td>
<td>23.023</td>
</tr>
</tbody>
</table>

Table 8.4 the processing economic of crude mint oil processing.

From the above table it is clear that:
1. Raw material cost is very high.
2. There is a heavy investment in the plant.

8.3.8 Sensitivity Analysis

Sensitivity analysis for mint oil processing to its different constituents is tabulated below:

<table>
<thead>
<tr>
<th>Plant Capacity T/A</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Investment</td>
<td>1106500</td>
<td>167718</td>
<td>2139233</td>
<td>2540045</td>
<td>10111042</td>
</tr>
<tr>
<td>Total Processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Fixed Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Variable Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Chemicals</td>
<td>56500</td>
<td>11300</td>
<td>169500</td>
<td>226000</td>
<td>360000</td>
</tr>
<tr>
<td>* Wages &amp; supervision</td>
<td>72000</td>
<td>108000</td>
<td>144000</td>
<td>180000</td>
<td>360000</td>
</tr>
<tr>
<td>* Interest of working capital</td>
<td>12338</td>
<td>19740</td>
<td>27143</td>
<td>37014</td>
<td>148056</td>
</tr>
<tr>
<td>* Diesel for Generator</td>
<td>79200</td>
<td>118800</td>
<td>158400</td>
<td>198000</td>
<td>396000</td>
</tr>
<tr>
<td>* Utilities cost</td>
<td>189562</td>
<td>379124</td>
<td>568686</td>
<td>758248</td>
<td>7582480</td>
</tr>
<tr>
<td>Total Cost</td>
<td>575575</td>
<td>989512</td>
<td>1388362</td>
<td>1780250</td>
<td>12261057</td>
</tr>
</tbody>
</table>

Processing cost Rs/Kg mint oil

|                 | 23.023 | 19.79  | 18.51  | 17.80  | 12.261 |

Table 8.5 the economic feasibility of crude mint oil at different plant capacity.
The variable of processing cost, total investment with respect to plant capacity as indicated in the above table and represented in Fig-8.5 gives the following observations.

By varying the plant capacity from 25 T/A to 1000 T/A the processing cost goes down from Rs 23.023 to 12.26 Rs/kg and the plant investment goes up from Rs 1106500 to 10111042.

8.4 Techano-economic feasibility of Mint terpene processing

8.4.1 Executive Summary

The present Techano-economic feasibility study is based on a plant capacity of 25 T/A of crude mint terpene to him value added chemicals. A summary of the process economics is given below:

1. Basic data available from pilot scale column for this study is given under the “Basis of study”.
2. From the data of pilot scale column, it can be concluded that yield of different constituents from mint terpene is 95% (by wt basis).
3. The raw material (mint terpene) is low cost and available at through away rate in market. The mint terpene is available in market at rate of Rs 25/kg.
4. The process is heavy investment oriented of the order of Rs 11,56,500 mainly due to column, reactor and Gas Liquid Chromatography (instrument for analysis) costs.
5. So, for economic feasibility, it is necessary to run the plant through out the year and raw material should be provided through working investment.

8.4.2 Introduction

It has been reported that mint terpene contain different high value added chemicals like α-pinene, β-pinene, 1-limonene, 1,8-cineole, cis-3-hexanol, 3-octanol, menthone, etc (Varsheny, S. C., 2001) So by applying different developed rectification and processing techniques these chemical can be separated from mint terpene mixture. So aim of the present study is to see the economic feasibility at different plant capacity.

8.4.3 Processing of mint terpene

The processing of mint terpene is already discussed in chapter number 5.

