Techno-Economic Feasibility Analysis of Tomato Processing Pilot Plant

THESIS

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In partial fulfilment of the requirements for

the Degree of

MASTER OF TECHNOLOGY

In

AGRICULTURAL ENGINEERING

(PROCESSING AND FOOD ENGINEERING)

By

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2016

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This is to certify that the thesis entitled **"Techno economic feasibility analysis of tomato processing pilot plant"** *submitted in partial fulfillment of the requirement for the degree of* ***MASTER OF TECHNOLOGY*** *in* ***Agricultural Engineering*** *in* ***Processing and Food Engineering*** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Mr. Eresh Kumar Kuruba*** *under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.*

All the assistance and help received during the course of the investigation has been acknowledged by her.

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This is to certify that the thesis entitled **"Techno economic feasibility analysis of tomato processing pilot plant"** *submitted by* ***Mr. Eresh Kumar Kuruba*** *to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of* ***MASTER OF TECHNOLOGY*** *in* ***Agricultural Engineering*** *in the Department of* ***Post Harvest Process and Food Engineering*** *has been, after evaluation, approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.*

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Place: Jabalpur

Date: **Eresh Kumar Kuruba**

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LIST OF ABBREVIATIONS AND SYMBOLS

%	:	Percent
C	:	Degree Celsius
Agril	:	Agricultural
Approx	:	Approximately
avg	:	Average
BEP	:	Break Even Point
B/C ratio	:	Benefit cost ratio
CAE	:	College of Agricultural Engineering
cm	:	Centimetre
cm3	:	cubic centimetre
dia	:	Diametre
eq.	:	Equation
et. al	:	et alibi (and others)
etc	:	Etcetera
e.g	:	example gratia (for example)
Fig.	:	Figure
G	:	gram(s)
h	:	Hour(s)
$H_2 SO_4$	:	Sulphuric acid
H.P	:	Horse Power
HCL	:	Hydrogen chloride
i.e	:	That is
JNKVV	:	Jawaharlal Nehru Krishi Vishwa Vidyalaya
$K_2 SO_4$	:	Potassium sulphate
Kg	:	Kilogram
Kg/h	:	Kilo gram per hour
Kw	:	Kilo Watt
Lab	:	Laboratory
m	:	metre
m3	:	cubic metre
mg	:	milligram

min	:	minute(s)
ml	:	millitre
mm	:	millimetre
NaOH	:	Sodium hydroxide
No.	:	Number
Nm	:	nano metre
pps	:	Parts per second
%	:	Percentage
Rs	:	Rupees
reps	:	Respectively
rpm	:	Revolution(s) per minute
SS	:	Stainless steel
Temp	:	Temperature
Ton	:	Tonnes
Ton/Hr	:	Tonnes per hour
Qt	:	Quintal
@	:	As per Rate
&	:	And

INTRODUCTION

Tomato (*Solanum lycopersicon*) is an important commercial vegetable crop. It is very popular vegetable throughout the country and it is grown in many states. Apart from use in vegetables, its downstream products like tomato concentrate, soup, sauce, puree, ketchup are very popular and they have a longer shelf life unlike fresh tomatoes. With the advent of new technology many down the line products are made and are consumed around the year, (Bhuvaneswari and Rao, 2012).

Origin of tomato:-

Countries across the world use tomatoes as a key ingredient in their dishes, but this wasn't always the case. For instance the people of fiancé, Italy used tomatoes as mere table top decoration until the late 17th century. Americans didn't harvest tomatoes until 1835 because of the belief they were poisonous.

The fruit came to India by the way of Portuguese explorers during 16th century because tomatoes thrive in warm, sunny conditions with no severe frost, the plants took well to Indian soils. Figures from 2010 show India as the world third largest grower of tomatoes, producing nearly 12 million tonnes .The national Horticultural board gives a higher figure, estimating India's production to be closer to 14 million. Tomato ranks third in priority after potato and onion but ranks second after potato in the world. Andhra Pradesh leads tomato growth in India by covering approximately 35 percent of the country's production or almost 6 million tonnes. Other top tomato producing states in India are Orissa, West Bengal, Bihar, Gujarat, Maharashtra, Chhattisgarh, Tamil Nadu and Jharkhand. According to NHB, India, Data Base 2015 the area and production of fruits is 7216 ha and 88977 lakh metric tonnes where as vegetable production area is 9396 ha and vegetable production quantity is 162897 lakh metric tonnes . In that tomato production is 19402 lakh metric tonnes with in an area of 1204 ha. The major tomato producing countries in world are China (30.7%), India (11.5%) followed by USA (8.1%). The percentage of share of major vegetable crops in India are Potato (25.5%) Onion (11.9%), followed by Tomato (11.5%) (Indian horticulture Database, 2014)

India grows several varieties of tomatoes, from the small lively cherry tomato bursting with juice to the large, fibrous beefsteak. The most common tomato varieties are beefsteak, cherry, heirloom, roma and pear. The taste of tomatoes varies greatly between cultivars. Cherry tomatoes tend to both sweeter and sourer than larger varieties. They are also juicer and pulpier than heirloom and beefsteak tomatoes.

Roma tomatoes share many characteristics with cherry tomatoes. It too juicy, sweet and tangy. The high pulp makes better suited for sauces and purees than for slicing.

Processed tomato products have wide applications in house hold consumption, food processing industry, snacks food, hotels, restaurants and fast food joints. Tomato products can be grouped into many end-use categories like peeled, concentrated, partially dehydrated, strained and diced tomatoes, tomato juice, pulp, paste, powder, sauce, jam, soups, and ketchup.

Tomato processing

Coming to Tomato processing food sector, application of modern technology has helped in enriching the quality of produce. It has tremendous growth opportunities in the country. As per data of department of commerce, India export of value added tomato products increased from 590 tonnes in the year 2002-03 to 991.46 tones in year 2005-06.

In the year 2006-2007 India’s export of value added products is estimated at 450.48 tons, which includes 18.46 tones canned tomato products 5.94 tonnes of tomato paste, 2.1 tonnes of tomato juice, and 423.98 tonnes of tomato ketchup.

India’s ketchup consumption is estimated as 13000 tonnes a year and its market is estimated around INR 1800 million. “Kissan”, “Maggi-Nestle” and “Heninz” are three well known brands engaged in manufacturing a range of tomato products in India . Some Medium and Small Companies are also engaged in its production. Tomato processing in India is still not very significant. Recently, there was a steady rise in production due to the entry of multinationals with better market infrastructure and sales promotion campaigns.

The largest portion of this crop is thermally processed and concentrated into tomato paste. The most important quality attributes in processing tomatoes are soluble solids, PH, titrable acidity, viscosity and colour (Saltveit, 2005). Tomato fruit composition is approximately 93% water and 7% solids. Approximately half of the total solids are having reducing sugars, with slightly more fructose than glucose. The remaining solids consists of acids, amino acids, proteins, lipds, minerals, cellulose and hemicelluloses (Barringer, 2004)

Soluble solids are key parameters in tomato paste production. Tomato paste is produced and sold based on its soluble solids content thus soluble solids dictate the factory yield. Higher soluble solids in the incoming fruit means that fewer tons of tomatoes will be needed to produce a given amount of paste. Furthermore, water removal during evaporation of juice is an energy intensive process.

The second key parameter in paste production is pH, which plays a vital part in microbiological safety and food spoilage. Tomatoes are high-acid foods, thus, require less thermal treatments than foods classified as low-acid foods (pH >4.6) . Generally the pH of tomatoes has been reported to range from 3.9 to 4.9 where as in standard cultivars, 4.0 to 4.7. The pH of tomato is determined by its organic acid content with citric acid being the most abundant. Sugars and organic acids are responsible for sweetness and tartness and are the major factors affecting flavour acceptability.

The agricultural sector in general and the tomato sector in particular have not met their potential. In this sector, production seasonality, the dominance of rain fed agriculture, high perishability of the vegetable, lack of ready market, lack of a reasonable alternative uses of the vegetable and poor pricing are some problems faced by farmers. In addition, it is probable that, poor postharvest practices coupled with poor storage facilities account for the recurrent seasonal postharvest losses of tomatoes.

With high fluctuation in market prices of fresh tomatoes in the urban market, there are good prospects for tomato juice, and tomato puree in place of fresh tomatoes in household sector. Besides the boom in the food service sector including fast food chain, has widened the demand potential for tomato ketchup and soups.

Experiments have shown that advertisement and publicity have influenced the pattern of consumption of tomato products. Besides, tomato products have good export potential especially in the Middle East.

Also, traders may be lacking the appropriate postharvest skills of prolonging the shelf life of tomatoes in commercial quantities. The unavailability of large scale processing factories in the tomato production areas to help preserve the surplus produce for future use, leave farmers with no option but to watch their produce go waste any time there is no ready market.

Indian tomato processing industry is rising from small scale to large one and it is for sure to compete with the international industries. Hence, in this competitive market it is necessary that processing operations become cost effective. As the material/ energy and money required for processing operation considerably bags a high cost, so it is necessary to optimize the technical and economic feasibility of tomato processing operations. This necessitates carrying out as a good guide for planners, financial agencies and small rural entrepreneurs who wish to establish "tomato processing" plant as a commercial viable industry.

It also gives information about the cost of machines, establishment charges, and recurring expenses involved in establishment/preparing the tomato sauce. This study is carried out to develop standards for regulating material and energy consumption and reduce the wastage of material and energy in tomato industry. It is expected that in the end, problems that account for inefficiencies in the local production industry would be identified to help build a stronger industry.

1.2 OBJECTIVE

The main objective of the study was to assess the various postharvest handling, processing and storage used by tomato farmers, traders and consumers.

The objectives of the present study are aimed at:-

1. To study the material balance of tomato sauce production process.
2. To study production economics of tomato sauce production process.

REVIEW OF LITERATURE

2.1 Taxonomy, origin, history, and uses of tomato

The tomato belongs to the *Solanaceae* family its genus (*Lycopersicon*) is believed to have originated in the coastal strip of western South America, a region that includes parts of Chile, Colombia, Ecuador, Bolivia, and Peru (Jones 1999; Sims 1980). The species was first domesticated in Mexico and was introduced into Europe in the mid-16th century but was not eaten often due to the misconceived notion that it was poisonous like its relative, the deadly nightshade (Heiser 1969). The tomato was re-introduced back into America in the 18th century and by the end of the 19th century processed products such as soups, sauces, and ketchup were regularly consumed (Harvey et al 2002).

Today, tomatoes are one of the most widely eaten vegetables in the world, mostly stemming from the fact that they can be eaten fresh or in processed form. Some processed tomato products include tomato juice, tomato pulp, tomato paste, ketchup, and chili sauce (Economic Research Survey 2012). In addition to consumption, tomatoes serve as an excellent tool to improve the knowledge of horticulture crops as it's a 'model crop' for diverse physiological and biochemical studies because they are easily grown, have a short life cycle and are easy to manipulate (e.g. grafting, cuttings) (Kinet and Peet 1997). Similarly, the plant species is valued to study the physiology and biochemistry of seed development, germination, and dormancy (Suhartanto 2002).

2.2 Overview of worldwide tomato industry

The most fundamental differences among fresh-market and processing tomato industries are (Santos, 2010)

1) Fresh-market tomatoes are handpicked, while processing tomatoes are machine harvested. All tomatoes were collected by hand before 1964 but, after labor shortages that year, mechanization was quickly adopted (Brandt and French 1983)
2) Processing tomatoes are harvested when red ripe; fresh-market tomatoes while still green (Saltveit ,2005a).

3) Once out of the field, fresh-market tomatoes are allowed to mature over time, sometimes accelerating the process by addition of ethylene gas. Processing tomatoes are used immediately, usually within the same day (Saltveit 2005a).

4) Growers establish business contracts with processing firms. Fresh tomatoes are sold on the open market (Economic Research Service, 2012).

5) Processing cultivars have been selectively bred for over 50 years to develop characteristics that noticeably differentiate them from fresh-market varieties.

Table 2.1 Major Tomato producing countries in the world

Country	Area (in ha)	Production (in mT)	Productivity (in mT/ha)
China	1000000	10000000	50
India	882032	18735912	21.2
USA	150140	13206950	88
Turkey	300000	11350000	37.8
Egypt	218395	8825219	39.9
Iran	160000	6000000	37.5
Italy	91850	5131977	55.9
Spain	48800	4007000	82.1
Brazil	63859	3873985	60.7
Mexico	98851	3433587	35.5
Others	1805985	38665136	21.4
World+(Total)	48199912	123229766	33.9

Source: FAO Website-February 2015 (Data for 2012, 2013 N/A) and for India Data- (Date for 2013-14) Department of Agricultural & Cooperation.

