Background:

• Statement of Problem: Grape seed oil is a popular and nutritious product which contains numerous potential in many industries. Consumption of various grape seed oil related products has been increased. Therefore, in order to fulfill the rise of demand more effectively, an efficient extraction method for grape seed oil is required.

• Previous related Work: Current extraction methods contain screw press (approx. 90% efficiency), Soxhlet extraction (approx. 90% efficiency) and supercritical fluid extraction (approx. 90% efficiency). These data are not for grape seed oil extraction.

Goal: A combination of mechanical press and organic solvent extraction process is to be utilized to improve the overall efficiency of grape seed oil extraction. The mechanical deconstruction of the seeds can also improve the performance in solvent extraction stage.

• Constraints: The modern supercritical method is not available in IN and would result a higher quality of pure product. The results of the lab scale experiment are not statistically strong enough thereby need further function.

Market Analysis:

• Easy & Efficient to obtain grape seeds from wine pomace (received grape pomace from Purdue Wine Grape Team for lab experiment)

• Increase of U.S. wine sales along with U.S. wine retail value

• Grape: Out of Top 10, 3rd valued commodity, worth 5.2 billion

• Grape seed oil product markets in industries (e.g. Food, Cosmetic, and Health)

• Annual grape growth causing industry to produce wine at certain time

• Increase of wine sales leading to more grape seeds left at a low price

• Grape seed oil contains numerous potential in many popular and nutritious product which required.

• The waste from the grape seed oil extraction is non environmental friendly wastes are also generated in SuperPro. The hot air produced from the drying part can be used for the extraction process. Expanding the production and batch on pressing improves the quality and conserves more beneficial nutrition.

• Using the current market price of grape seed oil online, annual revenue will not cover the annual cost. Thus a 11.5x current price is used.

• Economic Analysis:

  - Total Product Cost (TPC) $421,844.94
  - Total Capital Investment (TCI) $225,608.77
  - Total Annual Cost (TAC) $213,278.93
  - Annual Net Profit (ANP) $217,350.95
  - Return on Investment (ROI) 48.96%

  - Oil was obtained by first dissolving pure methanol. Extraction efficiency was calculated by comparing the amount of oil obtained with the amount of oil obtained from the wet seeds. Since all the oil obtained from the wet seeds was then used to calculate the efficiency, the efficiency should be accurate.

  - The complete process flow is generated in SuperPro. The total revenue per year for the grape seed oil production is $410,744.00. The process is expected to process 5000 kg pomace and produce 10 kg extra-virgin oil and 22.7 kg solvent extracted grape seed oil.

  - The waste from the grape seed oil extraction is generated in SuperPro. The hot air produced from the drying part can be used for the extraction process. Expanding the production and batch on pressing improves the quality and conserves more beneficial nutrition.

  - The process is expected to process 5000 kg pomace and produce 10 kg extra-virgin oil and 22.7 kg solvent extracted grape seed oil.

  - Non-environmental friendly wastes are also generated in SuperPro. The hot air produced from the drying part can be used for the extraction process.

  - In the solvent extraction, the solvent can be recycled and is hazardous for human health, the grape seed oil might cause some health problems. Possible health & contamination issues need to be considered.

Global/Societal Considerations:

• Efficient usage of waste seed products from wine making process leads to economic benefits (e.g. Profit, More jobs, and Broad market).

• Since honey is employed for the extraction process and is hazardous for human health, the grape seed oil might cause some health problems. Possible health & contamination issues need to be considered.

• Non-environmental friendly wastes are also generated in the process (e.g. Broken equipment and wasted chemicals).

Improvements and Recommendations:

• It is recommended that the super critical fluid should be used for the extraction process.

• In the solvent extraction, the solvent can be recycled and reused.

• Drying is supposed to use lower temperatures to conserve more beneficial nutrition.

• Expanding the production and batch on pressing extraction to have a more valuable product, virgin pressed grape seed oil.

• The hot air produced from the drying part can be used on distillation.

• The waste from the grape seed of extraction is totally organic, which can be used as a fertilizer of the plants or vines in the vineyard.

Morphological Analysis:

1. Mixing / Seeds Separation
2. Oven Drying
3. Pressing
4. Extraction

Experiments:

1. Mixing / Seeds Separation
2. Oven Drying
3. Pressing
4. Extraction

Final Design:

Fig. 5: First process flow diagram for grape seed oil extraction. The complete process flow is generated in SuperPro.

Fig. 6: The organizational and operation chart of the grape seed extraction process, based on the economic analysis. The production needs about 18 hours per day.

Fig. 7: The experimental and operation chart of the grape seed extraction process, based on the economic analysis. The production needs about 18 hours per day.

Fig. 8: Combined extraction method for grape seed oil.

Fig. 9: The complete process flow shown in Fig. 5 is separated in actual process. The complete process flow is calculated for the mechanical press (approx. press) and lab scale calculation for the lab scale experiment because of time limit in SuperPro.

Fig. 10: The complete process flow is calculated for economic analysis and total costs are generated in SuperPro.

Table 1: Cost breakdown

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Percentage</th>
<th>Amount 1</th>
<th>Amount 2</th>
<th>Amount 3</th>
<th>Amount 4</th>
<th>Amount 5</th>
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<tr>
<td>Total Product Cost (TPC)</td>
<td>8.28%</td>
<td>$421,844.94</td>
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<td>Total Capital Investment (TCI)</td>
<td>5.52%</td>
<td>$225,608.77</td>
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<tr>
<td>Total Annual Cost (TAC)</td>
<td>49.0%</td>
<td>$213,278.93</td>
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<tr>
<td>Annual Net Profit (ANP)</td>
<td>60.7%</td>
<td>$217,350.95</td>
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<tr>
<td>Return on Investment (ROI)</td>
<td>32.9%</td>
<td>48.96%</td>
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Technical Advisor: Dr. Martin Okos
Instructors: Dr. Martin Okos

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Reference:


Tray Drying: $1,220.00
Pipe/Pumping: 6.9%

Table 1: Cost breakdown