8.4.4 Basis of study

The following basis of study has been considered for the separation of different value added chemicals from crude mint terpene.
Figure-8.5 Techno-economics of mint oil processing to its different constituents
a. Plant Capacity - 25 T/ A
b. Stream factor - 8000 hr
c. Batch cycle time - 15 days /tonne / Batch
d. Material Balance
   Raw material - crude mint terpene
   Products - Menthol
   Menthone
   Cis-3-hexanol
   3-octanol
   l-limonene
   1,8-cineol
   α-pinene
   β-pinene
   other mixture
e. Chemicals consumed / Batch
   • Boric acid - 30 kg
   • Sodium hydroxide - 40 kg
   • Polyethylene -- 30 kg
f. Utilities consumption / Batch
   • Electricity -2250 units
   • Water - 75 m³
g. Chemical cost
   • Boric acid -- Rs. 50 / kg
   • Sodium hydroxide -- Rs. 20 / kg
   • Polyethylene -- Rs 74 / kg
h. Utilities cost
   • Power @ 350 paise / unit
   • Water @ 30 paise / m³
i. Wages & Supervision
   • Manager 01 No Rs 2500.00
   • Supervisor 01 No Rs 1500.00
   • Operator 02 Nos. Rs 1000.00
j. Plant investment
   • Plant and machinery cost
   • Add 15% extra for erection, piping, electric fitting, contingency, Generator, etc.
k. Fixed cost @ 15% of plant investment that includes
   • depreciation
   • interest
   • taxes and insurance
   • repair and maintenance
   • Generator repair & maintenance
1. Variable cost  
   - Chemicals  
   - Utilities  
   - Wages & Supervision  
   - Diesel for generator  
   - Hi-thermic oil (0-600°C)  
   - Interest of working capital  
   - Maintenance of lab equipment  

m. Working Capital  
   - Raw material – 30 days  
   - Chemicals – 30 days  
   - Wages & supervision – 3 months  

n. Interest on working capital @ 14%  

8.4.5 Process Economics  
The process economics is based on the plant capacity of 25 tonnes/annual of crude mint terpene to its different constituents. The details of the economics are given below: -  

1) Plant Investment  
   A) Plant and Machinery cost.  

   \begin{tabular}{|l|c|c|}  
   \hline  
   Particulars & Numbers & Rs \\  
   \hline  
   Column & 2 & 2,40,000 \\  
   Reboiler & 2 & 1,20,000 \\  
   Thermic oil tank & 1 & 30,000 \\  
   Reactors & 2 & 1,40,000 \\  
   Condenser & 3 & 70,000 \\  
   Vacuum pump & 1 & 30,000 \\  
   \hline  
   Total cost & & 6,30,000.00 \\  
   \hline  
   \end{tabular}  

   B) Add 15% extra for installation, electric-fitting, piping etc & 94,500 \\  
   C) Laboratory cost & 3,50,000 \\  
   D) Generator cost (40 kVA) & 82,000 \\  
   \hline  

   Total plant investment & 11,56,500.00 \\  
   \hline  

2) Processing Cost  
   1. Fixed cost @ 15% of total Investment  
      & 1,73475 \\  
   2. Variable cost  
      - Boric acid = 37500  
      - PEG = 55,500  
      - NaOH = 20,000
• Wages & supervision = 72,000
• Interest of working capital = 4338
• Diesel of Generator = 79200
• Utilities cost = 189562

Total Variable cost = 458100

Total processing cost = 631575
So, processing cost of per kg oil / annual = 25.26

8.4.6 Project Economic of mint terpene processing

The project economics is based on the plant capacity. The details of the economics are given below:
A) Raw material used for process = 1 tonnes/ batch
B) Cost of raw material = Rs. 25000
C) Products obtained

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity obtained (kg)</th>
<th>Rs /kg</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Menthol</td>
<td>28.5</td>
<td>350</td>
<td>9975</td>
</tr>
<tr>
<td>2) Menthone</td>
<td>142.5</td>
<td>210</td>
<td>29925</td>
</tr>
<tr>
<td>3) Cis-3 hexanol</td>
<td>5</td>
<td>15,000</td>
<td>75000</td>
</tr>
<tr>
<td>4) 3-Octanol</td>
<td>104.5</td>
<td>470</td>
<td>49115</td>
</tr>
<tr>
<td>5) L-limonene</td>
<td>209</td>
<td>150</td>
<td>31350</td>
</tr>
<tr>
<td>6) α-pinene</td>
<td>76</td>
<td>120</td>
<td>9120</td>
</tr>
<tr>
<td>7) β-pinene</td>
<td>114</td>
<td>160</td>
<td>18240</td>
</tr>
<tr>
<td>8) 1,8 cineol</td>
<td>66.5</td>
<td>250</td>
<td>16625</td>
</tr>
<tr>
<td>9) others (myrcene, sabinene, γ-terpinene)</td>
<td>204</td>
<td>15</td>
<td>3080</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>242410</strong></td>
</tr>
</tbody>
</table>