LEADING TOMATO PRODUCING COUNTRIES IN WORLD:

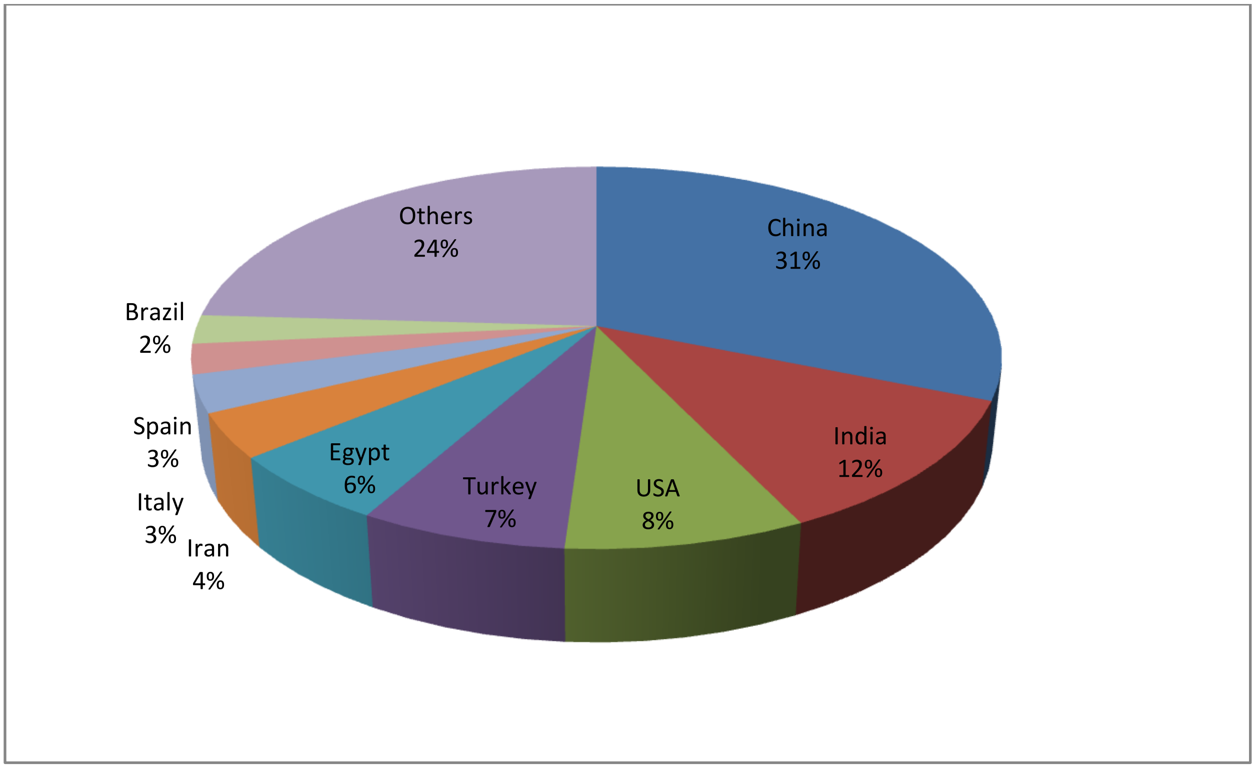


Fig 2.1 Leading tomato producing countries in world

Source: FAO Website-February 2015(Data for 2012, 2013 N/A) and for India Data-(Date for 2013-14) Department of Agricultural & Cooperation.

2.3 Processing tomato industry

(Economic Research Service, 2012) ERS, stated previously, grower's contract with processors to process ripe tomatoes. A common initial processing step is the manufacture of tomato paste as a raw ingredient. Paste is packed in bulk containers and stored for use up to 18 months. This raw ingredient is sold for remanufacturing to make retail and food service packs of soups, sauces, catsup, and paste.

American consume about 75% of their tomatoes in processed form which has been mostly attributed to the rise in pizza and pasta sauce intake over the last 30 years (Economic Research Service 2012). ERS estimates suggest that the largest use of processed tomatoes is in sauces (35%), followed by paste (18%), canned whole tomato (17%), and catsup and juice (each 15%). It is also thought that about one-third of all processed tomato products are purchased away from home at various food service restaurants (Economic Research Service, 2012).

2.4 Varieties of tomato

Sacco describes these two main types of tomato as the hybrid and the open pollinated. Other authors however describes what Sacco refer to as types, as groups. Hybrid tomatoes are a cross between two different tomatoes often with a positive and negative aspect (Sacco, 2007).

According to (Sacco, 2008), there are more tomato varieties sold worldwide than any other vegetable.

Domesticated tomatoes (*Solanum lycopersicum*) are naturally self-pollinating. Since they do not outcross very often, strains quickly become homogenous and produce 'true to seed' (Edlin, 2009). Colors of heirlooms range from yellow, red, orange, purple, white, green, and bicolor combinations of them all. There is also wide variety in their shapes and sizes. One can find tiny cherries and huge two-pounders in the same garden, along with globe, flattened, oblong, pumpkin, egg, pear, and pepper shaped fruits.

2.5 Major Tomato Varieties Grown in India

Vaishali: This is a determinate hybrid variety of tomato which produces medium sized (100 g) quality fruits. The variety is suitable for growing in hot and humid weather conditions. Variety is resistant to *Fusarium* and *Verticillium* wilts, suitable for tomato juice preparation.

Rupali: This is a determinate, compact growing, early tomato hybrid with good foliage cover which produces medium sized (100 g) round, firm, smooth and good quality fruits. The fruits are deep red in colour. Variety is resistant to *Fusarium* and *Verticillium* wilts. suitable for processing.

Rashmi: This is a determinate, widely adapted hybrid variety. The fruits are round, firm, smooth and with a good colour. Variety is resistant to *Fusarium* and *Verticillium* wilts. suitable for processing.

Rajni: This variety is very early growing and of determinate type. The fruits are round with red colour. The variety is suitable for long distance transportation.

Pusa Ruby: Variety is released by IARI, New Delhi. It is an early growing cultivar, fruits a have yellow stem end, slightly furrowed with uniform ripening. Variety is suitable for sowing both in spring-summer and autumn-winter seasons. Average yield is 32.5 t/ha. It is suitable for table as well as processing purpose.

Pusa Early Dwarf: Variety is released by IARI, New Delhi. It is an early ripening cultivar of determinate type; fruits are flattish round, medium-large with yellow stem end. Average yield is 35 t/ha. It is suitable for table as well as processing purpose.

Source: Agropeda, Indian Institute of Technology, Kanpur, http://agropedia.iitk.ac.in/ content.

MAJOR TOMATO PRODUCING STATES (2013-14)

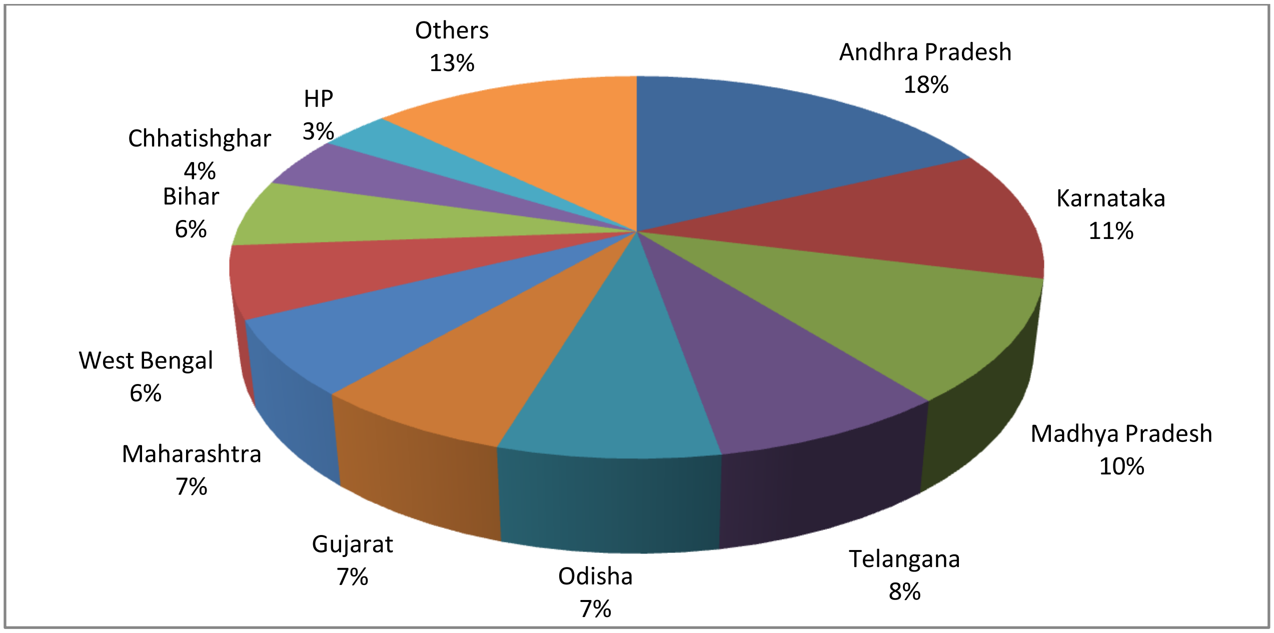


Fig 2.2 Leading tomato producing states in India

Source: All India 2013-14 (Final Estimates), Department of Agricultural & Cooperation.

MONTHLY AVERAGE WHOLESALE PRICE & TOTAL ARRIVAL OF TOMATO DURING THE PERIOD OF JANUARY TO DECEMBER IN 4 MAJOR CITIES -2014

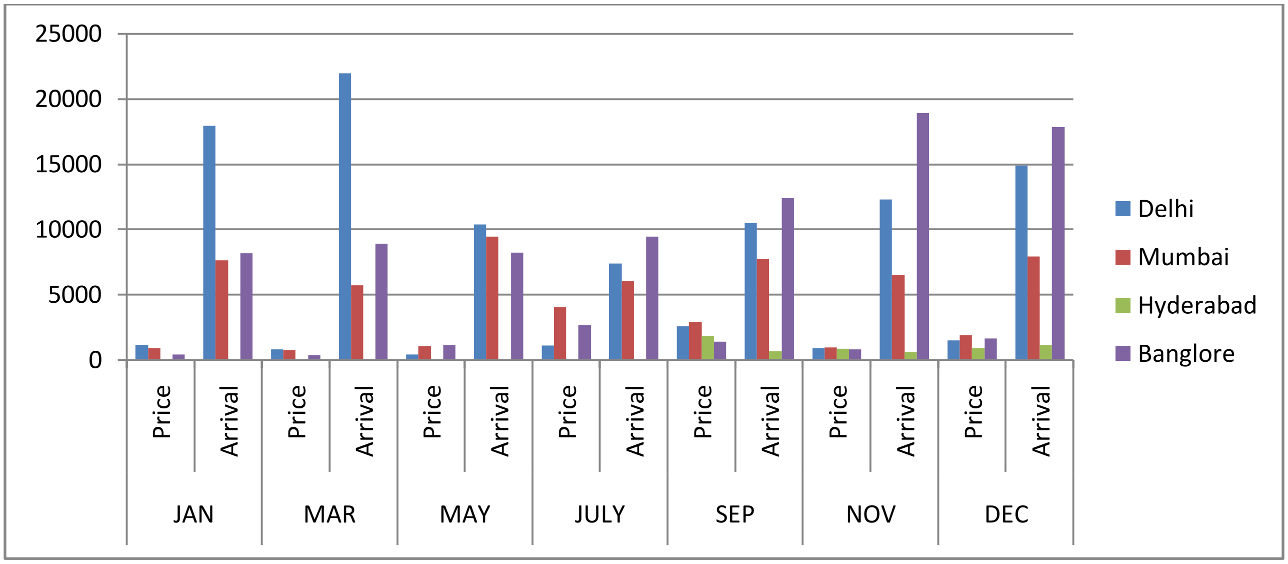


Fig 2.3 Monthly average whole sale price and total arrival of tomato during year 2014.

Source: All India 2013-14 (Final Estimates), Department of Agricultural & Cooperation.

Criteria and description of grades

Details of grade designation and sizing of Tomato as per AGMARK standard

PROVISION CONCERNING SIZING

Sizing is determined by the maximum diameter of the equatorial section in accordance with following table 2.2. The provision shall not apply to "cherry" tomatoes. The minimum size is set at 35 mm for "round" and "ribbed" tomatoes and 30 mm for "oblong" tomatoes:

size code	Diameter in mm(min-max)
1	30-34
2	35-39
3	40-46
4	47-56
5	57-66
6	67-81
7	82-101

Table 2.2 Details of sizing in Tomato

Source: Post Harvest Manuals on Export of Fruits, APEDA, New Delhi.

2.6 Fruit Characteristics

Costa and Heuvelink, (2005).The tomato is an annual shrubbery plant with yellow clustered flowers on trailing stems (Yamaguchi 1983). The growth habit varies from indeterminate (shoot tips remain vegetative), to semi-determinate and determinate (shoot tips terminate in a flower cluster). Processing tomatoes are most commonly determinate which lends themselves to once-over mechanical harvesting when the fruit is ripe Tomato fruits are round, lobed, or pear-shaped varying in size from ½ to 5 inches in diameter The ultimate size of the tomato fruit is correlated to a several parameters including (i) the number of carpels in the ovary; (ii) the number of seeds; (iii) the position of the fruit; (iv) the sequence of set in a truss; (v) the environmental conditions prevailing during the growth phase (Kinet and Peet 1997). Most tomato varieties' fruits are red when ripe but not all including *L. peruvianum, L. chilense,* and *L. hirsutum* which are green (Yamaguchi, 1983).

The tomato plant is adapted to a wide range of climatic and soil conditions. Optimal temperature ranges is 70-75°F and chilling injury can occur if the temperature dips below 53°F for a long period of time. If the temperature exceeds 90°F during the storage of harvested mature green tomatoes, the formation of the red color, lycopene is inhibited and the fruit is more yellowish when ripe (Yamaguchi,1983). There is a substantial range in fruit characteristics available today mainly due to disease-resistant hybrid.

2.7 Composition

Jones, (1999) proposed that tomato fruit is classified botanically as a berry, with the size varying from small cherry types to larger 'beefsteak' types. Tomatoes contain 2-12 locules (divisions of the ovary) with many seeds .This physical attribute is used to define the fruit type. For example, two locules are typically found in cherry and plum tomatoes which are commonly used for processing. Four to six locules are common commercial cultivars for fresh market and more than six locules are commonly home-grown as they are subject to cracking during shipping

Most tomato varieties are red in color due to the presence of the carotenoid, lycopene, an antioxidant. Water is the major component in ripe tomato followed by carbohydrates (4.7 g/100g) and protein (1.1 g/100g).

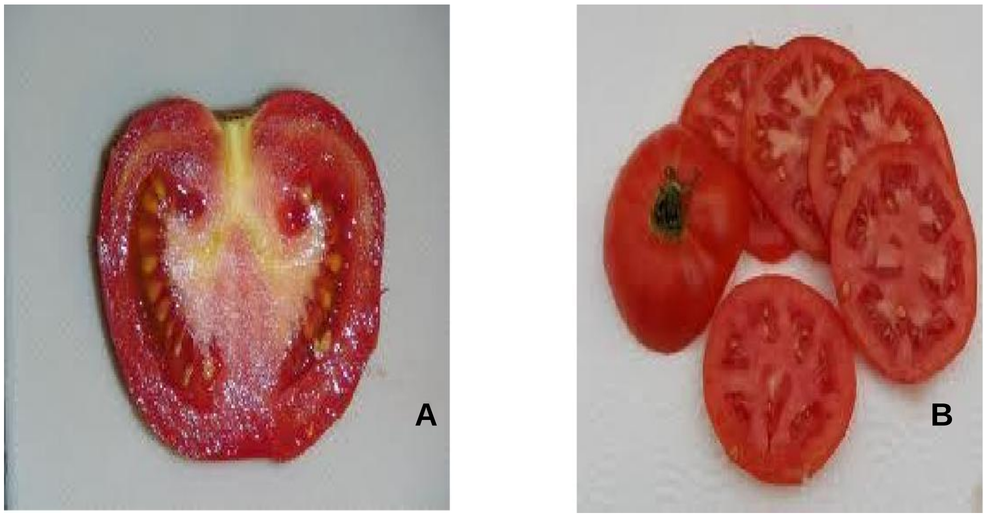


Figure 2.4. Cross-section of two (A) and seven (B) locule tomato fruits. Two-locule fruits are more common in the processing market whereas larger locule-containing fruits are found in the fresh tomato market (Jones, 1999).

