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Analysis of Manufacturing and Operation Analytics for a Grape Processing Unit

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Abstract: Over the past several decades there has been a growing trend toward adding value to raw agricultural products. As populations have become more urban, this trend has accelerated. The need for stable, convenient foods has increased along with the demand for exotic products for international cuisine. With the globalization of the food industry, the demand for quality juice and juice type beverages has markedly expanded. Traditionally, only a handful of fruit and vegetable juices have served this market as large multinational companies or their affiliates, have captured the majority of national and international juice trade. Juices such as orange, grape, pineapple, pomegranate, apple, tomato and blends are well established in developed countries. Now, minor juices, tropical juices and juice products are attracting new attention. The Nasik district is especially famous for grapes with being the biggest producer of grapes in India. More than 1.75 lakh acres of land is under grape cultivation. Because of the suitable soil and climatic conditions, Nasik is very suitable for cultivation of crop like horticulture, which is a very important contributor towards economy of the district. This project puts forward a study of factory setup for manufacturing grape pulp. A study of various industries running in District of Nasik was done, based on which Agro based industry was selected for further study. Agro industry manufactures various products among which grape products contribute to major revenue generation. Manufacturing process of grape pulp and juice was studied. The machinery required to setup the manufacturing units were decided. A quotation was crafted for installing the machinery. Raw material required, utility expenses along with other expenses such as selling expenses were projected. The Debt Equity ratio was decided. Further, the Break-Even Analysis was performed. Profitability of the processing unit was indicated using financial indicators.

Index Terms **– Agricultural product, Food industry, Juice trade, Grape pulp, Debt Equity, Break even analysis.**

I. INTRODUCTION

As mentioned in the title, the work in this report, aims to study the manufacturing and operations analytics of Grapes Processing Unit based in Nasik. Grapes products are famous worldwide giving an opening to the idea of establishing a Grape Processing Unit. The location Nasik was selected as it is the leading producer of Grapes in Maharashtra. As we go further, the project describes the processes of producing processed Grape juice and pulp. Project also gives an insight about the capital investments required to set up a processing unit.

Table 1: The FPO specifications and preservation methods of various fruit-based products

Classification	Min. Juice (%)	Min. TSS (%)	Methods of preservation
Natural Juice	100	Natural	Canning, Heat, Chemicals
SweetenedJuice	85	10	Canning, Heat, Chemicals
RTS beverage	10	10	Heat, Chemicals
Squash	25	40	Chemicals
Cordial	25	30	Chemicals
Crush	25	55	Chemicals
Syrup	25	65	Chemicals
Nectar	20	15	Heat
Fruit juice concentrate	100	32	Chemicals, Aseptic packaging

Growth Drivers in fruit based beverage industry in India

1) Changing consumer lifestyles
2) Increased health awareness
3) Hygiene matters
4) Growing category of informed buyers
5) Booming modern retail
6) Habitual purchase

Opportunities in fruit based beverage industry in India

1) Shift towards 100 percent juices from sweetened juices
2) Healthy proposition
3) Unique offering
4) Wider option
5) Product extension

Problem Definition

Manufacturing and Operation Analytsis for a Grape Processing Unit using primery as well as secodnary data with quantitative and qualitative analysis.

Objectives

1) To study and verify the literature survey for effective solution in Manufacturing and Operation Analytics for a Grape Processing Unit.
2) To finalize the ideal location to set up Grape Juice Factory on basis of product rating.
3) To collect primary, secondary, qualitative and quantitative data related to grapes processing units.
4) To finalize suitability of material and machinery with financial requirements.
5) To perform data analysis and interpretation using financial indicators.