D) Raw material cost (Rs/kg) = 25
E) Processing cost = 25.26
F) Average cost of product = 255.16
G) Loss during processing = 5%
H) Cost of losses (Rs/kg) = 1.25
I) Total expenditure cost (Rs/kg) = 51.51
   (Raw material + processing cost + losses)
J) Net profit Rs/kg oil = 203.65
K) Profit / annual (year) = 5091250
8.4.7 Result Summary

Following result summary table has been prepared based on mint terpene processing.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw material cost Rs / kg</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Plant Capacity (T/A)</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Plant investment</td>
<td>1156500</td>
</tr>
<tr>
<td>4</td>
<td>Fixed cost</td>
<td>173475</td>
</tr>
<tr>
<td>5</td>
<td>Variable cost</td>
<td>458100</td>
</tr>
<tr>
<td>6</td>
<td>Total processing cost</td>
<td>631575</td>
</tr>
<tr>
<td>7</td>
<td>Processing cost Rs /kg</td>
<td>25.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw material cost Rs / kg</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Plant Capacity (T/A)</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Plant investment</td>
<td>1156500</td>
</tr>
<tr>
<td>4</td>
<td>Fixed cost</td>
<td>173475</td>
</tr>
<tr>
<td>5</td>
<td>Variable cost</td>
<td>458100</td>
</tr>
<tr>
<td>6</td>
<td>Total processing cost</td>
<td>631575</td>
</tr>
<tr>
<td>7</td>
<td>Processing cost Rs /kg</td>
<td>25.26</td>
</tr>
</tbody>
</table>

Table 8.6 Processing economic of crude mint terpenes

From the above table it is clear that:

1. Raw material cost is very cheap.
2. Yet heavy investment in the plant. But the processing cost per kg oil is not too much.

8.4.8 Sensitivity Analysis

Sensitivity analysis for mint terpene processing to its different constituents is tabulated below:

<table>
<thead>
<tr>
<th>Plant Capacity T/A</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Investment</td>
<td>1156500</td>
<td>1753529</td>
<td>2235898</td>
<td>2654821</td>
<td>10567925</td>
</tr>
<tr>
<td>Total Processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A) Fixed Cost</td>
<td>173475</td>
<td>262183</td>
<td>335121</td>
<td>398203</td>
<td>1582954</td>
</tr>
<tr>
<td>B) Variable Cost</td>
<td>458100</td>
<td>826127</td>
<td>1194155</td>
<td>1312183</td>
<td>12018987</td>
</tr>
<tr>
<td>Total Processing</td>
<td>631575</td>
<td>1088310</td>
<td>1529276</td>
<td>1710386</td>
<td>13601941</td>
</tr>
<tr>
<td>Processing cost Rs/Kg mint oil</td>
<td>25.26</td>
<td>21.76</td>
<td>20.39</td>
<td>17.10</td>
<td>13.60</td>
</tr>
</tbody>
</table>

Table 8.7 Processing economic of mint terpene at different plants capacity

The variation of processing cost, total investment with respect to plant capacity as indicated in the above table and represented in Fig-8.5 given the following observation.

By varying the plant capacity from 25 T/A to 1000 T/A the processing cost decrease while the total investment increase.
Fig-8.6 Sensivity analysis for mint terpene processing
8.5 Economics of Palmarosa oil production.