The pH of tomato is normally around 4.5 and is carefully monitored during processing tomato manufacturing for the prevention of *Clostridium botulinum*. The ratio between the pH and solids content of the tomato fruit is a significant factor in its perceived flavour (Jones 1999).

2.8 Quality Characteristics

Tomatoes are harvested at different stages of ripeness depending on its purpose: whether they are for fresh or processing market use. Processing tomatoes are harvested mechanically when 90% of the tomatoes in the field are red-ripe and immediately transferred to the processing plant (Salveit, 2005a). In contrast, fresh tomatoes are harvested by hand at the mature-green to partially ripe stage. The fruit is picked at this stage for fresh market as it is better able to handle the stress of shipping. Quality characteristics of fresh-market fruit are similar to processing tomatoes in some ways, but the weight of the consumer's visual appeal (color, size, shape, firmness, and aroma) dominates the others (Saltveit, 2005a).

2.9 Quality assessment of processing tomatoes

The major quality components of processing tomatoes are soluble solids, pH, titratable acidity, viscosity, and color (Saltveit 2005b). The production of tomato concentrates and paste requires the removal of water, which is an energy intensive process. It is cheaper to manufacture a tomato with higher solids content since that is less water to boil off (Saltveit 2005b). Viscosity is a complex physical property that is influenced by the amount and suspension of tomato solids, the solution of salts, proteins, sugars, and organic acids, as well as the size and linkage of pectins (Saltveit 2005b). Lycopene and beta-carotene are predominantly responsible for the color in tomato products. Breeders have focused on increasing the soluble solids, viscosity, and color of processing tomatoes over the past several years. Some difficulty has been found since the trait is polygenetic and greatly influenced by the environment. It has been suggested that the product of yield multiplied by the soluble solids content is more useful in estimating the productivity of processing tomatoes (Saltveit 2005b). In general, the tomato yields have increased but the soluble solids only slightly (Stevens 1994; Zamir and others 1999). Some success has been found, with high sugar and acid hybrids being rated as higher overall flavor intensity than standard cultivars (Ruiz and others 2006).

Soluble solids (SS) and titratable acids (TA) are important components of flavor. Interestingly, they provide an effect not only through their presence but also through their ratio. Fruit high in SS and high in TA impart ‘good’ flavor while those low in SS and high in TA were ‘tart’ ‘Tasteless’ fruit is noted when both sugars and acids are low in concentration. For fresh tomatoes, this may be due to the fact that harvested fruit that is stored at elevated temperatures hastens the respiratory loss of carbohydrates along with the acceleration of ripening (Saltveit 2005b). There is large variation among tomato cultivars for pH, total acidity, and sugar content. The pH of a ripe tomato typically ranges from 4.1 to 4.8. Storage at higher temperatures causes the organic acids to metabolize and the pH to increase which is undesirable from a flavor and processing standpoint (Saltveit 2005b). The fresh tomato market also values the acid content of tomatoes from a flavor standpoint, but the firmness and color of the fruit are very important indicators of good quality to the consumers.

Table 2.2 Relationship between the level of sugars and titratable acids on the taste and flavor of fresh tomato fruit (Source: Kader and others 1978).

	Sugars (soluble solids)	
Titratable acidity	High	Low
High	Good	Tart
Low	Bland	Tasteless

2.10 Antioxidant properties and other health benefits of tomatoes

Sun *et al.* (2009 c). Antioxidants are naturally occurring chemicals in many foods, especially fruits and vegetables. Foods rich in antioxidants help protect us from disease attack and they slow the aging process .The balance between free radicals and antioxidants will determine the amount of oxidative stress a person is undergoing. Decreasing free radical production, increasing dietary antioxidant intake or both can reduce oxidative stress .

Ibitoye *et al.,* (2009). Lycopene is the pigment responsible for the characteristic deep red colour of ripe tomatoes and their products According to Lindshield *et al.* (2006) lycopene has earned a plethora of interest for its use as a preventative measure and possible treatment for cardiovascular disease, skin health, eye health, and prostate cancer. Lycopene has also been shown to be the most potent antioxidant produced by the carotenoid pathway (Di Mascio *et al.,* **(**1989); Cox, 2001).

According to Challem (1999), the evidence is so convincing that the National Cancer Institute recommends consumption of at least five servings of fruits and vegetables a day to ward off cancer (Cox, 2001). Consumption of fruits and vegetables is linked to lower incidence and lower mortality rates of several types of cancer .These positive effects on human health are attributed in large part to the antioxidant compounds found in high quantities in fruits and vegetables

Research findings by Garmyn *et al.,* (1995) on the one hand and (Arab *et al.* (2002) on the other have found that lycopene is likely to also play a role in the prevention of skin and lung cancers respectively. After a research reported that the dietary intake of lycopene from tomatoes was associated with a 31% reduction in pancreatic cancer risk among men.

According to Cox (2001), a University of California Davis survey ranked the tomato as the single most important fruit or vegetable of Western diets in terms of overall source of vitamins and minerals. Aside lycopene, tomatoes are also an excellent source of flavonoids and polyphenols, which are also associated with lower cancer risk (Campbell *et al.*, 2004).

It has also been demonstrated that dietary intake of tomatoes especially in the cooked form, are associated with a decreased risk cardiovascular diseases. Cooked tomatoes according Knekt *et al.,* (2002) contain significant amounts of absorbable naringenin and chlorogenic acid.

Lycopene works synergistically with the other phytochemicals in whole tomatoes to provide a wide range of health benefits. New evidence shows that the protective effects of tomatoes against cancer and cardiovascular disease are due to a combination of lycopene and the other phytonutrients naturally present in the fruit and skin of the tomato. In other words, you will not obtain all the nutrients if you skin the tomatoes (Heber and Lu, 2002).

2.11 Post harvest losses in India

Vishal Singh et al., (2014) studied and proposed that Harvested fruits and vegetables require adequate and advanced postharvest processing technologies for minimizing the qualitative as well as quantitative losses after harvesting. Nearly 40% fruits and vegetables are wasted every year due to improper handling, storage, packaging, and transportation. Wastage of fruits and vegetables in huge amount due to un-implementation of advance postharvest technological approaches also reduces the per capita availability of fruits and vegetables. Intensive emphasis is required to develop the advance postharvest technologies for improving the global food security by enriching the economy of agricultural produce of the world with minimal losses of consumable fruits and vegetables. The present article discusses the common yet important postharvest technologies to maintain the quality of fruits and vegetables.

Gaurav Sharma et al., (2011) has examined the nature and extent of post-harvest losses in vegetable supply chain in the Kumaon division of Uttarakhand. Multistage cluster sampling has been used for selection of 80 vegetable growers, 40 farmers from the hilly region and 40 farmers from the bhabhar region. The sample has also included 25 market functionaries. Twelve major vegetables have been selected for the study. The maximum aggregate post-harvest losses have been found in tomato, followed by potato, brinjal, chilly, French bean and pea. The study has suggested that establishment of producer co-operatives to handle various activities relating to production and marketing of vegetables would help in reducing post-harvest losses.

2.12 Harvesting, postharvest handling, processing and storage of tomatoes

2.12.1 Harvesting

Postharvest activities include harvesting handling, storage, processing, packaging, transportation and marketing (Mrema and Rolle, 2002). The principles that dictate at which stage of maturity of fruit or vegetable should be harvested are crucial to its subsequent storage and marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest (FAO, 2008). According to Orzolek *et al.*(2006), tomatoes for the wholesale market should usually be picked at the mature green to breaker stage to prevent the fruit from becoming overripe during long transportation/shipping and handling

2.12.2 Postharvest handling of fresh tomatoes

According to Kitinoja and Gorny (2009), postharvest handling of fresh vegetables has a direct link with its shelf life. They reported that, handling starts right from harvesting and put estimates of losses in developing countries in the range of 20% to 50% tracing causes of losses to the field, during transport and marketing.

Tomatoes are highly perishable and very susceptible to mechanical damage with poor handling and transportation (Bani *et al.*, 2006). In addition, at usually high temperatures fruits and vegetables transpire and respire at high rates therefore they need shade from the sun's heat (Harvey and Harris, 1986; D'sousa and Ingle, 1989; Eckert and Eaks, 1989; Robbins and Moore, 1992). It is also recommended the produce be harvested in the morning to ensure that they are at the coolest possible temperature during the delay between harvest and initial cooling.

Most often losses of fresh vegetables occur along the long chain of supply from the producer to the consumer. Losses occur at the stages of sorting, packaging, storage, transport and marketing stages of the life the fresh horticultural produce

As a remedy, Kitinoja and Gorny (2009) recommend that when handling fresh produce at its market destination, it is important to avoid rough handling, minimize the number of handling steps and strictly follow a temperature and relative humidity management. Stacking of non uniform containers should also be done with care to prevent collapse of weaker packages and heavier cartons should always be placed at the bottom of a stack (Kitinoja and Gorny, 2009).

Conversely, according to the World Resource Institute (1998), post-harvest losses for horticultural produce are difficult to measure. The authors affirm that in some cases everything harvested may end up being sold to consumers whiles in others, losses or waste may be considerable. Use of average loss figures is thus often misleading. Also, there could be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity (World Resource Institute, 1998). Not only are losses clearly a waste of food, but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water (World Resource Institute, 1998).

2.12.3 Processing of Tomatoes

Gould, (1992). studied that right after harvesting, if the tomato is to be processed, little handling is required before they are transported to the processing plant in the shortest possible time. Once at the plant, they should be processed immediately or at least stored in the shade .

2.12.4 Storage of fresh tomatoes

According to Kitinoja and Gorny (2009), in developing countries, there is lack of storage facilities on-farm or at wholesale or retail markets and lack of ventilation and cooling in the very few existing on-farm facilities. Others include over-loading of cold stores (where available) including placing warm produce into the cold room, stacking produce too high (beyond container strength) and the practice of mixing produce with others having different temperature and relative humidity requirements. There are few key factors to consider when storing fresh produce.

FAO, (2008) reported that when stored at 10ºC with the optimum humidity of about 80%, green tomatoes can be stored for 16 - 24 weeks. In another report, Ashby, (2000) recommend 13º to 21ºC and a relative humidity of between 90 to 95% as the best transport conditions for green-mature tomatoes.

2.12.5 Processing and Preservation of Tomatoes

Ellis *et al.* (1998) reported that although tomato is a highly perishable crop, the rate and extent of spoilage depends on several factors and that, to overcome this problem calls for the need to develop simple, cost-effective and easily adaptable preservation techniques. They added that doing this requires a better understanding of the farm management system of farmers.

Tomatoes can be processed into many forms to be consumed instantly or preserved for future use. For example, according to Kitinoja and Gorny (2009), horticultural produce are usually processed to become part of the following categories: beverages (juices, sparkling fruit-flavored waters), condiments (salsas, pickles, chutneys, herb-vinegars, jams, jellies and preserves), confections (fruit-based candies, cookies, cakes) and miscellaneous (bottled herbed-mushrooms, fruit or vegetable-based snack-foods).

Ashby (2000) described a simple home-drying method for stewing tomatoes. Ripe tomatoes are steamed or dipped into boiling water to loosen skin, chilled in cold water, peeled and cut into sections about ¾ inch wide, or sliced. These are blanched for three minutes and dried in the dehydrator for 10 – 18 minutes or twice for time using the conventional oven

Other preservation methods are described by the Food and Agriculture Organization (FAO) and the Information Network on Post-Harvest Operations (INPhO). FAO and INPhO (1998) describes the pulping method, the drying method and the peeled tomato preservation method.

Fresh and processed produce can be marketed on the farm, at the farm gate, locally or regionally via wholesale or retail operations, or through exports to other countries. When deciding how to market your fresh and processed produce, each postharvest handling step taken provides an opportunity to make additional profits (Kitinoja, 2004).

2.13 Study on production economics:

Mandhyan et al., (2008) studied on techno-economic feasibility of commercial soymilk production in Jabalpur region of M.P and provide a good guide for planners, financial agencies and small rural entrepreneurs who wish to establish "tomato processing" plant as a commercial viable industry. They also provided information about the cost of machines, establishment charges, and recurring expenses involved in establishment of soymilk through study of Break even period (BEP) and Benefit cost ratio (B/C) ratio.

Khare et al., (1997) studied on application of management techniques to establish an agro -industry based on crop production and proposed a rice mill of one tone per hour capacity in one of the blocks of Jabalpur district through the analysis of Break Even point and profit method.

Mandhyan et al., (1998) proposed techno economic feasibility of agro processing centre and studied the techno economic feasibility of machines installed in agro processing center and the labor requirement of the machines.

