Research Article

Theoretical Material Balance Analysis of Tomato Products Developed at Tomato processing Pilot Plant

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Abstract

Processed tomato products have wide applications in house hold consumption, food processing industry, snacks food, hotels, restaurants and fast food joints. Lack of technical knowledge on storage, processing and value addition and lack of factories with in the production area to process the surplus tomatoes. Material balance of the plant reveled that that on feeding 100 kg of tomato(5-7% TSS) into tomato processing unit there was a mass reduction of 1 kg, 6 kg, 2 kg, 7 kg, 2 kg, and 50 kg in washer, sorting table, crusher, pulper-1, pulper-2, and evaporator respectively (total 68 kg) during the process. At final stage on adding 5 kg ingredients in mixer finally, the obtained output is 37 kg tomato sauce (13-15% TSS).

Keywords: Processed tomato products, mass balance, yield, input and output

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Introduction

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 [19]. 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 [1and 2].

Material quantities, as they pass through processing operations, can be described by material balances. Such balances are statements on the conservation of mass. If there is no accumulation, what goes into a process must come out [1-5]. This is true for batch operation. It is equally true for continuous operation over any chosen time interval. Material and energy balances are very important in an industry. Material balances are fundamental to the control of processing, particularly in the control of yields of the products [9]. The material balances are determined in the exploratory stages of a new process, improved during pilot plant experiments when the process is being planned, tested, and checked out when the plant is commissioned and then refined and maintained as a control instrument as production continues [12]. When there are any changes occur in the process, the material balances need to be determined again [11, 13].

Material and Methods

The experiment was conducted in a plant which is proposed to have a processing capacity of 50 kg/hr of tomato concentrate. The pilot plant is located in Maharajpur, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. It has good transport facility interconnected with road and rail. The tomatoes for mass balance analysis are procured from local market.

Methodology

Discussions on various aspects will be made covering analysis of material balance each component wise and over all plant wise also. The results are interpreted with the help of flow charts and equations [8, 10, and 15].

Result and Discussions

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. Figure 1 shows a diagram of mass flow of

the process for tomato processing used for preparation of tomato sauce [14]. It clearly presents all unit operations and the mass flow of the process stream through the production stages, starting from the raw material feeding, removal of waste material, addition of intermediate materials to final products [17].