The basics of palmarosa oil production are same as mint oil production. The biomass production and process (steam distillation) economic of palmarosa oil is as:

1. Land under cultivation ------ 40 hectare
2. Biomass production capacity T/A --------- 725
3. Oil production capacity (kg) ----------- 6872

Figures in Rs

   (like storage, transport from field to site, land revenue etc.) 120000

5. Variable Cost 265600

6. Cost of establishing cultivar
   - land preparation       120000
   - Cost of seeds         73280
   - Broad casting of seeds 9600
   Total                   202880

7. Cost of cultivation of palmarosa crop.
   - Cost of weeding       161600
   - Cost of harvesting   182000
   Total                   343600

Total Cost                   932080

Biomass processing economics (steam distillation)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Particulars</th>
<th>Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fixed cost</td>
<td>23250.00</td>
</tr>
<tr>
<td>2</td>
<td>Variable cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labour cost</td>
<td>44000</td>
</tr>
<tr>
<td></td>
<td>Fuel cost</td>
<td>35200</td>
</tr>
<tr>
<td></td>
<td>Total variable cost</td>
<td>79200</td>
</tr>
</tbody>
</table>

Total Cost                   102450

8.5.1 Result Summary

Following result has been obtained based on biomass production and biomass processing for the production of palmarosa oil.
Table 8.8 Production economic of palmarosa oil production

8.5.2 Sensitivity analysis for palmarosa oil production

The sensitivity analysis for biomass production and biomass processing (steam distillation) to palmarosa oil is tabulated below:

A) For Biomass Production

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Figure in Rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land under cultivation (hectare)</td>
<td>20  40  60  80  100</td>
</tr>
<tr>
<td>2</td>
<td>Biomass production capacity T/season</td>
<td>362.5 725 1087.5 1450 1812.5</td>
</tr>
<tr>
<td>3</td>
<td>Palmarosa oil production capacity kg/season</td>
<td>3436 6872 10308 13744 17180</td>
</tr>
<tr>
<td>4</td>
<td>Total prod. Cost A) Fixed cost B) Variable cost C) Establishing cost of cultivar D) Cultivation cost E) Total cost</td>
<td>75000 150022 101440 171800 498262 120000 265600 202880 343600 932080 204684 371575 304320 515400 1395979 471669 405760 687200 2235863</td>
</tr>
<tr>
<td>5</td>
<td>Production cost Rs/kg mint oil</td>
<td>145.0 135.6 135.42 132.92 130.14</td>
</tr>
</tbody>
</table>

Table 8.9 The production economics of palmarosa oil at different production capacity.

The variation in the production cost (Rs/kg) and total production cost with respect to biomass production in the above table and Fig -8.7 shows that by varying the production capacity from 20 to 100 T/A the production cost Rs/kg decreases while the total expenditure cost increases.
Fig-8.7 Biomass production of palmarosa

Production cost Rs/kg palmarosa oil

Biomass production capacity t/season

Total production cost (lakhs)

275
Table 8.10 The processing economics of palmarosa oil at different plant capacity.

Variation of processing cost (Rs/kg) and total processing cost with respect to plant capacity as indicated in above table has been further graphically represented Fig-8.7. Base on these variation it has been observed that as the plant capacity increases from 1 to 5 T/ Batch the processing cost goes down to 46.88 to 8.22 while the total processing cost goes increasing from Rs 80590 to 112990.

8.5.3 Conclusion

It has been concluded that as the plant capacity increases the processing and production cost of per kg palmarosa oil decreases. The decrement is much higher in processing (steam distillation) than the biomass production. The data obtained are on the basis of a farmer having own land.
Fig-8.8 Palmarosa biomass processing to palmarosa oil
8.5.4 Economic feasibility of palmarosa oil production

The economic feasibility under different capacity of oil production can be tabulated as:

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Land under cultivation</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>2.</td>
<td>Oil production capacity (kg/season)</td>
<td>3436</td>
<td>6872</td>
<td>10308</td>
<td>13744</td>
<td>17180</td>
</tr>
<tr>
<td>3.</td>
<td>Biomass production capacity T/season</td>
<td>362.5</td>
<td>725</td>
<td>1087.5</td>
<td>1450</td>
<td>1812.5</td>
</tr>
<tr>
<td>4.</td>
<td>Total production &amp; processing Cost per kg oil</td>
<td>171.85</td>
<td>150.5</td>
<td>145.95</td>
<td>141.14</td>
<td>138.19</td>
</tr>
<tr>
<td>5.</td>
<td>Sale price</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>6.</td>
<td>Net profit (Rs/kg)</td>
<td>48.15</td>
<td>69.5</td>
<td>74.05</td>
<td>78.86</td>
<td>81.81</td>
</tr>
<tr>
<td></td>
<td>Total Profit</td>
<td>165443</td>
<td>477604</td>
<td>763307</td>
<td>1086217</td>
<td>1405495</td>
</tr>
</tbody>
</table>

Table 8.11 The economic feasibility under different capacity of oil production

8.6 Economics of oyster mushroom (pleurotus sp) cultivation from spent residue

Layout plan and total infrastructure required for producing 100-120 tonnes of fresh oyster mushroom per annum is presented below:

8.6.1 Project Infrastructure

Production targets for the above project are around 100 tons of fresh mushrooms per annum or about 300 kg mushroom per day. To achieve this much production eight cropping room (polyhouses) are required to built of 75’× 15’× 12’ dimensions. Each room holding around 1000 bags of 3 kg dry wt. Substrate (12 kg wet weight) or around 12 tons wet compost giving around 2.4 tons of fresh mushroom in each cropping cycle. Six such cycles will be taken in a year giving around 13-14 tons of fresh mushrooms per room. In this manner around 115 tons of fresh mushroom production can be achieved in year from 8 rooms. For pasteurization of spent residue from *mentha* & *cymbopogoan* one bulk pasteurization tunnel would also required to be built which may produce around 12 tons of compost at a time. A tunnel of size 25’× 9’× 14’,
can easily produce this much quantity of pasteurized compost. Besides above structures one composting yard of 40'(l) × 40'(b) dimensions would also required to be constructed. Other facilities required are presented separately.

8.6.2 Layout plan of a mushroom farm

The layout is so planned that all the infrastructure required to be built are accommodated in the least possible land, without over looking to the mushroom cultivation requirements. The composting yard should be so located that it is accessible to the road easily for the supply of raw materials and should be away from the growing rooms. One bulk chamber would also required to be built on one end of the composting yard fitted with a blower and duct for circulation of air and steam. Spawning area (15’x 12’x 12’) is built on far end of the tunnel away from the composting yard and nearer to the cropping rooms. Ancillary rooms are so, situated that they are easily accessible to the cropping rooms and pasteurization tunnel for their operational convenience. Growing rooms are built nearer to the spawning area in 2 rows facing each other and separated by a12’ wide corridor. Besides above structure there should be ample supply of water at the farm which would either be met by underground water (boaring) or by some perennial source of water.

A) Total Infrastructure Required

<table>
<thead>
<tr>
<th>Facility</th>
<th>Unit</th>
<th>Size</th>
<th>Total area (sqft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poly houses</td>
<td>8</td>
<td>75’x 15’x 12’</td>
<td>9000</td>
</tr>
<tr>
<td>Composting yard</td>
<td>1</td>
<td>40’x 40’</td>
<td>1600</td>
</tr>
<tr>
<td>Tunnel</td>
<td>1</td>
<td>25’x 9’x 14’</td>
<td>225</td>
</tr>
<tr>
<td>Boiler room</td>
<td>1</td>
<td>15’x 12’x 12’</td>
<td>180</td>
</tr>
<tr>
<td>Store room</td>
<td>1</td>
<td>15’x 12’x 12’</td>
<td>180</td>
</tr>
<tr>
<td>Spawning room</td>
<td>1</td>
<td>15’x 12’x 12’</td>
<td>180</td>
</tr>
<tr>
<td>Packing/drying room</td>
<td>1</td>
<td>15’x 12’x 12’</td>
<td>180</td>
</tr>
<tr>
<td>Office</td>
<td>1</td>
<td>30’x 12’x 12’</td>
<td>360</td>
</tr>
<tr>
<td>Raw material shed</td>
<td>1</td>
<td>100’x 20’x 14’</td>
<td>2000</td>
</tr>
<tr>
<td>Total area</td>
<td></td>
<td></td>
<td>13905 sqft.</td>
</tr>
</tbody>
</table>

Or say 1290 sqmt.