Methodology

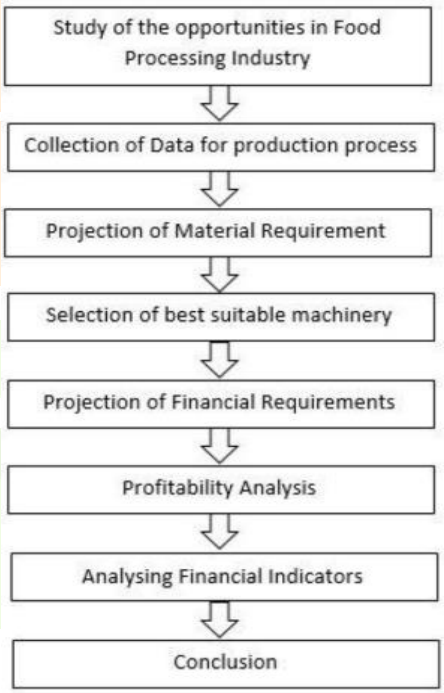

Figure 1: Methodology of the project work

II. LITERATURE REVIEW

The following papers discussed below help to build a basis to develop manufacturing processes for Grape pulp and essentials for setting up processing plant. These research papers provide information on various aspects of a grape juice and pulp processing plant right from raw materials to the packing of product. With the help of these papers and my own study, I aim to develop a manufacturing process for various grape juice and pulp.

Table 2: Literature review

Sr. No.	Name of Author, Publisher and Year of Publication	Title of Paper	Findings
1	Anushree Priyadarshini and Akanksha Priyadarshini in ScienceDirect journal of fruit juices 2017	Market dimensions of industrial juice industry	Insight and overviewed the trends, opportunities and threats of the fruit juice industry and highlight the factors affecting consumers' food choices and innovations in fruit juice marketing.
2	F. J. Vázquez-Armenta, A. T. Bernal-Mercado et.al. in researchget article of Plant Food By-Products 2018	Winery and Grape Juice Extraction By-Products	Presented an overview of the characterization of bioactive compounds from grape by-products and its uses as natural food additives with antimicrobial and antioxidant properties. In addition, the potential of phenolic compounds from grape by-products to be used for development of nutraceutical products to improve human health.
3	Carmela Conidi and Roberto Castro-Muñoz et.al. in MDPI review article on beverages, 2020	Membrane-Based Operations in the Fruit Juice Processing Industry	Reviewed the significant progresses on the use of membrane-based operations in fruit juice processing industry in the light of the growing interest towards products with improved safety, quality and nutritional value and sustainable processes characterized by low energy consumption and low environmental impact.
4	Agostino Cavazza, Elena Franciosi, researchget article 2007	Washing the grapes before crushing: effects on contaminants and fermentation	The effect of White and red grapes grape washing was evaluated at winery scale in two premium white and red vinifications in Trentino (Italy) in winery scale with 1 % citric acid solution, and the compositions of the musts were compared with that of the untreated controls. The yeast content of musts was also reduced by the washing procedure. The fermentation rate was measured in musts inoculated with native yeast (spontaneous fermentation) and with two differently prepared starter cultures. In all cases the fermentation rate was higher with washed grapes.
5	Corne´ J. Coetzee, Stephanus G. Lombard, ELSEVIER publication, 2013	The destemming of grapes: Experiments and discrete element modeling	Experiments were designed to measure the material properties of the grapes, including the stem stiffness and break strength under tension, the berry stiffness under compression, and the berry detachment force. The Discrete Element Method (DEM) was then used to model a bunch of grapes. In a model of a simplified destemmer, a single bunch of grapes was hit by a set of rotating beaters. The number of berries removed from a bunch could be accurately predicted as influenced by the rotation speed of the beaters and the mass of the bunch.

III. THEORETICAL AND ANALYTICAL APPROACH

Fruit Juice Processing

The process starts with sound fruit, freshly harvested from the field or taken from refrigerated or frozen storage. Thorough washing is usually necessary to remove dirt and foreign objects and may be followed by a sanitation step to decrease the load of contaminants. Sorting to remove decayed and moldy fruit is necessary to make sure that the final juice will not have a high microbial load, undesirable flavors, or mycotoxin contamination. For most fruits, preparation steps such as pitting and grinding is required prior to juice extraction. Heating and addition of enzymes might also be included before the mash is transferred to the extraction stage. Juice extraction can be performed by pressing or by enzymatic treatment followed by decanting. The extracted juices will then be treated according to the characteristics of the final product. For cloudy juices, further clarification might not be necessary or may involve a coarse filtration or a controlled centrifugation to remove large insoluble particles. For clear juices, complete depectinization by addition of enzymes, fine filtration, or high speed centrifugation is required to achieve visual clarity. The next step is usually a heat treatment or equivalent non-thermal process to achieve a safe and stable juice and final packaging if single-strength juice is being produced. For a concentrate, the juice is fed to an evaporator to remove water until the desired concentration level is obtained. Other processes used for water removal include reverse osmosis and freeze concentration, which are best suited for heat-sensitive juices. The concentrate is then ready for final processing, packaging, and storage.