Ramanathan et al., (2015) stated that the by-products of cashew viz., cashew nut shell liquid (CNSL), shell cake, testa and cashew apples are commercially exploitable. The method of processing technology affects the outturn, quality of the output, health of the workers, quality of by-products and the cost of production. The adoption of appropriate methods of processing technology can bring efficiency in the form of higher outturn, better quality kernels and cashew nut shell liquid. To use these by-products economically and to create awareness on the business opportunities in cashew processing, the present study attempts to find out the economic feasibility of cashew nut and oil (CNSL). The cost of raw material has been the major component in the cost of production of kernels, constituting 86.64 and 86.86% of the total cost of production of kernels in steaming method and drum roasting methods, respectively. proceeds has been Rs. 4693.62 and the profit per quintal of raw nut has been Rs. 76.99. Thus it is concluded that the steam processing method realized better returns than drum roasting method due to the adoption of latest technology in the cashew processing methods in India. Cashew nut shell liquid (CNSL), a by-product of the cashew industry has always been credited

2.14 Technical study of tomato process:-

Tan and Kerr (2015) suggested that tomato puree was processed by continuous high-pressure (CHP) homogenization at 69–276 MPa, for 1–3 passes. Laser scattering and light microscopy showed CHP reduced the pulp particles to 10–100 lm, producing smaller and more uniform particles, with processing at 276 MPa and 2 passes producing great-est particle reduction. No differences in moisture or color were found due to different treatments. In general, $G^0 > G^{00}$ for all samples, suggesting a soft gel network. Both the storage modulus (G^0) and loss modulus (G^{00}) decreased with CHP pressure. G^0 decreased modestly with frequency between 0.1 and 2 Hz, and more dramatically between 2 and 30 Hz, with behavior characteristic of entangled polymers. In general, yield stress decreased with homogenization pressure, but increased with number of passes. CHP-treated sam-ples had lower consistency and were less shear-thinning than the control. Repeated passes increased the consistency of CHP samples. The results suggest CHP processing produced smaller and more uniform par-ticles, causing a reduced level of microstructure that contributes to elastic properties at small deformation.

Bhuvaneswari., *et al.*, (2012) stated that a protocol for preparation of whole tomato concentrate was standardized in cvs. Vaibhav Ananya and Allround. 100 kg fruit gave 32 kg concentrate in open pan. The concentrate had 20 mg/100g acrobic acid content in Vaibhav while lycopene (6.43 mg/100 g) was estimated in Allround. There was slight decrease in acidity after 3 month storage.

2.15 Study on material balance

Hosain Darvishi *et al*., (2015) studied on six different voltage gradients ranging from 6 to 16 V/cm were used to evaporate water from tomato samples of 9.3 (kg water/kg dry matter) to a safer level of 2.3 (kg water/kg dry matter). Energy efficiency decreased from 100 to 55.53% with decreasing moisture content and increasing voltage gradient, while, exergy efficiency increased from 3 to 83.51% with decrease in moisture content (Pb 0.05). Average energy and exergy efficiency were found to be in the range of 67.07–85.40% and 27.75–60.34%, respectively. The electrical conductivity increased (2.36–12.38 S/m) with a decrease in moisture content and voltage gradient up to the boiling point. Specific energy consumption and average improvement potential decreased from 4.64 to 2.73 MJ/kg of water evaporation and 14.18–2.82 kW with increasing voltage gradient, respectively.

The values of energy and exergy losses increased from 6.88 to 21.48 kW and 6.81–21.47 kW, respectively, as the voltage gradient and moisture content decreased. Industrial relevance: due to the ability of the ohmic heating technologies to achieve rapid and reasonably uniform heating of electrically conductive materials its impact on food quality is of interest. Based on literature review, in ohmic heating process it could be possible to obtain efficiencies greater than 90% in an industrial process in which these losses were controlled by the wall insulation. However there is limited information on the exergy analysis of ohmic processes and systems, to the best of the authors' knowledge. Exergy analysis becomes more crucial, especially for the industrial (large-scale) high temperature heating applications, and it can reveal whether or not and by how much it is possible to design more efficient thermal systems by reducing the sources of existing inef-ficiencies.

Ahmet Karakaya et al. (2011) studied and calcultated on energy utilization and carbon dioxide emission during the production of fresh, peeled, diced, and juiced tomatoes. The energy utilization for production of raw and packaging materials, trans-portation, and waste management were also considered. The energy utilization to produce one-ton retail packaged fresh tomatoes was calculated to be 2412.8 MJ, whereas when the tomatoes were converted into paste, the energy utilization increase almost twofold; processing the same amount into the peeled or diced-tomatoes increases the energy utilization seven times. In case of juice production, the increase was five times. The carbon dioxide emission was determined by the source of energy used was 189.4 kg/t of fresh tomatoes in the case of retail packaging, and did not change considerably when made into paste. The carbon dioxide emission increased two fold with peeled or diced-tomatoes, and increased three fold when juiced. Chemical fertilizers and transportation made the highest contribution to energy utilization and CO_2 emission. The difference in energy utilization is determined mainly by water to dry solids ratio of the food and increases with the water content of the final product. Environmentally conscious consumers may prefer eating fresh tomatoes or alternatively tomato paste, to minimize carbon dioxide emission.

2.16 Future innovations in tomato processing

Barret (2015) studied on while tremendous improvements in efficiency and cost of production have been made in the processing tomato industry world-wide over the past 100 years, there is still opportunity for innovation. For decades, processing tomatoes have been direct seeded in many parts of the world, however, over the past ten years the use of transplants has increased the success rate and yield of the crop. Likewise, the use drip rather than furrow irrigation has improved the grower’s control over production. Breeding of multi-use and extended field storage (EFS) cultivars has dominated in California and other locations. On the processing side, higher value whole peel and diced tomato products have benefited from innovations in the peeling process. Advanced technologies which utilize less energy, and result in a higher quality product, are being studied and to some extent commercialized. These include electric field process such as ohmic, pulsed electric fields, microwave and radiofrequency as well as high pressure processing. Both production and processing of tomatoes is currently being carried out under more sustainable practices, and this will continue to be a goal for the future.

MATERIAL AND METHODS

The study was planned to study the technology and economics of tomato processing of pilot plant .The current chapter deals with technical information of tomato processing plant, the sequence of unit operations followed, machines used for producing tomato products, and analysis of economic feasibility and mass balance of the material.

3.1 General information of the processing plant under study:-

The tomato processing plant was established in the year 2007 under experiential learning programme for B.Tech students located at Maharajpur, Jabalpur .This is one of the smallest, ultra modern, fully automated tomato processing unit . The products produced from this plant are tomato sauce, tomato ketchup, tomato juice. etc. The unit has capacity of processing 50 kg/ hr of tomato sauce. The layout of tomato processing pilot plant inside the building are shown in plate 3.1 and figure 3.1

Plate 3.1 Pilot Plant

LAYOUT OF PILOT PLANT

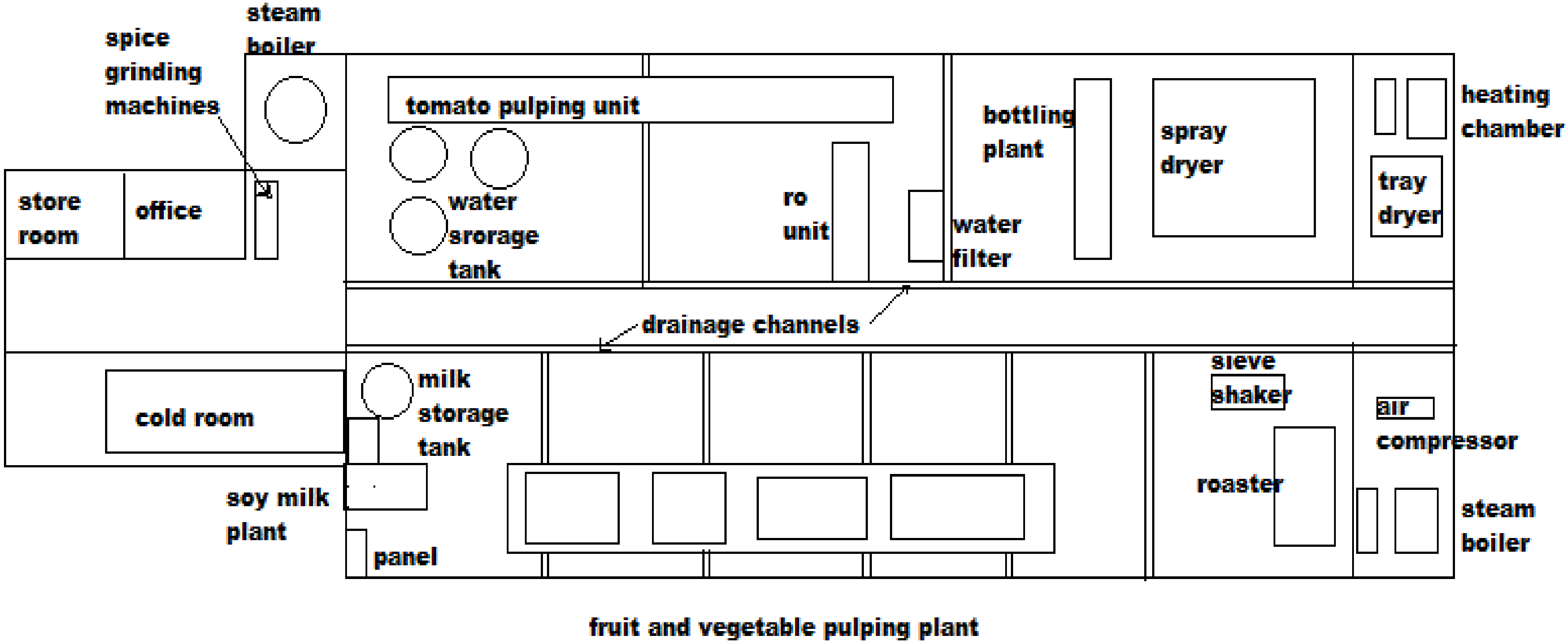


Fig 3.1 Layout Of Pilot Plant

3.2 Processing of tomato:-

For the production of various tomato products different unit operations are required to perform as discussed below:-

FLOW CHART OF TOMATO PROCESSING:-

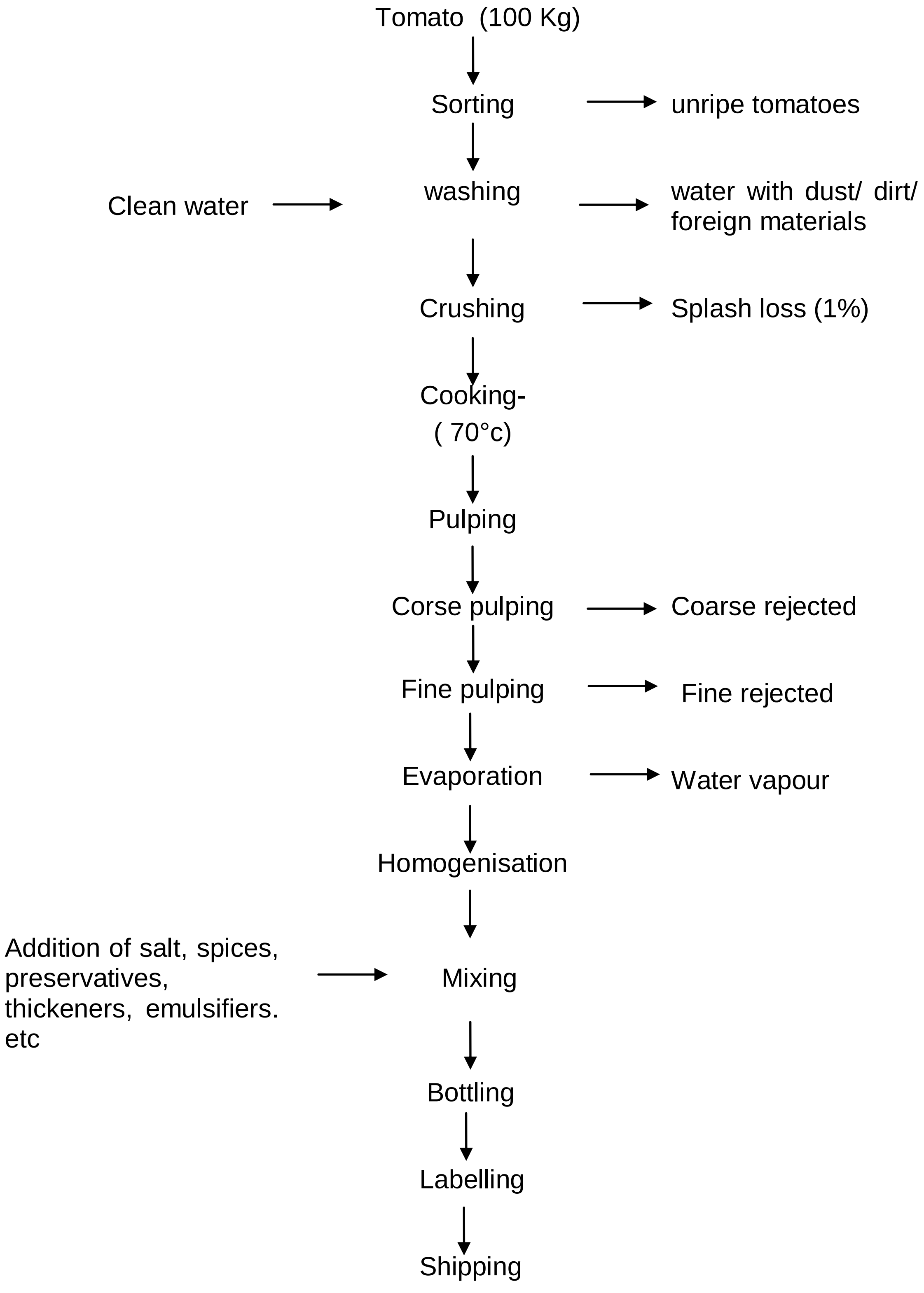


Fig 3.2 Process flow chart for preparation tomato processing products

3.2.1 Procurement of raw material:-

For the preparation of tomato products various raw materials like tomatoes, ingredients are required. The plant procures the raw material from near by market of Jabalpur.

3.2.2 Receiving and Weighing:-

After receiving, the tomatoes are weighed along with the caret using a weighing balance (Plate 3.21) in the plant. It make is M/s Unitech Enterprises.

3.2.3 Washing and Sorting:-

After receiving and weighing the tomatoes are taken into large perforated containers sufficient to accommodate one caret of tomatoes and this perforated container placed inside a large SS container of similar geometry having an opening at the bottom to drain out the water. Here caret of tomatoes placed in perforated container is washed with the help of water jet so as to remove the dirt, dust, other impurities and undesirable foreign matter adhering to tomatoes.