Total land required for the project would be around 1 acre.

B) Machinery required

- Air handling units (AHU) / heavy duty coolers: 8 nos.
- Boiler 150 kg/h steam generation capacity: 1 no.
- Blower 1800 m³/h capacity: 1 no.
- Bamboo racks: 16 sets
- Drier: 1 no.
C) Total power requirement of the project

<table>
<thead>
<tr>
<th>Component</th>
<th>HP</th>
<th>KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolers /AHU</td>
<td>12</td>
<td>9.0</td>
</tr>
<tr>
<td>Water pump of AHU/cooler</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>Motors of the Boiler</td>
<td>4</td>
<td>3.0</td>
</tr>
<tr>
<td>Heaters of the Boiler</td>
<td></td>
<td>18.0</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>10</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>42KW</td>
</tr>
</tbody>
</table>

D) Economics of the Project

1. Fixed Capital
   A. Land 1 acre                      2,00,000.00
   B. Civil work / building
      - Cost of construction of composting yard 80,000.00
        40’×40’ @ Rs 50/- sqft.
      - Cost of construction of pasteurization tunnel 56,200.00
        25’×9’×14’ @ Rs 250/-
      - Cost of construction of spawning area, Boiler room, packing room, store room, Office (1000sqft) 2,16,000.00
      - Cost of construction of polyhouses 9,00,000.00
        75’×15’×12’ @ Rs 100/- sqft.
      - Cost of construction of raw material shed 1,00,000.00
        100’×20’×14’ @ Rs 50/- sqft.
   Total                                          Rs. 13,54,000.00

E) Plant and Machinery
   - Modified Heavy duty coolers 8 nos. @ Rs. 6000/- piece 50,000.00
   - Boiler 1 no. Including ducting 1,00,000.00
   - Blower 1no. including ducting for tunnel 50,000.00
   - Bamboo racks and grating in the tunnel 80,000.00
   - Mushroom drier 1 no. 50,000.00
   - Miscellaneous- like sprayer, pumps, buckets, harvesting trays etc. 50,000.00
   Total                                          3,80,000.00

F) Total Fixed Capital
   A. Land                                    2,00,000.00
   B. Building / Civil work                    13,54,000.00
   C. Plant and machinery                      3,80,000.00
   **Total**                                   19,34,000.00
G) Recurring Expenditure

1. Manpower requirement of the project

Manager- 1no. @ Rs 5000/- per month 60,000.00

Total mandays required for substrate preparation and spawning, 20 mandays/ outing. Total 48 outing in a year Total mandays required = 960 @ Rs. 40/- per day

Labour requirement for harvesting, spraying, drying and packing Total 2000 mandays @ Rs 80,000.00 40/- per day

Total 1,78,400.00

2. Raw material required

Spent residue from mint/cymbopogoan

Supplement 10 tons @ Rs. 15000/- ton 1,50,000.00

Water requirement
i) Compost preparation app. 600 k liter
ii) For cropping, app. 1000 k liter 1,00,000.00

Polythene bags 2,00,000.00

Pesticides 10,000.00

Energy and Fuel 1,50,000.00

Spawn: 38000 bottles of 300g each @ Rs 10/- bottle 3,80,000.00

Selling expenses/freight etc. 50,000.00

Total 10,40,000.00

3. Depreciation and Interest

A. Land- 15% interest 30,000.00

B. Building and civil work 5% depreciation & 15% interest 2,70,800.00

C. Machinery 10% depreciation & 15% interest 95,000.00

Total 3,96,800.00
Total Recurring Expenditure (cost of production)