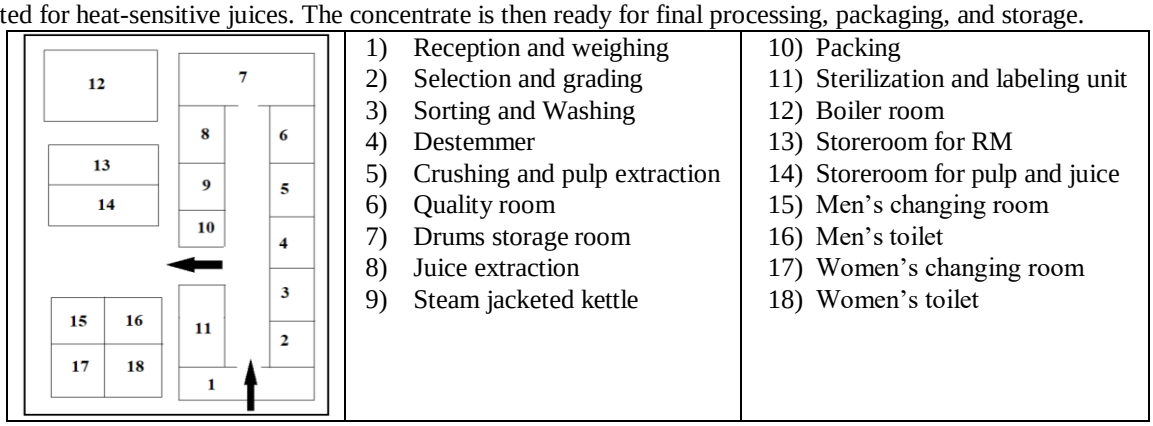

Figure 1: Basic layout of grape processing unit

Harvesting and Maturity Indices for Harvesting

Grape juice consists of a natural aqueous mixture of various carbohydrates, organic acids, anthocyanin's and flavor compounds. In the soluble solids of grape juice, the primary sugars are glucose and fructose. In unripe grapes, glucose accounts for as much as 85% of the sugar content. As the grape approaches full ripeness there is generally a slight excess of fructose. Bunches should be harvested during the early morning hours before the berry temperature rises above 20°C. It is advisable to close harvest by 10 a.m. Otherwise the berry's temperature can't be bring down to 4°C by pre-cooling within the stipulated time of six hours. Bunches harvested during high temperature leads to loss of more physiological weight and pedicel desiccation. If rainfall has occurred just prior to harvest, the fruit should not be picked for at least 3-4 days, as the free moisture present on the surface of the berries can lead to fungal infections. Harvesting period is determined by the variety, climatic conditions, TSS, acidity and sugar acid ratio, depending on whether the grape is for local or export market. Maturity standards of grapes fixed under the AGMARK states that the minimum TSS of 16 °B and sugar acid ratio of 20:1 and this has to be complied or export and domestic market. Although the sugar content of the berries is considered as the indicator of their level of ripening, the ratio of sugar/acid is the correct index of ripening, since this ratio indicates the taste of berries. Berries with same content of sugars, taste sour and less sweet when their acid content is more in white varieties, uniform green color is preferred in the export market. Change of green color to straw or amber color should not be taken to indicate the stage of ripening as exposed clusters shows more color change even at less maturity as compared to shaded clusters. With the maturity of berries, the color of peduncle also changes. Harvesting is done by A day prior to picking, the broken, along with decayed, deformed, undersized, and discolored berries are removed by cutting their pedicels from the selected bunches, using a long nosed scissors followed by Bunch collection and Sorting and grading requirement.