Plate 3.2 Washing container

While spraying water jet initially the drain is closed for some time, later the lid opened to drain out the water so that, undesirable foreining matter is washed away. The cleaned tomatoes are now spread on the sorting trays where is sorted manually. In sorting fully ripe, soft and red tomatoes are picked up and fed into the crusher. The remaining tomatoes which are either unripe and green and red but firm are kept aside and left for more ripening so that they become fully ripe red and soft.

Plate 3.3 Sorting table

3.2.4 Crusher:-

Fully ripe red and soft tomatoes are fed to the crusher. In the crusher tomatoes pressed by rotating hammers against battery of slit kneaded by fixing the curved knives fitted along the periphery of crusher located at the lower side of crusher. While passing through the battery slits, the tomatoes cut into smaller pieces and collected in the balance tank placed below the crusher. Its make is SSP(PVT) Limited, Faridabad. Once the balance tank was full with the crushed tomatoes these are moved by a transfer pump (Plate 3.5) fitted on the downstream of crusher and the crushed tomatoes are fed to the cooker by the transfer pump.

Plate 3.4 Crusher **Plate3.5 Transfer Pump**

3.2.5 Cooker:-

A steam jacketed cooker (Plate3.6) is fitted between crusher and the pulper. Its purpose is to soften the tissues of crushed tomatoes by heating at about 70°C by application of heat while passing through a 1m long tubular heat exchanger. Heat is supplied to the heat exchanger in the form of steam by the steam boiler. After passing through the cooker, tomato pulp was fed to the pulper. Its make is SSP(PVT) Limited, Faridabad.

Plate3.6 Cooker

3.2.6 Pulper: -

In the plant there is a provision of pulping in two stages, in first stage coarse pulping was done and in second stage fine pulping was done.

In the coarse pulping size of opening in the centrifugal rotating screens is litter larger than that for fine pulper. Its make is SSP(PVT) Limited. The tomato pulp coming from cooker was fed into the coarse pulper. Here during pulping more amount of waste was rejected. Pulping takes place due to screening of tomato pulp against pulper screen by centrifugal force generated due to high speed rotation of pulper rotor. The thick juice of tomatoes coming out of coarse pulper was fed into fine pulper. In the fine pulper again due to similar screening process some fine particles are removed as rejected and comparatively a thinner juice was received from fine pulper.

Plate 3.7 Coarse Pulper **Plate 3.8 Fine Pulper**

3.2.7 SS Kettle:-

The transfer pump located at downstream to the balance tank (which is receiving juice from fine pulper) was started once the balance tank was full and the juice is transferred into the SS kettle (Plate3.9). When the SS kettle is half filled, a steam supply from the boiler was started. The SS kettle has provision for motorised stirrer and provision for manual tilting of kettle. In the SS kettle the juice was evaporated by heat supplied by a steam passing through the jacket of SS kettle. While heating simultaneously stirring also takes place. So sticking and charring of juice does not take place. In the kettle the evaporation process continues till the required consistency of concentrated tomato product was obtained.

Usually for tomato sauce a consistency of 12° Brix where as for tomato puree a consistency of 16-18° Brix and for tomato paste 25-30°Brix is accepted (Srivastava and Snjeev Kumar). After getting the required consistency steam supply valve is closed and SS Kettle is slowly tilted manually to discharge the concentrated tomato product into the balance tank placed downstream to the SS kettle. After collecting the entire concentrated tomato product in the balance tank the high pressure transfer pump is started to pass the concentrated product through the homogeniser at 2kg/cm² pressure. The purpose was to ensure a smooth and uniform consistency. The resulting tomato product which may be tomato sauce, tomato puree, or tomato paste. After passing through the homogeniser the tomato product was delivered into the mixer.

Plate 3.9 Steam kettle

Plate 3.10 Homogenizer

3.2.8 Mixer:-

The mixer (Plate3.11) placed downstream through the homogeniser consists of cylindrical SS container fitted with a motorised stirrer. Its make is SSP(PVT) Limited, Faridabad.In the mixer the entire batch of tomato product is collected and all the necessary ingredients like taste makers, colour, salt, preservatives, thickener, emulsifier etc are added and the mixer stirred continuously until uniform belt of mixture was obtained. The sampling of quality tomato product was taken from the mixer for a given batch. There after a discharge valve is left open for filling the tomato product into the bottles.

Plate 3.11 Mixing Tank

3.2.9.1 Materials required:

INGREDIENTS

- Tomato pulp - 100kg
- Sugar - 12kg
- Salt - 2kg
- Onion powder - 50g
- Garlic powder - 10g
- Spice blend - 40ml
- Starch powder - 100g
- Preservative (Sodium benzoate) - 60g

3.2.9 Bottling machine:-

The bottling machine (Plate3.12) is a vacuum driven bottle filling unit. It is placed downstream to the mixer. Once the discharge valve of the mixer is left open the tomato product was ready to move into the bottles under vacuum created inside the air tank by pressing the plunger top by the bottle, through the length of bottle and fitting the bottle neck to the rubberised seat of discharge outlet of the bottling machine.

Due to vacuum, tomato product measuring 1liter in volume was drawn from the mixer and delivered into the bottle. Once the delivery is complete the bottle was taken out and crown cork was fitted to the bottle to seal the product. The bottling machine consists of two such bottle filling heads to ensure the speedy operation. After crown corking the bottles was placed in chilled water for cooling. After cooling the labels consisting batch number and date of manufacture was pasted on the bottle.

Plate3.12 Bottling Machine

3.2.10 Corking machine: -

The indexing rotary bottle carrousel (Star Wheel) carries bottle once they was loaded manually on it.

Plate3.13 Corking Machine

3.10.11 Labelling and shipping:-

Plate 3.14 Labelling and Shipping

Plate 3.15 Control Panel **Plate 3.16 Cold Storage Room**

3.5.12 Boiler: -

The boiler is used for producing steam used for concentration of tomatoe pulp by supplying steam to kettle at 5kg/cm². It is a maker of Ross boiler, pune and model is RSB 100/337.

Plate 3.17 Boiler

3.3 Equipments and instruments used

3.3.1 Mixer

Plate 3.18 Mixer

Is used to make the ingredients into powder form the mixer is manufactured by Usha Lexus, Company .

3.3.2 Digital Refractometer

Plate 3.19 Digital refractometer

Methodology:

Digital refractometer (Plate 3.19) was held horizontally and pointed towards a light source and it was set to zero Brix. The temperature of sample was measured as it should not be more than 30°C. The reading of the sample was taken. The refractometer was calibrated by placing several drops of sample for accurate reading. After the completion, it was cleaned carefully with a muslin cloth. The temperature correction was added or subtracted from the temperature correction chart. It is manufactured by ATAGO.

3.3.3 Caret: -

The caret is used for transporting and storing of tomatoes from market to plant safely. It was made of light weight and high strength and available in number of specifications. The dimensions of caret are as follows:-

542mm X 360mm X 300 mm.
Capacity: 44 Liters

3.3.4 Weighing scale: -

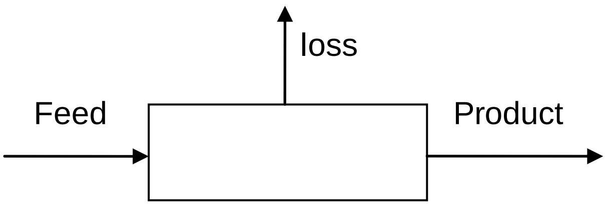
The weighing scale is used for weighing the tomatoes, tomato juice , tomato concentrate at various stages and it is a maker of M/S Unitech Enterprises, Jabalpur.

Plate 3.21 Weighing Scale

3.4 Material Balance

Material Balance is also called as mass balance is an application conservation of mass to the analysis of physical systems. By accounting for material entering and leaving a system. Material balance can be based on total mass, mass of dry solids, or mass of particular components. Material and energy balances have applications in mixing, mechanical separations, drying, evaporation etc. Material balance are very important in the food industry because the objective of any industry is to maximize product yields and minimize costs.

MASS IN = MASS STORED+ MASS OUT



3.5 Production Economics:

3.5.1 Break – Even Analysis:

The cost analysis was made using break even analysis technique. Break even analysis(Fig 3.3) is also known as *profit contribution analysis* which is an important analytical technique used to study the relationship between the total costs, total revenue and total profits and losses over the whole range of stipulated output. It integrates the cost and revenue estimates to ascertain the profits and losses associated with different levels of output. The break-even analysis provides a relationship between revenues and costs with respect to volume (quantity) of sales. It represents the level of sales at which costs and revenues are in equilibrium; the equilibrium point being known as the break-even point (BEP). At the break even point, total revenue is equal to the total cost; it is a no-loss point. This analysis assumes that the total costs can be separated into fixed costs and variables costs.

The formula Approach:

The break even can be computed in terms of units or in terms of money values of sales volume or as percentage of estimated capacity.

In units:

For a single product firm, the break-even point in terms of units will be reached when the total earned revenue becomes equal to the total costs. If "**S**" denotes the unit selling price , "**V**" the unit variable cost, "**F**" the fixed cost and "$\mathbf{Q_B}$" the break-even point (units), then

Total revenue = $Q_B \times S$, ...Eq 3.1

and

Total costs = $F + Q_B \times V$... Eq 3.2

Therefore, the break-even point, $Q_B \times S = F + Q_B \times V$....................Eq 3.3

(Or)

$$Q_B = \frac{F}{S-V}$$

$$\text{Break even points (units)} = \frac{\text{Fixed costs}}{\text{Selling price per unit- Variable cost per unit}}$$

In money value:

The break even point for a single product firm can also be expressed in terms of rupee value of sales volume. If both sides of equation below are multiplied by the unit selling price, we get the break even point in terms of rupees. Thus

$$R_B = Q_B X S = \frac{F}{S-V} X\ S$$

$$\text{Break-even point (in rupees)} = \frac{\text{Fixed costs}}{\text{Selling price per unit- Variable cost per unit}} \text{ X Selling price per unit}$$

Eq……………….3.5

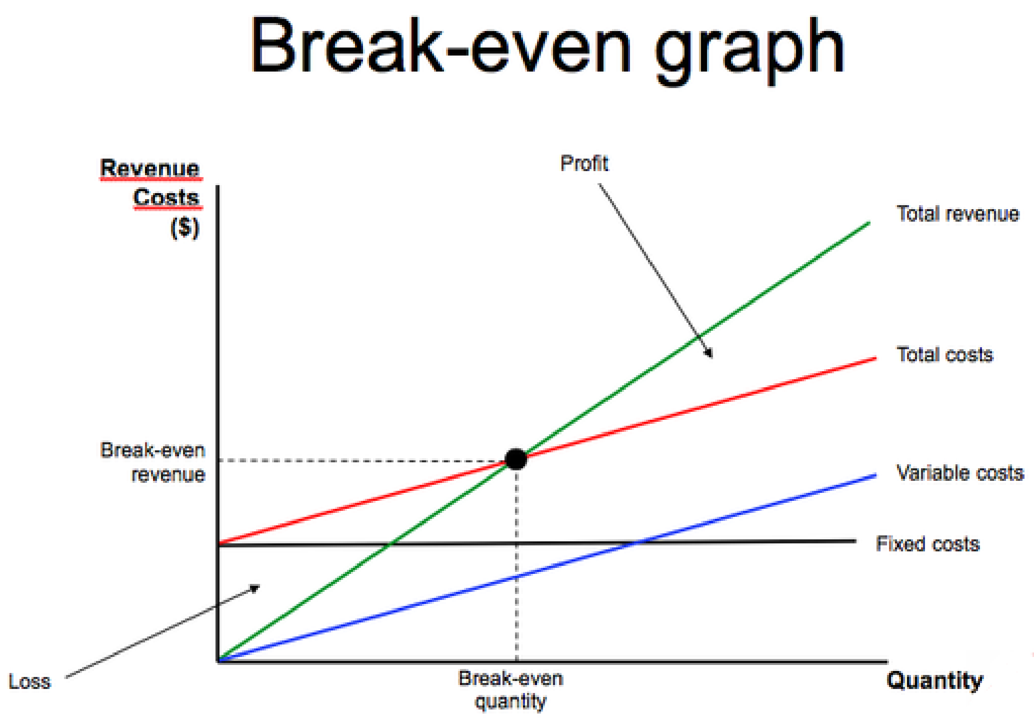


Fig 3.3 Break Even Graph

3.5.2 Benefit Cost Analysis

Benefit cost analysis is done by considering a factor called benefit cost ratio, it should be greater than 1 to ensure profitability of the unit. Benefit cost ratio is expressed as follows:

Benefit Cost Ratio = $\frac{\text{Present worth of Benefits}}{\text{Present worth of costs}}$ ....Eq 3.6

Present worth of benefits B =$\sum_{1}^{n} \frac{B_n}{(1+i)^n}$, and ....Eq 3.7

Present worth of costs C = $\sum_{1}^{n} \frac{C_n}{(1+i)^n}$ ....Eq 3.8

Therefore:

Benefit Cost Ratio = $\frac{B}{C}$ = $\frac{\sum_{1}^{n} \frac{B_n}{(1+i)^n},}{\sum_{1}^{n} \frac{C_n}{(1+i)^n}}$ ....Eq 3.9

Discounting factor = $\frac{1}{(1+i)^n}$ ....Eq 3.10

n = time period, and; i = rate of interest

Discounted cost = total cost x discount factor

Discounted benefits = annual benefits x discount factor

RESULTS AND DISCUSSIONS

This chapter covers the results obtained from data collected with reference to the objectives stated earlier. Discussions on various aspects will be made covering analysis of material balance, each component wise and over all plant wise also. This discussion also includes the analysis of economics of profitability, production, turn over, break even quantity, break even Period with respect to capacity, fixed cost, variable cost and analysis of benefit cost ratio (B/c). The results are interpreted with the help of flow charts and tables.

Location of the unit:-

The pilot plant is located in Maharajpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. It has good transport facility interconnected with road and rail.

Capacity Proposed:-

The plant is proposed to have a processing capacity of 50 kg/hr of tomato concentrate.

Technical study:

4.1 Material Balance:

Material Balance also called as mass balance is an application of law of conservation of mass to the analysis of physical systems. By accounting for material entering and leaving a system. Fig 4.1 shows a diagram of mass flow of the process for tomato processing used for preparation of tomato sauce. It clearly presents all unit operations, the increase of TSS by these operations and the mass flow of the process stream through the production stages, starting from the raw material feeding, waste products and intermediate materials to final products.