Raw materials 10,40,000.00
Wages and Salary 1,78,400.00
Depreciation and interest 3,96,800.00
Total 16,15,200.00

H) Total Production and Income

Total production taking 80% B.E. of the straw 115 tons
Sale price of fresh mushrooms Rs 30,000 / ton
Total sale Rs 34,50,000
Net Profit (Rs 3450000 – 1615200) 18,34,800.00
Cost of production / per kg Rs. 14.04

Alternatively complete production can be dried and exported / sold in the local market

Total production 115 tons
Mushroom available after drying 12 tons
Energy consumed in drying this much quantity of fresh mushrooms 90,000 KW
Sale price of dried mushrooms @ 30,000/ ton
Total sale Rs. 36,00,000.00

NET PROFIT (Rs. 3600000/ - 17,95,200) = Rs. 18,04,800

* If the produce is sun dried/ solar dehydrated this expenditure can be saved and thus giving extra income.
### 8.6.3 Sensitivity analysis for mushroom production

The sensitivity analysis for mushroom production from spent residue is tabulated below:

<table>
<thead>
<tr>
<th>Mushroom Production capacity (dry) T/A</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mushroom Production capacity (fresh) T/A</td>
<td>76.666</td>
<td>95.833</td>
<td>115</td>
<td>134.166</td>
<td>153.33</td>
</tr>
<tr>
<td>Total Investment</td>
<td>2982869</td>
<td>3242248</td>
<td>3449200</td>
<td>3604414</td>
<td>3712546</td>
</tr>
</tbody>
</table>

#### Production Cost

1. **Fixed Cost**
   - *land 15% interest*
   - *building & civil work 5% depreciation & 15% interest*
   - *machinery 10% depreciation & 15% interest*

<table>
<thead>
<tr>
<th></th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>25944</td>
<td>28200</td>
<td>30,000</td>
<td>31350</td>
<td>32290</td>
<td></td>
</tr>
<tr>
<td>204734</td>
<td>243720</td>
<td>270800</td>
<td>292464</td>
<td>310011</td>
<td></td>
</tr>
<tr>
<td>73530</td>
<td>85500</td>
<td>95000</td>
<td>102600</td>
<td>108756</td>
<td></td>
</tr>
</tbody>
</table>

**Total Fixed Cost**

<table>
<thead>
<tr>
<th></th>
<th>306908</th>
<th>357420</th>
<th>395800</th>
<th>426414</th>
<th>451057</th>
</tr>
</thead>
<tbody>
<tr>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>85437</td>
<td>104192</td>
<td>110400</td>
<td>130240</td>
<td>140659</td>
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<tr>
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<td>330000</td>
<td>363000</td>
<td>384780</td>
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<tr>
<td>204960</td>
<td>264000</td>
<td>300000</td>
<td>330000</td>
<td>356400</td>
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<tr>
<td>7392</td>
<td>8800</td>
<td>10000</td>
<td>10800</td>
<td>14448</td>
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<tr>
<td>104333</td>
<td>135100</td>
<td>150,000</td>
<td>174900</td>
<td>199386</td>
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<tr>
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<td>291666</td>
<td>380000</td>
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<tr>
<td>33333</td>
<td>41666</td>
<td>50000</td>
<td>58333</td>
<td>66666</td>
<td></td>
</tr>
</tbody>
</table>

The variation in the production cost and total investment with respect to total mushroom production (tonnes) in the above table can also be represented in graphical Fig-8.8 show that by varying the production capacity (dry) from 8 tonnes to 16 tonnes. The production cost per kg goes down from 163.84 to 136.92 while the total production cost goes up from 1310773 to 2190729. In this project the raw material other than supplement is not counted due to the waste of *mentha* or *cymbopogon* are used as cost less raw material.

### 8.6.4 Conclusion

So it has been concluded that at any production capacity the project of mushroom production from spent residue of *mentha/ cymbopogon* is economically sound.

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Fig-8.9 Sensitivity analysis for mushroom production from spent residue of mint/Cymobopogon