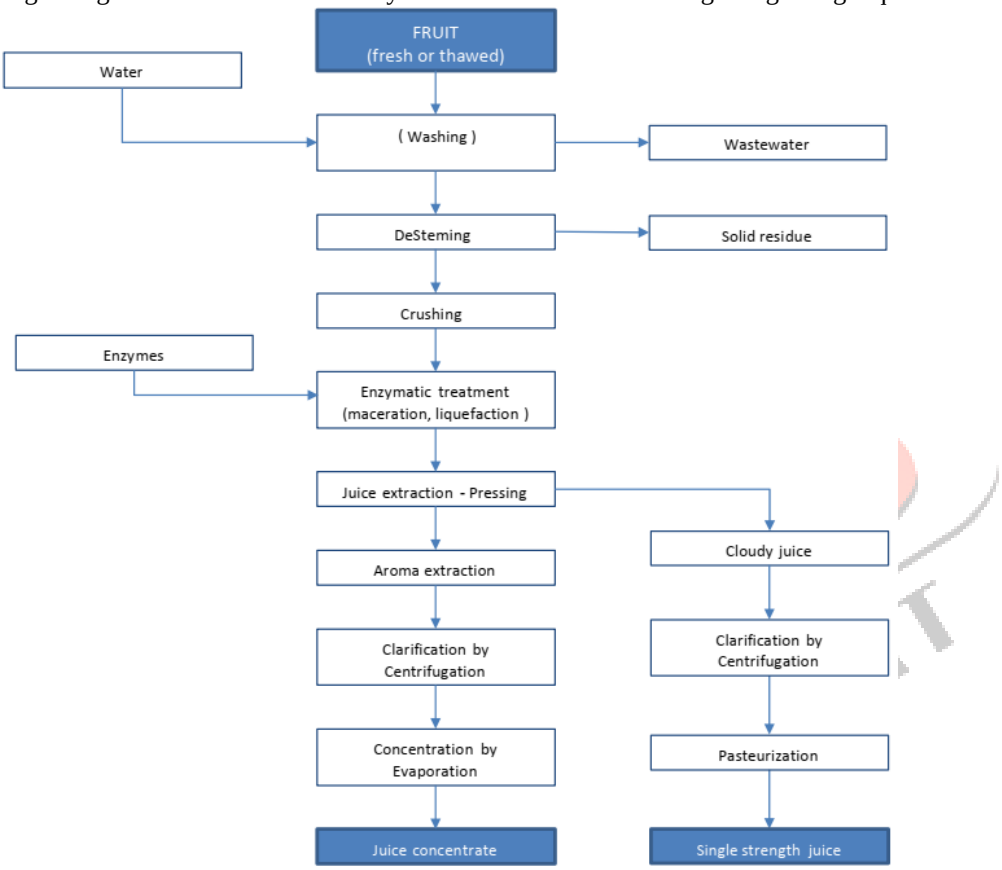

Figure 2: Grape pulp and juice manufacturing

Factor Rating Method for Location Planning

In the location factors rating method, factor rating and scores for various potential sites are shown here, location 1- Niphad, location 2 – Sinner, location 3 – Igatpuri, location 4 – Yeola. Further process followed as, rating each factor, rating each location, compute the product and compute the sum.

Table 3: factor ratings and location ratings for location alternatives.