Equipment/unit wise mass flow rate was determined by weighing losses and making mass balance.

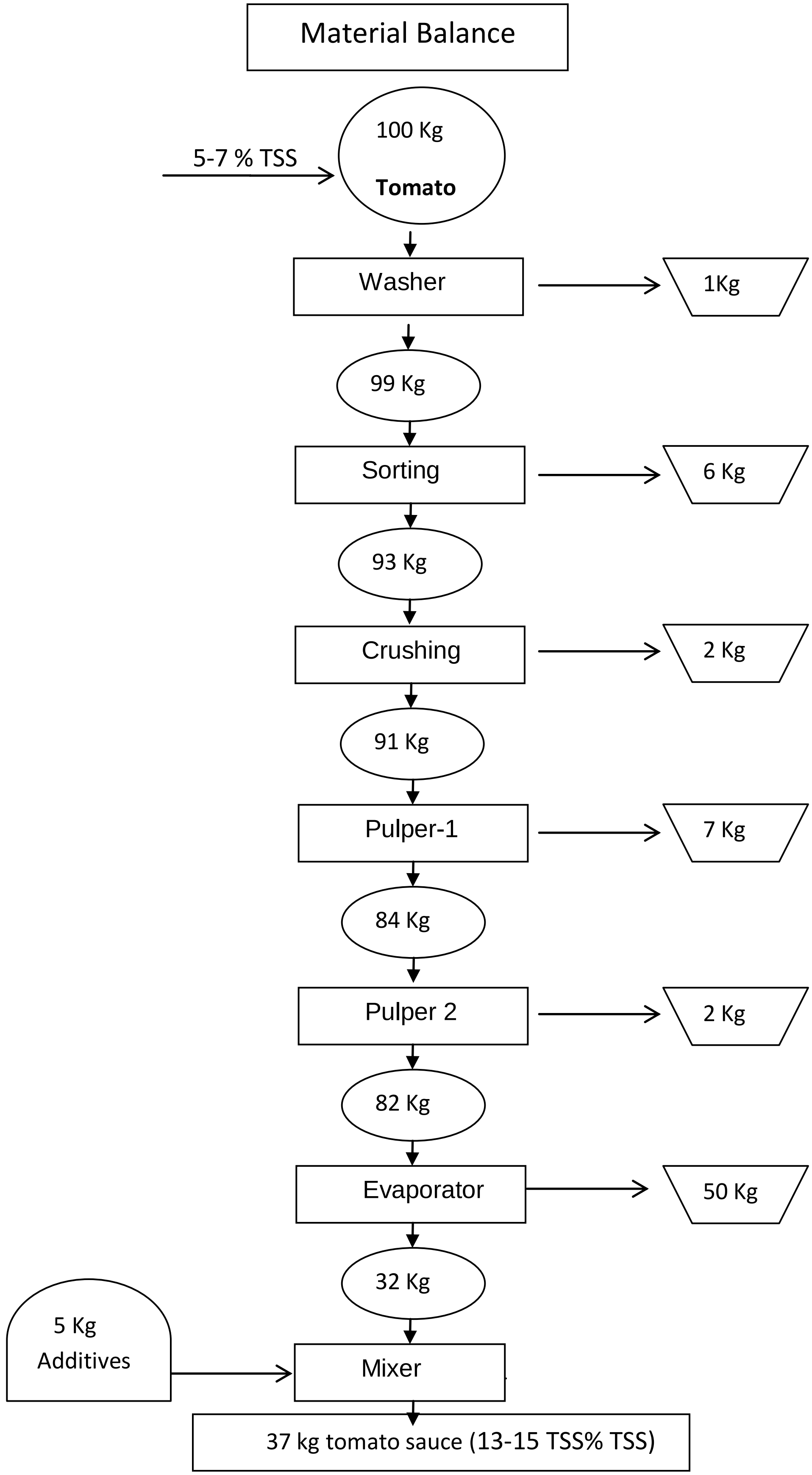


Fig. 4.1 Flow chart showing material movement in tomato sauce production process

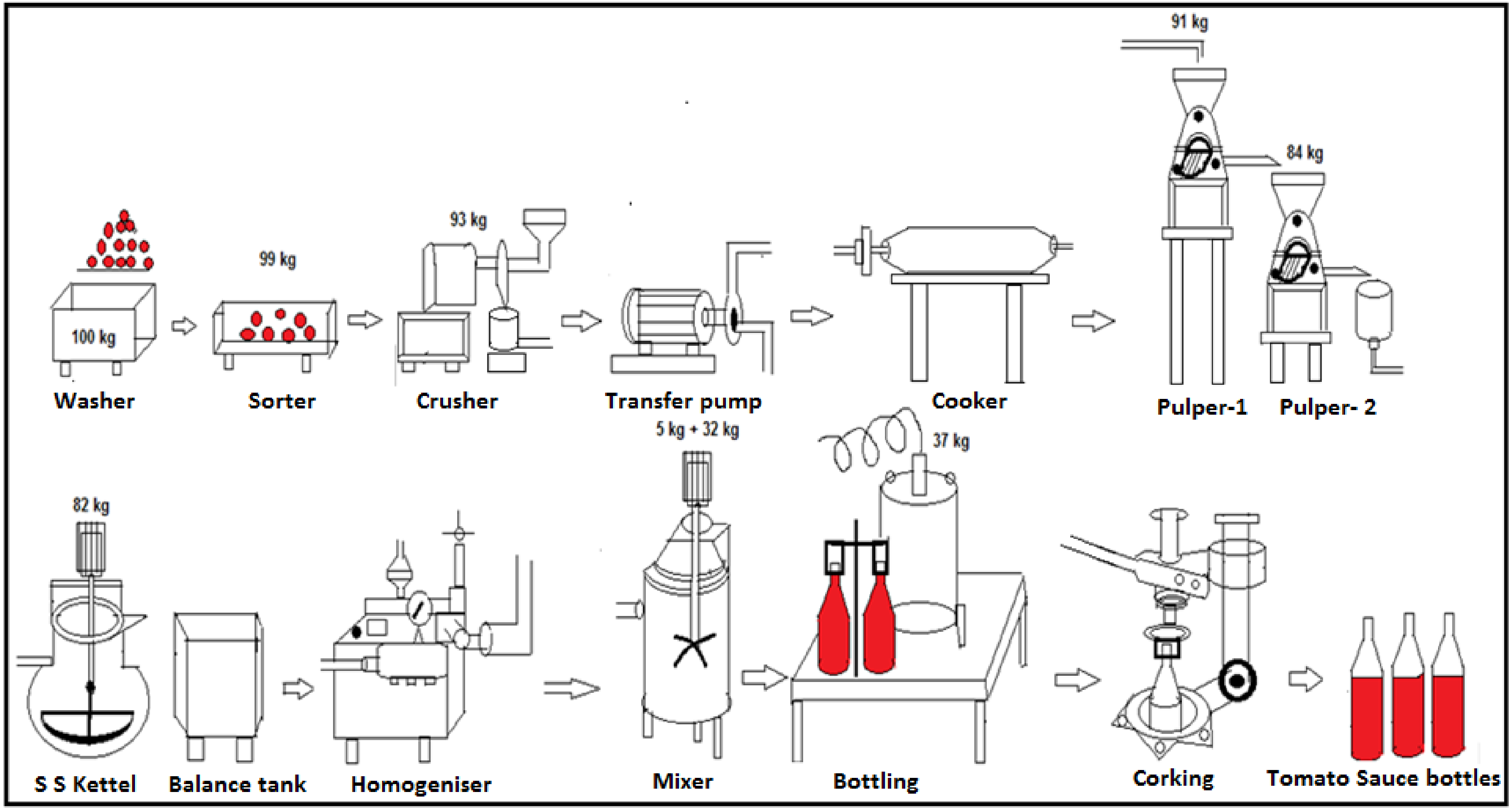


Fig 4.2 Line diagram showing tomato sauce production

4.1.1 Over all mass balance of tomato processing process:

(Raw tomato) Input = Rejection – Output (sauce)

Feed = Wastage - Product

F = V - P ……………………………………….4.1

(OR)

Wastage = Feed + output

Over all mass balance of process:

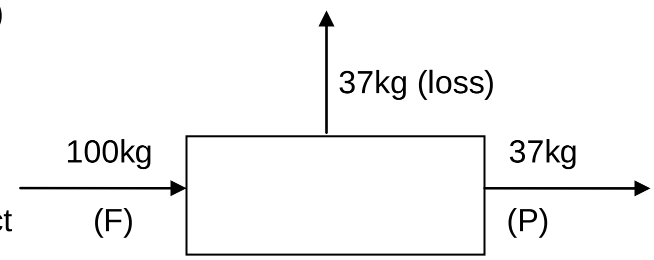
Input (or) feed = 100 kg (Tomato)

Output (or) product = 37 kg (sauce)

Rejection (or) loss = 63 kg

F = V+ P

Loss = Feed – Product



V = F - P …………………………………….4.2

= 100-37

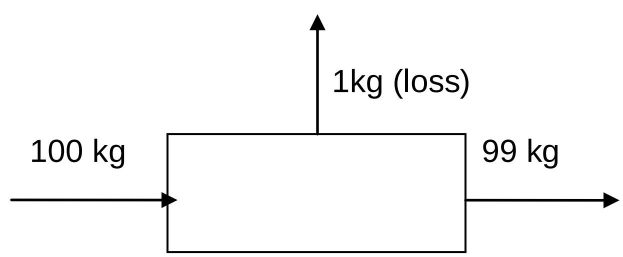
= 63 kg Loss

4.1.2 Component wise material balance:

(I) **Material balance of washer**:

F = V+ P

Loss = Feed – Product



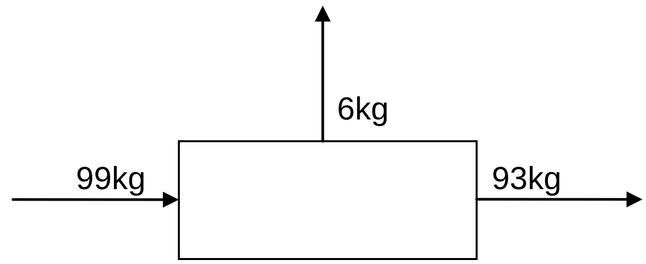
V = F (tomato) - P (tomato) …..…………………..4.3

= 100 - 99

= 1 kg Loss

Washer was used for washing the tomatoes. In washer if we feed 100kg of tomato 99kg of tomato was obtained as output and there is a loss of 1kg.

(ii) **Material balance of sorter**:



F = V+ P

Loss = Feed – Product

V = F (tomato) - P (tomato) ……………………………..4.4

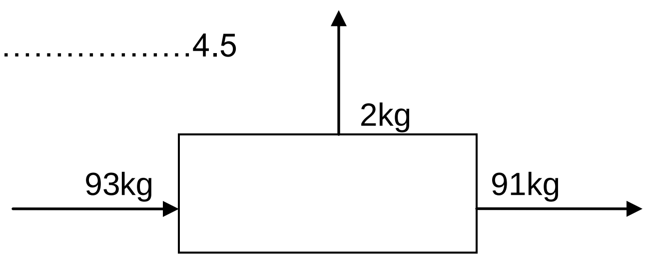
= 99 - 93

= 6 kg Loss

On sorting table, sorting is done to remove foreign matter, in this operation if feed 99 kg of tomato as input 93 kg tomato was obtained as output and 6 kg is lost as impurities.

(iii) **Material balance of crushing**:

V = F (tomato) – P (tomato pulp) ……………………4.5



Loss = Feed – Product

= 93-91

= 2 kg Loss

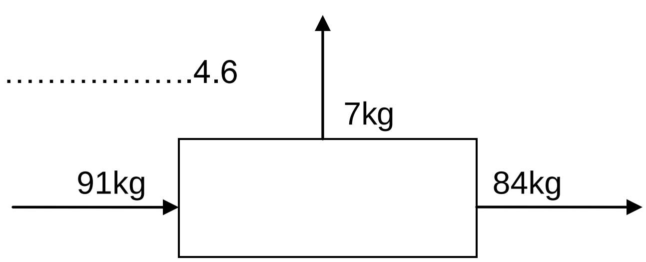
In crusher, crushing of tomatoes is done, in crusher on feeding of 93kg of tomatoes as input 91kg of tomato pulp was obtained as output, remaining 2kg as spill loss.

(iv) **Material balance of cooker**:

Here no loss of feed material was observed and the product recovery is 100% for this component.

(v) **Material balance of pulper-1**:

V = F (coarse pulp) – P (thick juice) ………………….4.6



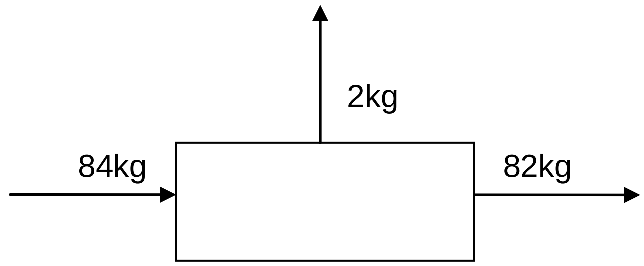
Loss = Feed – Product

= 91- 84

= 7 kg Loss

In Pulper -1 coarse particle was used to remove. In pulper on feeding the weighted 91kg coarse pulp 84kg thick juice was obtained as output leaving 7kg as rejected material.

(vi) **Material balance of pulper -2**:



Loss = Feed – Product 4.7

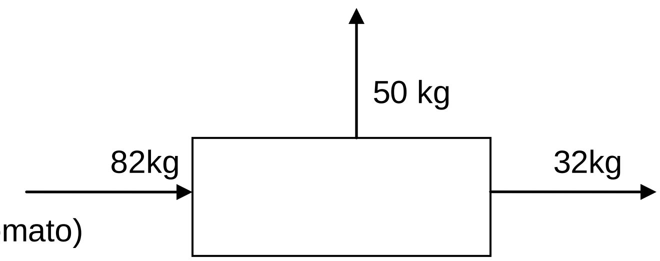
V = F (thick juice) – P (thinner juice)

= 84 - 82

= 2 kg Loss

In pulper -2 coarse particles is removed. On feeding 84 kg thicker juice into pulper-2 82kg thinner juice was obtained as output product leaving 2kg as rejected material of fine particles.