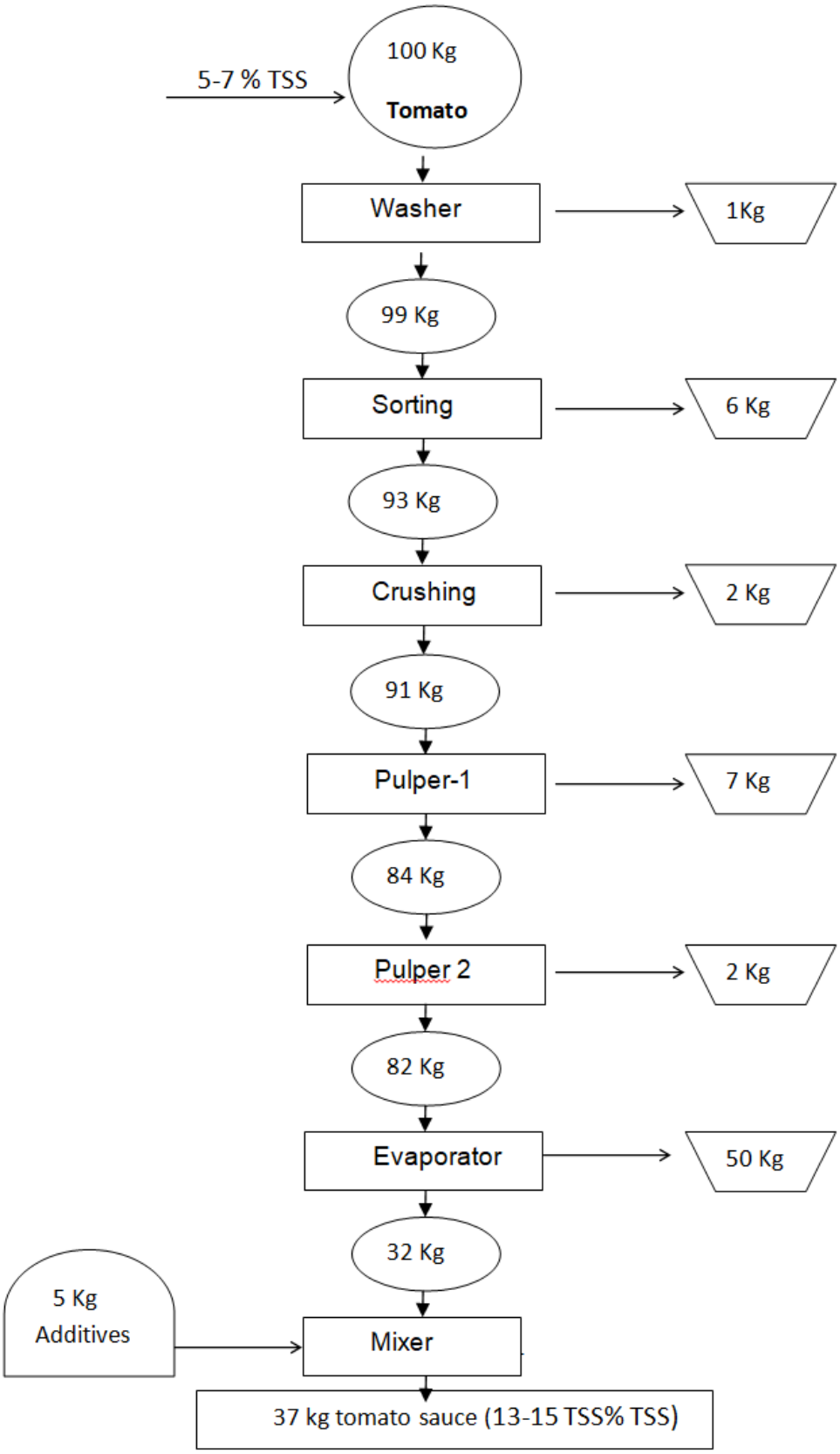


Figure 1 Flow chart showing material movement in tomato sauce production process

Equipment/unit wise mass flow rate was determined and mass balance is calculated by weighing losses at all stages of processing [16, 18].