		Location rating				Product of rating			
Factors	Factor rating	Loc . 1	Loc . 2	Loc . 3	Loc . 4	Loc. 1	Loc. 2	Loc. 3	Loc. 4
1. Tax advantage	4	8	6	7	5	32	24	28	20
2. Suitability of labour skill	3	6	5	8	4	18	15	24	12
3. Proxiity to market	3	8	6	7	5	24	18	21	15
4. Proximity to suppliers	5	7	8	9	6	35	40	45	30
5. Adequacy of water	4	8	5	7	9	32	20	28	36
6. Receptivity of community	1	5	6	4	8	5	6	4	8
7. Future growth prospects	4	9	5	7	6	36	20	28	24
8. Suitability of climate	3	6	7	6	8	18	21	18	24
9. Availability of power.	2	8	7	9	8	16	14	18	16
TOTAL						216	178	214	185

Data Analysis & Interpretation

Capital Inputs

1. Land: Undertaking construction by purchasing land is not required in the initial stages. Instead, readymade premises of about 6000 SqFt can be taken on rent.
2. Machinery: The rent processing of 78.75 tonnes per month for 12 months would require following facilities

Table 4: Machinery required

Sr. No.	Item	Quantity	Price (Rs.)	Total Cost (Rs.)
1	Fruit Washer	1	2,60,500.00	2,60,500.00
2	Inspection conveyor	1	1,20,000.00	1,20,000.00
3	Elevating Conveyor	1	1,35,800.00	1,35,800.00
4	Fruit Crusher	1	1,02,000.00	1,02,000.00
5	Collection Tank with Pump	1	1,06,000.00	1,06,000.00
6	Twin Pulper with Collection Tank and Screw Pump	1	2,30,000.00	2,30,000.00
7	Steam Jacketed Kettle with Screw Pump	2	1,30,500.00	2,61,000.00
8	Over Head Insulated Storage Tank	1	1,06,000.00	1,06,000.00
9	Electric Boiler	1	4,35,000.00	4,35,000.00
10	Steam Line	1	32,500.00	32,500.00
11	Slurry Line	1	61,200.00	61,200.00
12	Automatic four Head Filling Machine with Roller Stand	1	9,81,000.00	9,81,000.00
13	Working Table	2	25,000.00	50,000.00
14	Plate UHT Sterilizer	1	5,20,000.00	5,20,000.00
15	Loading and Unloading System	1	80,000.00	80,000.00
16	Drums	200	250.00	50,000.00
17	Falling film Evaporator	1	6,40,000.00	6,40,000.00
18	Packaging Machine	1	2,56,000.00	2,56,000.00
Total		**44,27,000.00**		

3. Miscellaneous Assets: Other items like furniture, light bulbs, fan, storage racks shall be required for which a provision of Rs.2 lakhs is to be made.
4. Other items like furniture, light bulbs, fan, storage racks shall be required for which a provision of Rs.2 lakhs is to be made.

Manpower requirements:

The manpower requirement for operating the proposed plant is as follows:

The envisaged project requires 35 work forces. The list of manpower for the envisaged project is indicated in Table. The annual cost of labour including fringe benefits is estimated at Rs 4046400.

Table 5: Manpower Requirement

Particulars	Nos.	Salary/ Months	Total Salary	Particulars	Nos.	Salary/ Months	Total Salary
General Manager	1	30000	360000	Production Head	1	28000	336000
Secretary	1	20000	240000	Mechanic	1	20000	240000
Marketing Officer	1	25000	300000	Electrician	1	20000	240000
Purchaser	1	22000	264000	Store keeper	1	17000	204000
Accountant	1	25000	300000	Operators	7	14000	168000
Personnel	1	23000	276000	Laborers	15	10000	120000
Cashier	1	19000	228000	Guards	2	8000	96000
Sub Total	35	**281000**	**3372000**				
Benefits (20% BS)	56200	674400					
Grand Total	337200	**4046400**					

Tentative Implementation Schedule

Table 6: Tentative Implementation Schedule

Activity	Period in Months
Application and sanction of loan	1.5
Site selection	0.5
Completion of civil work and placement of order for machinery	3
Installation and trial run	1

Details of the Proposed Project

1) *Building:* The readymade premises of around 6000 SqFt may be rented. The rent for the same will be around 1lac per month.
2) *Machinery:* The expenditure of Rs.44,27,000.00/- is expected as explained earlier.
3) *Miscellaneous Assets:* A provision of Rs.2,00,000.00/- is to be made as mentioned earlier.
4) *Preliminary & Co-operative Expenses:* There will be a certain pre-production expenses on travelling, registration, administrative expenses, trial run expenses etc. A provision of Rs.5,00,000.00/- would be sufficient.
5) *Working Capital Requirement:* Almost every company incurs expenses before getting the payment from its customers. A provision should be made to bridge the gap between disbursements (payment from suppliers) and receipts (payments from customers). A provision is Rs. 5, 00,000.00 is to be made under this head.
6) *Cost of the Project & Means of Financing:* Financial assistance in form of grants is available from the Ministry of Food Processing Industries, Govt. of India, towards expenditure on technical civil works and plant and machinery for eligible projects subject to certain terms and conditions.