(vii) **Material balance of evaporator**:



Loss = Feed – Product ……………4.8

V = F (thinner juice) - P (concentrated tomato)

= 82-32

= 50 kg Loss

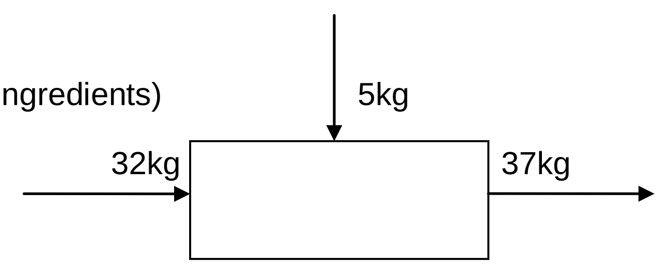
On weighing and feeding the obtained 82kg output of pulper-2 into evaporator 32kg of concentrated tomato was obtained as output leaving 50kg wastage as water.

(viii) **Material balance of mixer**:

Mixer = Output + Input …………4.9

= 32kg (concentrated tomato) + 5kg (Ingredients)

= 37 Kg



Total output = 37 Kg of tomato sauce.

The mixer was used to mix all the ingredients like salt, sugar, preservative etc. which is a weighted quantity of about 5kg id added to the obtained output product of evaporator which was of about 32kg. Here no loss will occur; here 100% efficiency was achieved.

By adding above all the equations 4.3, 4.4, 4.5, 4.6, 4.7 and 4.8

we get the total mass lost/reduced during process is,

= 1+6+2+7+2+50 kg

= 68 kg

Therefore, total reduction in mass of 100kg feed i.e., tomato = 68 kg

Input (tomato) = 100 kg

Output (tomato sauce) = 32 +5

= 37 kg

Input = loss+ output **loss = input – output ………4.10**

(105) 100+5 = 68 + 37 **(OR)** 68 = 105 - 37

105 = 105 kg **68 = 68 kg**

4.1.3 Material balance according to TSS:

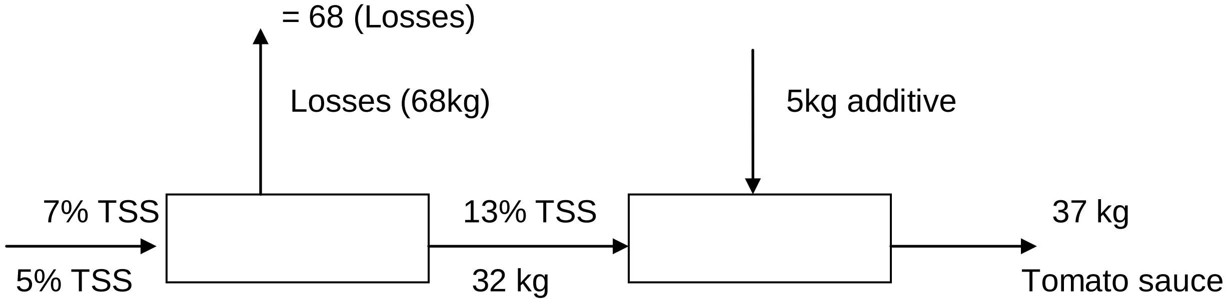
1. Considering tomato concentrate was brought from 7% TSS to 13 TSS%.
2. 100kg tomato was used in process.
3. 68kg of material was obtained as rejected
4. The product (tomato sauce) yield obtained from 100 kg of raw tomato at final stage =

Let consider 32kg tomato concentrate is obtained from evaporator

then losses = 100-100 x 0.32

= 100 – 32

= 68 (Losses)



NOW, $P = \frac{5}{13} x\ 82$

= 32 kg (Tomato concentrate) + 5kg (additives) = **37 kg Tomato sauce**

4.1.4 Mass Balance Analysis:

On feeding of 100kg raw tomato into the washer of tomato processing unit 99kg of tomato was obtained with a loss of 1kg. After that 99kg of tomato obtained was fed on to the sorting table during this sorting process a loss of 6 kg was obtained due to removal of damaged, unripe, over ripe tomatoes. Then the obtained output from crusher is 93kg which was fed into crusher.

After sorting, fully ripe red and soft tomatoes are fed into crusher. During crushing 2 kg of feed was lost due to splash loss and the obtained tomato pulp was 91kg which is fed into cooker. Here no loss of feed material was occurred so, 100% efficiency was achieved in this system. The obtained 91kg of feed material fed into pulper-1, Here a large amount of waste was rejected which is about 7kg because in the first stage (coarse pulper) a large amount of coarse pulp was rejected as waste and the obtained out from pulper-1 was 84kg.

The juice of tomato which was coming out of pulper-1 was fed into pulper-2 (coarse pulper) weighing of 84kg. In the fine pulper an amount of 2kg was rejected as waste due to removal of fine particles of tomato juice. After this operation a thinner juice was received from fine pulper which was about 82kg was collected in a balance tank and then passed into evaporator to bring it to a concentration of 13-15% TSS. In the above evaporator a large amount of water was evaporated which was loss of about 50kg. This operation was performed until the required consistency was obtained. After obtaining the required consistency finally the obtained output was about 32kg of tomato concentrate. After obtained the required TSS the concentrate is passed into mixer. Here an amount of about 5kg ingredients like salt, sugar, preservatives etc are added. Here also no losses were occurd and finally the obtained output was about 37 kg tomato sauce. Then after mixing finally filling and bottling was done.

4.2 Production Economic Analysis.

Basis and Assumptions:

1. It is proposed the total working days of plant per year = 300 Days
2. Number of working hours per day = 8
3. Total production for 8 hours = 400 kg
4. Total quantity processed throughout the year = 1, 20,000 kg
5. If 1kg of tomato sauce is sold @ Rs.80/- then cost of 1,20,000 kg = 96,00,000/-
6. Labor charges have been taken as per market rates.
7. Different products like tomato juice, tomato sauce, and tomato ketchup are produced from tomato pulp.
8. The rate of interest has been taken 10% on an average both for fixed and working capital.
9. The rates quoted in respect of machinery/equipment, raw material are those prevailing at the time of preparation of report and are likely to vary from place to place and supplier to supplier and changes can be made depending on requirement of user.

4.2.1 A) Financial Aspects – Fixed Capital

Table 4.2.1 Land and Building:

The unit is located in the marble city of Jabalpur where the transport facilities already exists and there is continues supply of water and electricity.

The required plot area for the project is 36x12 Sq. ft and it can be purchased on the appropriate site.

The investment on land @500 Sq. ft	= 2, 16,000/-
The investment on building @ 2500 Sq. ft	= 10, 80,000/-
Total	= 1296000/-

Table 4.2.2. Machinery:

S.no	Item	Specifications	No of units	Unit price	Total in Rupees
1	Tomato processing unit (including boiler)	50kg/hr	1	20,00,00	28,00,00
2	Cold room	10X5 Sq ft	1	11,00,000	11,00,000
3	Weighbridge	1. Quintal(cap) L.C= 10g	1	80,000	80,000
		2.10 kg(cap) L.C= 0.01g	2	10,000	20,000
4	Carets and Kitchen Utensils	510mmX 327mmX 280mm	2	10,000	10,000
5	Crown corking machine	2000 bottles/day	1	25,000	25,000
		Total			**32,35,000/-**

Table 4.2.3. Pre Operative Expenses:	**Total in Rupees**
Registration and documentation	50,000/-
Travelling	10,000/-
Enquiry and consultancy	20,000/-
Others	20,000/-
Total	**1, 00,000/-**

Table 4.2.4 Office Furniture:

S. No	Item	No of units	Unit price	Total in Rupees
1	Tables	02	2000	4000/-
2	Chairs	06	500	3000/-
3	Almirah	01	3000	3000/-
4	Fan	02	2500	5000/-
		Total		**15,000/-**

Total fixed cost = 4.2.1+ 4.2.2+ 4.2.3 + 4.2.4

= Rs. 46, 46,000/-

4.2.1 B) Working Capital (per month)

Table 4.2.5 Raw Material:

S.No	Material	Quantity	Amount in Rs
1	Tomato	100 kg @6/-	600/-
2	Cardamom	20g	44/-
3	Cloves	20g	30/-
4	Onion	2kg	30/-
5	Cumin seeds	20g	10/-
6	Black pepper	10g	20/-
7	Salt	1 kg	10/-
8	Sugar	15kg	525/-
9	Chili powder	25g	10/-
10	Garlic& Ginger	500g	20/-
11	Cinnamon	20g	10/-
12	Acetic acid	50ml	5/-
13	Sodium Benzoate	20g	5/-
14	Thickening agent	20g	10/-
15	Bottles+cap+Labelling	34 No @10/-	340/-
16	Gas/Diesel	30 lit @ 50/-	1500/-
		Total	**3179/-**

Monthly working capital of raw material $=3179 \text{ X } \frac{400}{100} \; X \; 25$

= Rs. 3, 17,900 /-

Table 4.2.6 Electricity: Charges @ 6/- per unit

S.No	Machinery	Hp	Units/hr	Units/day	Units/month	Cost/Month
1	Tomato processing unit	5	10	80	2000	12,000/-
2	Boiler					6000/-
3	Cold storage					12,000/-
4	Water pump					150/-
5	Fans and Lights					75/-
				Total		**30,225/-**

Table 4.2.7 Staff and Labor Requirement:

S.No	Staff	No of Positions	Salary/Month
1	Plant Operator	1	8000/-
2	Helper	2	3000/-
		Total	**11,000/-**

Table 4.2.8 Other Expenses:

S.No	Others	Rupees
1	Stationary	5000/-
2	Travelling	5000/-
3	Repair and Maintenance	6000/-
4	Other Miscellaneous	4000/-
	Total	**20,000/-**

Then working capital per month = 4.2.5+ 4.2.6 + 4.2.7 + 4.2.8

= 3, 17,900 + 30,225 + 11,000 + 20,000

= Rs. 3, 79,125/-

Therefore then working capital per year = 3, 79,125 x 12

= 45, 49,500 /-

4.2 2 Depreciation cost of machinery @ 10% =

$$\textbf{D.C} = \frac{M-\frac{M}{10}}{10}$$

$$= \frac{3235000 - 323500}{10}$$

$$= \frac{2911500}{10}$$

=Rs. 2, 91, 150/-

4.2.3 Depreciation cost of Building @5% = **Rs. 54,000/-**

4.2.4 Interest on total investment = 10% of F.C per year + 10% of W.C per year

= 464600 + 454950

= Rs. 9, 19,550 /-

4.2.5 Cost of production

3.4.1. Total working capital per year	= Rs. 45, 49,500/-
3.4.2. Depreciation on Building @ 5% per year	= Rs. 54000/-
3.4.3. Depreciation on Machinery @ 10% per year	= Rs. 2, 91,150/-
3.4.4 Depreciation on Furniture @ 20% per year	= Rs. 3000/-
3.4.5 Interest on total investment @ 10% per year	= Rs. 9, 19,550/-
Total	**= Rs. 58, 17,200/-**

4.2.6 Turn over sale (per year):

Tomato Sauce = 1, 20,000 kg @ 80/- = 96, 00,000/-

4.2.7 Net Profit = Sales Cost – Production Cost

= 96, 00,000- 58, 17,200

= 37, 72,000 /-

4.2.8 Net profit ratio $= \frac{Net\ profit \times 100}{turn\ over\ per\ year}$ ……………..Eq 4.2.1

Or

Profit on sell **=** $\frac{3772000 \times 100}{9600000}$

= **39.2%**

4.2.9 Total Capital investment:

4.2.9. a) Fixed capital = 46, 46,000/-

4.2.9. b) Working Capital (per month) = 3, 79,125/-

Total **= 50, 25,125/-**

4.2.10 Rate of return **=** $\frac{Net\ profit \times 100}{Total\ investment}$ ……………..Eq 4.2.2

$= \frac{3772000 \times 100}{5025125}$

= 75.06%

4.3 Break even analysis:

4.3.1 a) Fixed costs = Rs. 4646000

Selling Price of the unit = Rs. 80/-

Total no of units produced per year = 120,000 Kg

4.3.1 b) Variable costs: Rs. 5817200/-

4.3.2 Break even quantity = $\frac{Fixed\ cost}{selling\ price\ \frac{Varible\ cost}{No\ of\ units}}$ ….Eq 4.2.3

$= \frac{4646000}{80 - \frac{5817200}{1,20,000}}$

$= \frac{4646000}{31.5}$

= 147492.06 kg

4.3.3 Break even sales **=** 147492.06 x 80

= Rs. 11799364.8/-

4.3.4 Breakeven percentage = $\frac{\text{FC}}{\text{TR} - \text{VC}}$

$$= \frac{4646000}{9600000 - 5817200}$$

= 1.22 %

4.3.5 Breakeven period:

$$= \frac{\text{Break even volume}}{\text{Total number of units produced per day.}}$$

$$= \frac{147492.06}{400}$$

= 368.7 Days

$$= \frac{368.7}{365}$$

= 1.01 Years

Table 4.3 The result of cost analysis is tabulated as follows:

S.No.	Item	Values Rupees
1.	Fixed Cost	Rs. 4646000 =00
2.	Variable Cost	Rs. 5817200=00
3.	Variable cost per pack of 1000 g	Rs. 48.4
4.	Break even quantity p.m.	12291.0 kg of 1000g each
5.	Break even sales p.m.	Rs. 11799364.8=00
6.	Break even period	1.01 Years

Therefore, from the break even analysis it was found that in order to produce 1, 20,000 units of 1000 g bottle of tomato sauce with identified infrastructure the break even quantity is 147492.06 kg, the break even sales is Rs. 11799364.8 and break even period comes out to be 1.01 Years **.**

4.4 Benefit Cost Ratio

Benefit cost analysis is done by considering a factor called benefit cost ratio, it should be greater than 1 to ensure profitability of the unit. Benefit cost ratio is expressed as follows:

Benefit Cost Ratio = $\frac{\text{Present worth of Benefits}}{\text{Present worth of costs}}$

Present worth of benefits B =$\sum_1^n \frac{B_n}{(1+i)^n}$, and;