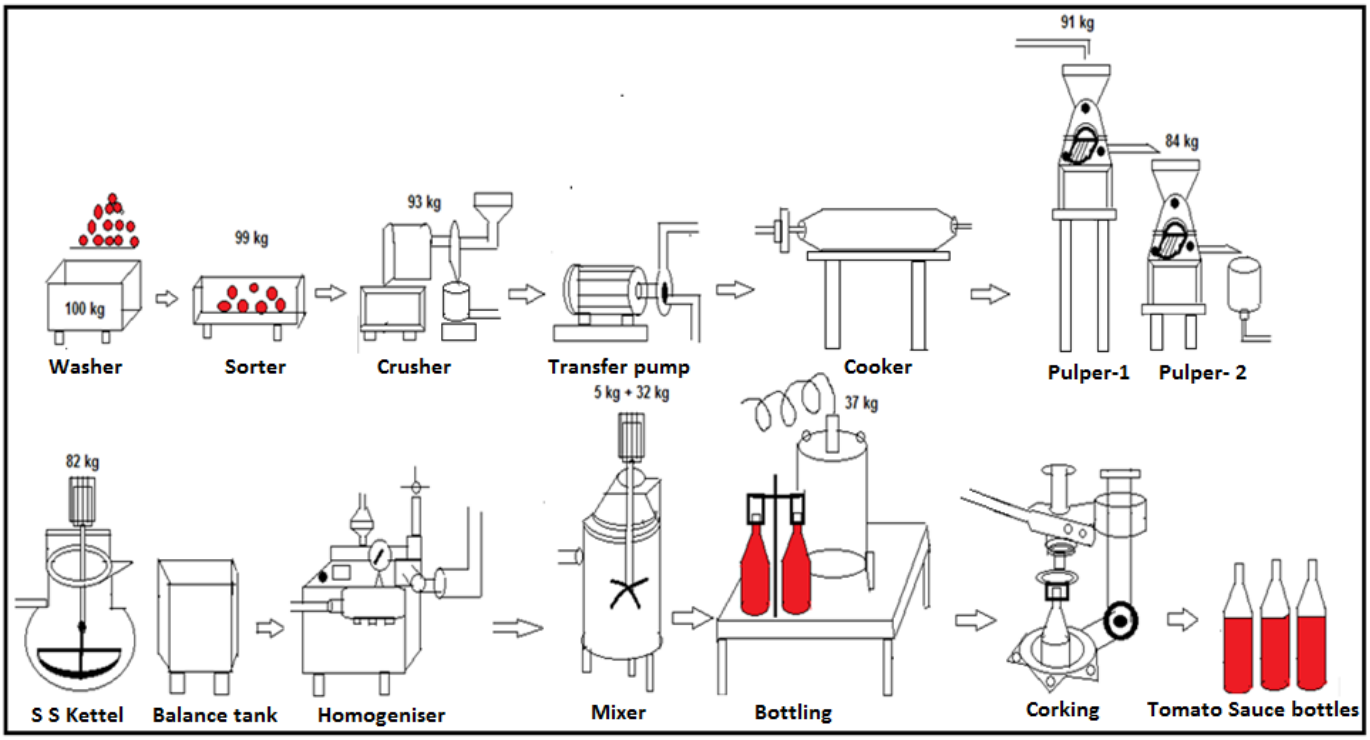
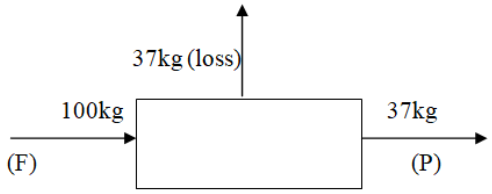


Figure 2 Line diagram showing tomato sauce production

Over all mass balance of tomato processing process

(Raw tomato) Input = Rejection – Output (sauce)
Feed = Wastage - Product
F = V – P (1)
(OR)
Wastage = Feed + output

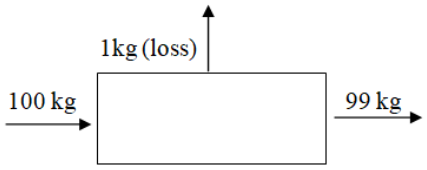
Over all mass balance of process



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 (2)
= 100-37
= 63 kg Loss

Component wise material balance

Material balance of washer

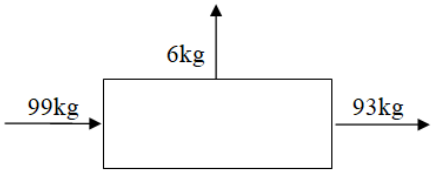


F = V+ P
Loss = Feed – Product
V = F (tomato) – P (tomato) (3)
= 100 – 99
= 1 kg Loss

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

Material balance of sorter

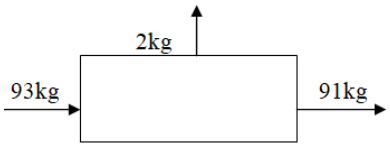
F = V+ P
Loss = Feed – Product
V = F (tomato) - P (tomato) (4)
= 99 - 93
= 6 kg Loss



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.

Material balance of crushing

V = F (tomato) – P (tomato pulp) (5)
Loss = Feed – Product
= 93-91
= 2 kg Loss



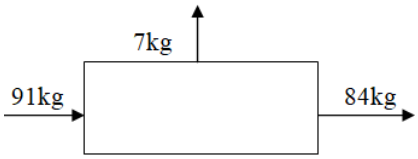
In crusher, crushing of tomatoes is done, in crusher on feeding of 93 kg of tomatoes as input 91 kg of tomato pulp was obtained as output, remaining 2 kg as spill loss.