Table 7: Cost of the Project & Means of Financing

Item	Amount (Rs.)	Item	Amount (Rs.)
Machinery	44,27,000.00	Means of Finance	
Miscellaneous Assets	2,00,000.00	Promoter's Contribution	18,20,910.00
P&P Expenses	5,00,000.00	Term Loan from Bank / FI	42,48,790.00
Contingencies @10% for machinery	4,42,700.00	Total	60,69,700.00
Working capital margin	5,00,000.00	Debt Equity Ratio	2.33 : 1
Total	60,69,700.00	Promoter's Contribution	30%

Profitability Calculation

1) *Production Capacity and Build-up:* As against the processing capacity of 78.75 tonnes per month, the actual utilization is assumed to be 65% in the first year and 75% thereafter.
2) *Sales Revenue at 100%:* Processing of 78.75 tonnes every month would result in production of about 59.06 tonnes of total product. Assuming selling price of Rs 100,000/- per ton for Grape pulp, and Rs.70,000/- per ton for Grape juice , total sales will be Rs.877.5 lac during a period of 8 months.
3) *Raw & Packing Material required at 100%:*

Table 8: Raw and Packing Materials Required at 100%

Product	Qty (Tonnes)	Price/Ton (Rs.)	Total Cost (Rs. In lac)
Grapes	900	6000.00	54.00
Sugar	15	40,000.00	6
metatartaric acid	30	50,000.00	15
Packing Material @5625 per Ton	200		11.25
Total	**945**	**86.25**	

4) *Utilities:* Total cost of utilities at 100% activity level for a period of 12 months is estimated to be approximately Rs.3,00,000/-
5) *Selling Expenses:* A provision of 15% of total sales is to be made towards selling commission, transportation, publicity, free sampling etc.
6) *Interest:* Interest on term loan of Rs. 42,48,790 /- is calculated @ 15% per year assuming total repayment in 4 years, whereas interest on working capital loan is calculated @14% every year.
7) *Depreciation:* Depreciation is computed on WDV basis on machinery and miscellaneous assets @ 20%

Projected Profitability

Table 9: Projected Profitability

		Rs. in Lac	
No.	**Particulars**	**1st Year**	**2nd Year**
A	**Installed Capacity**	945 Tonnes	
	Capacity Utilization	65%	75%
	Sales Income	570.375	658.125
B	**Cost of Production**		
	Raw & Packing Materials	56.06	64.68
	Utilities	1.95	2.25
	Salaries	21.91	25.29
	Rent	8.4	8.4
	Repair & Maintenance	1	1.5
	Selling Expense @15%	85.56	98.72
	Administrative Expense	1	1.5
	Total	**178.88**	**202.34**
C	**Profit before Interest and depreciation**	**391.495**	**455.785**
	Interest on Term Loan	6.37	5.41
	Interest on Working Capital	0.7	0.84
	Depreciation	8.85	7.08
	Profit before Tax	375.575	442.455
	Income-tax @25%	93.89	110.61
	Profit After Tax	**281.69**	**331.85**
	Cash Accruals	**290.54**	**338.93**

Break-Even Analysis

Table 10: Break-Even Analysis

Sr. No.	**Particulars**	**Amount (Rs.in Lac)**	
[A]	Sales		**570.375**
[B]	Variable Cost		
	Raw & Packing Material	56.06	
	Utilities (80%)	2.4	
	Salaries (75%)	25.29	
	Selling Expenses (70%)	59.892	
	Interest on WC	0.7	
	Admin. Exp (50%)	0.5	**144.842**
[C]	Contribution [A]-[B]		**425.533**
[D]	Fixed Cost		**64.34**
[E]	Break-Even Sales [D]/[1-([B]/[A])]		**86.24**
[F]	Break-Even Point (%) [D]/[C]		**15.12%**