Present worth of costs C = $\sum_1^n \frac{C_n}{(1+i)^n}$

Therefore:

Benefit Cost Ratio = $\frac{B}{C} = \frac{\sum_1^n \frac{B_n}{(1+i)^n},}{\sum_1^n \frac{C_n}{(1+i)^n}}$

Discounting factor = $\frac{1}{(1+i)^n}$

n = time period, and; i = rate of interest

4.4.1 (A) Fixed costs

Fixed cost = Rs. 4646000/-

Depreciation cost of machinery =

$$D.C = \frac{M - \frac{M}{10}}{10}$$

$$= \frac{3235000 - 323500}{10}$$

$$= \frac{2911500}{10}$$

=Rs. 2, 91, 150/-

Depreciation cost of Building @5% = Rs. 54,000/-

4.4.2 Total depreciation cost = 291150 + 54000

= Rs. 345150/-

4.4.3 Interest on total investment = 10% of F.C per year + 10% of W.C per year

= 464600 + 454950

= Rs. 9, 19,550 /-

4.4.4 F.C in the first year = Total depreciation cost + interest on total investment

= 345150+ 990926

= Rs. 12, 64,700/-

4.4.5 (B) Variable costs: = Rs. 58, 17,200/-

Table 4.4: Calculation of present worth of benefits and present worth of cost

Year (n)	Fixed cost in ₹	Variable cost in ₹	Total Cost in ₹	Annual Benefits ₹	Discount factor	Discounted cost	Discounted Benefits
0	4646000	---	4646000	---	1	4646000	---
1	1264700	5817200	7081900	9600000	0.8927	6322012.1	8569920
2	1264700	5817200	7081900	9600000	0.7972	5645690.6	7653120
3	1264700	5817200	7081900	9600000	0.7118	5040896.4	6833280
4	1264700	5817200	7081900	9600000	0.6355	4500547.4	6100800
5	1264700	5817200	7081900	9600000	0.5674	4018270.0	5447040
Summations:						3017346.5	34604000

Then, Discounted cost = total cost x discount factor

Discounted benefits = annual benefits x discount factor

Therefore;

$$\text{Benefit Cost Ratio} = \frac{34604000}{3017346.5}$$

$$= 1.14$$

$$\text{Rate of return} = \frac{\text{B}}{\text{C}} \times 100$$

$$= \frac{34604000}{3017346.5} \times 100$$

$$= 114.6\%$$

Therefore, every one rupee invested is expected to earn 1.14 rupees.

4.5 Variation of break even quantity with respect to Fixed cost, Variable cost and capacity.

From the above it is clear that the proposed capacity of the plant is 50 kg/hr and the number of working hours is 8hrs per day with production capacity of the plant of 400 kg/day. Mean while if the plant is worked for 25 days in a month, the production quantity will be 10,000 kg/ month and 1, 20,000 kg/year. If each unit of 1 kg tomato sauce is sold at a price of Rs.80/- then the total sales is Rs. 96, 00,000/- per year. After reducting production cost of Rs. 58,17, 200/- from sales of Rs. 96,00,000/- the net profit obtained at the end of the year is Rs. 37,72,000/-

Details of different cost parameters and Break even parameters are shown in table 4.1 from the break even analysis it was found that in order to produce 1, 20,000 units of 1000 g bottle of Tomato ketchup with identified infrastructure the break even quantity is 147492.06 kg, the break even sales is Rs. 11799364.8=00 and break even period comes out to be 1.01 Years**.** The ratio between the capacity (50kg/ hr) and break even quantity (147492.06 Kg) of plant is 1: 2949. Indicating break even quantity is not the function of only capacity but also F.C, V.C and average return. The table further revels that the quantity processed is 1, 20,000 kg and tomato processing plant will be profit after one year or after 368 days

4.6 Benefit cost ratio (B/C) with respect to Fixed cost, Variable cost and Annual benefits.

The benefit cost ratio is presented in the table 4.2. It can be observed that from benefit cost ratio (B/C) (Or) rate of return, means that on every one rupee invested in the process of tomato sauce production is expected to earn 1.14 rupees.

SUMMARY AND CONCLUSIONS

Tomato (*Solanum lycopersicon*) is an important commercial vegetable crop. It is very popular vegetable throughout the country and it is grown in many states. Apart from use in vegetables, its downstream products like tomato concentrate, soup, sauce, puree, ketchup are very popular and they have a longer shelf life unlike fresh tomatoes. Processed tomato products have wide applications in house hold consumption, food processing industry, snacks food, hotels, restaurants and fast food joints. Tomato products can be grouped into many end-use categories like peeled, concentrated, partially dehydrated, strained and diced tomatoes, tomato juice, pulp, paste, powder, sauce, jam, soups, and ketchup.

As per data of department of commerce, India export of value added tomato products increased from 590 tonnes in the year 2002-03 to 991.46 tones in year 2005-06.India's ketchup consumption is estimated at 13000 tonnes a year and its market is estimated at around INR 1800 million. "Kissan", "Maggi-Nestle" and "Heninz" are three well known brands engaged in manufacturing a range of tomato products in India . Apart from them, Godrej Foods and NAFED are also in manufacturing tomato paste and puree.

The largest portion of this crop is thermally processed and concentrated into tomato paste. The most important quality attributes in processing tomatoes are soluble solids, PH, titrable acidity, viscosity and colour (Saltveit 2005). Tomato fruit composition is approximately 93% water and 7% solids. Approximately half of the total solids are reducing sugars, with slightly more fructose than glucose. The remaining solids consists of acids, amino acids, proteins, lipids, minerals, cellulose and hemicelluloses (Barringer 2004)

Indian tomato processing industry is rising from small scale to large one and it is for sure to compete with the international industries. Hence, in this competitive market it is necessary that processing operations become cost effective. As the material/ energy and money required for processing operation considerably bags a high cost, so it is necessary to optimize the technical and economic feasibility of tomato processing operations. This necessitates study production economics and it also carries out as a good guide for planners, financial agencies and small rural entrepreneurs who wish to establish “tomato processing” plant as a commercial viable industry.

This study is carried out to develop the material balance and to characterize the wastage of material in tomato processing pilot plant located in the experiential learning centre of JNKVV. The specific objectives of the study were to study the material balance of tomato sauce production process, and to study production economics of tomato sauce production process.

The tomato processing plant was established in the year 2007 is one of the smallest, ultra modern, fully automated tomato processing unit. The products produced from tomato processing are tomato sauce, tomato ketchup, tomato juice. etc. The unit has capacity of processing of 50 kg/ hr of tomato sauce.

Material balance of the plant revealed that on feeding of 100 kg raw tomato into the washer of tomato processing unit 99Kg of tomato is obtained with a loss of 1 kg. After that 99 kg of tomato obtained is fed on to the sorting table during this sorting process a loss of 6 kg is obtained due to removal of damaged, unripe, over ripe tomatoes. Then the obtained output from crusher is 93 kg which is fed into crusher.

After sorting, fully ripe red and soft tomatoes are fed into crusher. During crushing 2 kg of feed is lost due to splash loss and the obtained tomato pulp is 91 kg which is fed into cooker. Here no loss of feed material is occurred so, 100% efficiency is achieved in this system. The obtained 91 kg of feed material fed into pulper-1, Here a large amount of waste is rejected which is about 7 kg because in the first stage (coarse pulper) a large amount of coarse pulp is rejected as waste and the obtained out from pulper-1 is 84 kg.

The juice of tomato which is coming out of pulper-1 is fed into pulper-2 (coarse pulper) which as a weight of 84 kg. In the fine pulper an amount of 2 kg is rejected as waste due to removal of fine particles of tomato juice. After this operation commonly a thinner juice is received from fine pulper which is about 82 kg is collected in a balance tank and then passed into a SS Kettle (or) evaporator to bring it to a concentration of 13-15% TSS.

In the above evaporator a large amount of water is evaporated which is a loss of about 50 kg. This operation is performed until the required consistency is obtained. After obtaining the required consistency finally the obtained output is about 32 kg of tomato concentrate. After obtaining the required TSS the concentrate is passed into mixer here an amount of about 5kg ingredients like salt, sugar, preservatives etc. are added. Here also no losses will occur and finally the obtained output is 32 kg + 5kg (ingredients) of about 37 kg tomato sauce. Then after mixing operation finally filling and bottling operation is done.

The economic analysis of plant was conducted based on following pre determined operational parameters:-

1. It is proposed the total working days of plant per year = 300 Days
2. Number of working hours per day = 8
3. Total production for 8 hours = 400 kg
4. Total quantity processed throughout the year = 1, 20,000 kg
5. If 1kg of tomato sauce is sold @ Rs.80/- then cost of 1,20,000 kg = 96,00,000/-
6. Labor charges are have been taken as per market rates.
7. Different products like tomato juice, tomato soup, and tomato ketchup are produced from tomato pulp.
8. The rate of interest has been taken 10% on an average both for fixed and working capital.
9. The rates quoted in respect of machinery/equipment, raw material are those prevailing at the time of preparation of report and are likely to vary from place to place and supplier to supplier.
10. Depreciation of Building @ 5% per year.
11. Depreciation of Machinery @ 10% per year.
12. Depreciation on Furniture @ 20% per year.
13. Interest on total investment @ 10% per year.

Break even analysis of tomato processing plant revealed that in order to produce 1,20,000 units of 1kg bottle of tomato sauce with identified infrastructure the break even quantity is 147492.06 kg, the break even sales is Rs. 11799364.8=00 and break even period comes out to be 1.01 Years**.** Also from benefit cost analysis it was found that every one rupee invested in the process of tomato sauce production is expected to earn 1.14 rupees i.e. a profit of about 14 percent.

SUGGESTIONS FOR FUTURE WORK

Following points may be considered for conducting any other similar studies in feature:

1. Varietal effect of tomato on product recovery.
2. Time and motion study of pilot plant operations.
3. Effect of ergonomics on productivity of plant.
4. Market linkage study for disposal of tomato products.
5. Organoleptic evaluation and consumer feedback of tomato products.
6. A studies on local seasonal fluctuation in price of raw material and demand of tomato product may provide a successful inventory control model for tomato products.

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Appendix- A

1. **Indian Standard- specification for tomato ketchup**

This standard was adopted by the Indian standards institution on 2nd December 1966, after the draft finalized by the fruits and vegetables sectional committee had approved by the agricultural and food products division council.

There is usually a gult of tomatoes, when they are in season. Therefore considerable scope exists for further development of processed tomato products which are in good demand as tomatoes are a rich source of vitamins.

Tomato ketchup also known as “catsup” or “catchup” occupies an important place among processed tomato products. In view of the popular demand for this product, there is scope for its sophistication by substitution by cheaper raw materials, a practice which would be discouraged. Therefore, in order to ensure the quality of the product and also to built up an increasing demand for it, it is necessary to have strict quality control based on specifications.

In the preparation of this standard, due consideration has been given to the Prevention of Food Adulteration Act, 1964. This standard prescribes the requirements and the methods of test for tomato ketchup.

2. **Terminology**

For this purpose of this standard, the following definitions shall apply.

IS: 3882-1966

2.1 **Tomato juice**- Expressed liquid derived from ripen tomatoes containing a minimum of 5% by weight of total soluble solids. The tomato juice may contain finely divided insoluble solids. Common salt, sugar, dextrose, malic acid, ascorbic acid, citric acid and permitted colors may be added.

2.2 **Tomato ketchup (sauce)**- Preparation from sound and ripe tomatoes with more than 25% by weight of TSS. Common salt, spices, sugar, vinegar, onion, garlic and other permitted additives may be added to tomato ketchup.

2.3 **Tomato puree**- Concentrated tomato juice containing 9- 25% by weight of TSS. The puree may contain common salt, permitted colors and additives.

2.4 **Defects**- presence of seeds, skins, stems, core and other coarse and hard substances.

3. Requirements

3.1 Tomatoes of the following varieties or any other suitable variety may be used for preparing tomato ketchup:

a) Ponderosa
b) Marglobe
c) Sioux
d) Rutgers

3.2 Additives: The only substances that may be added to the tomato ketchup are slt, spices, sugar, vinegar, onion, garlic, permitted colors and other approved additives.

3.3 No preservative other than benzoic acid shall be used in tomato ketchup. The benzoic acid content shall not be exceed 750 ppm when tested according to the method.

Appendix-B

Tomato product details

Tomato Puree : 9- 20 degree Brix
Tomato sauce & ketchup: 12 degree Brix
Tomato paste : 20-30 degree Brix (28 is standard)

Yield of Tomato Products:

1. **Tomato Sauce**
   100 Kg tomato (consisting of 10 kg reject in pulper) at 5 degree Brix is when converted into tomato sauce at 12 degree brix will yield 90 x (5/12) = 37.5 kg sauce.

2. **Tomato Puree**
   100 Kg tomato (consisting of 10 kg reject in pulper) at 5 degree Brix is when converted into tomato puree at 16 degree brix will yield 90 x (5/16) = 28.125 kg puree.
3. **Tomato paste**
   100 Kg tomato (consisting of 10 kg reject in pulper) at 5 degree Brix is when converted into tomato paste at 28 degree brix will yield 90 x (5/28) = 16.1 kg paste.

Specificstion of Equipments

Steam generator

Make : Ross Boiler

Model No : RSB 100/337

Steam OP : 100 kg s/ cm^2

Working PR : 10.5 kg/cm^2

Fuel : L.S.D – 6 kg/hr

Electrical : kw 3PH, 415V, 50 HZ

High pressure Homogenizer

Make : GOMA, Mumbai

Model No : RSB 100/337

Capacity : 50 LPM/LPH

Pressure : 200 kg/cm^2 /Psi

RPM : 200

Transfer Pump

Make : GOMA, Mumbai

Model No : GCP -02

Sr no : 0506070070

Head : 100 mtr

Discharge : 83.3 LPM

Year of mfg : 2007/08

Cold storage

Room size : 23ft x 11ft x 11ft

Room temp required: + 2 to 8^0 c

Product to be stored : fruits and vegetables -15 ton

Incoming product temp : + 38^0c

Ambient temp : +42^0c

Refrigerant : R-22

Compressor type : Hermetic

Power consumption : 1.3 kw

VITAE

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