Material balance of cooker

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

Material balance of pulper-1

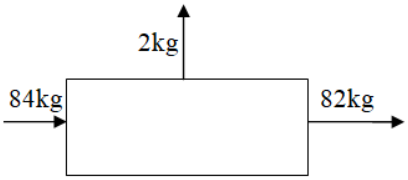
V = F (coarse pulp) – P (thick juice) (6)
Loss = Feed – Product
= 91- 84
= 7 kg Loss



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

Material balance of pulper-2

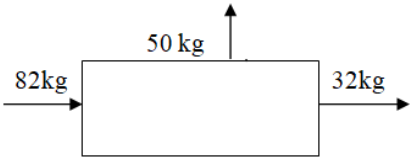
Loss = Feed – Product (7)
V = F (thick juice) – P (thinner juice)
= 84 – 82
= 2 kg Loss



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

Material balance of evaporator

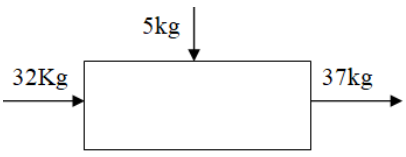
Loss = Feed – Product (8)
V = F (thinner juice) - P (concentrated tomato)
= 82-32
= 50 kg Loss



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

Material balance of mixer

Mixer = Output + Input (9)
= 32 kg (concentrated tomato) + 5 kg (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 5 kg id added to the obtained output product of evaporator which was of about 32 kg. Here no loss will occur; here 100% efficiency was achieved.

By adding above all the equations 3, 4, 5, 6, 7 and 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 100 kg feed i.e., tomato = 68 kg

Input (tomato) = 100 kg

Output (tomato sauce) = 32 +5

= 37 kg

Input = loss+ output

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

105 = 105 kg

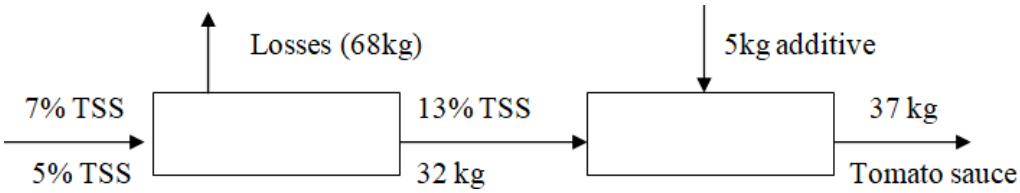
loss = input – output (10)

68 = 105 - 37

68 = 68 kg

Material balance according to TSS

- Considering tomato concentrate was brought from 7% TSS to 13 TSS%.
- 100 kg tomato was used in process.
- 68 kg of material was obtained as rejected
- The product (tomato sauce) yield obtained from 100 kg of raw tomato at final stage = Let consider 32 kg 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) + 5 kg (additives) = 37 kg Tomato sauce

Conclusion

On feeding of 100 kg raw tomato into the washer of tomato processing unit 99 kg of tomato was obtained with a loss of 1 kg. After that 99 kg 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 93 kg 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 91 kg which is fed into cooker. Here no loss of feed material was occurred so, 100% efficiency was achieved in this system. The obtained 91 kg of feed material fed into pulper-1, Here a large amount of waste was rejected which is about 7 kg 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 84 kg.

The tomato juice which was coming out of pulper-1 was fed into pulper-2 (coarse pulper) weighing of 84 kg. In the fine pulper an amount of 2 kg 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 82 kg 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 50 kg. This operation was performed until the required consistency was obtained. After obtaining the required consistency finally the obtained output was about 32 kg of tomato concentrate. After obtained the required TSS the concentrate is passed into mixer. Here an amount of about 5 kg 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.

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