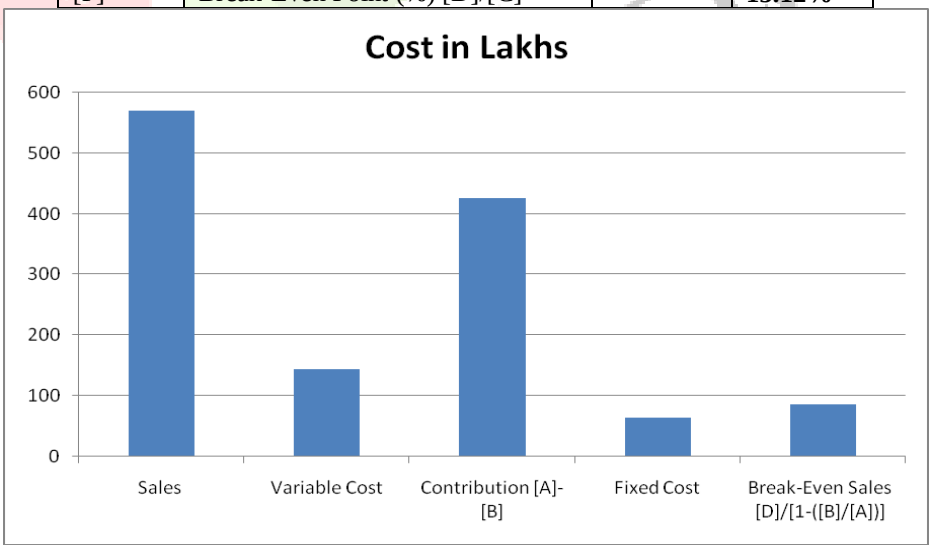

Figure 3: Break even analysis of vaious cost (lakhs)

Financial Indicators (Leverages)

1) Financial Leverage = EBIT / EBT = 382.65 / 375.58 = 1.02
2) Operational Leverage = Contribution / EBT = 425.53 / 375.58 = 1.13
3) Degree of Total Leverage = FL * OL = 1.02 * 1.13 = 1.15.

Results Discussion

1) From the profitability forecast it can be seen that Rs.281.69 lac of profit after tax is achieved with 65% utilization capacity.
2) As utilization capacity is increased to 75% the PAT is increased at a rate of 17.80%.
3) The Break-Even Analysis it can be seen that the Break-Even Sales is achieved at Rs.86.24lac. Which means that, operating at 65% capacity, the Break-Even point is achieved at only 15.12 % of sales which is commendable.
4) The desired financial leverage ratio is usually below 0.5. But in the proposed processing unit, it has turned out to be 1.02 which indicated that the processing unit is using more debt and less equity to finance the purchase of assets. This can be reasoned by higher debt-equity ratio i.e. 2.33:1 which is common in manufacturing companies Operating leverage measures the sensitivity of a company's operating income.
4) In this case the operating leverage is 1.15 which means that 10% in sales will result in 11.5% increase in operating income.

IV. CONCLUSION AND FUTURE SCOPE

Conclusions

1) From the research data provided by juice Industries it can be concluded that there is ample amount of opportunities in Food Processing Industry.
2) Nasik district's economy mainly depends on Agriculture sector and majority of the population is dependent on agriculture for employment, because of which cheap labour is available in the district. There is plenty of opportunity available in the processing sector.
3) From the manufacturing processes described in the project it can concluded that the waste produced during manufacturing of Grape processed products is biodegradable and can be put to good use.
1) Although it may seem at the first glance that the investment is quite high in the processing unit, from the profitability projections it can be concluded that the Grape processing setup would result in profit.
2) Further worked can be done for other processing plant of juice extraction with different fruits variety.
3) Other industrial engineering aspects can be considered for further efficient results and optimized solution.

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