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Time and motion study of mango pulp industry (Shree Samarth Foods, Palgad, Tal Dapoli, Dist Ratnagiri)

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■ **ABSTRACT :** Konkan region of Maharashtra is the leading producer of Alphanso mango. The Alphanso mango is having highest market value during the season. But as the season passes near to the onset of monsoon season, the market rate of the mango falls down drastically as rains affects the taste and quality of the mango fruit. Hence, the mango growers in this area prefer to sale mango to the processing industries in this region. The mango processing industries for the mango pulp production are having good demand. The mango pulp production process is divided in few distinct operations like procurement, ripening, cleaning, peeling, pulp extraction, stone removal, pulp boiling, can filling, sealing, labelling etc. If the process line for these operations is set properly and maintained, then the time and motion required for doing these operations can be optimum one. But the pulp processing industries in this area are setup mostly as per the convenience of the owner and availability of space. Hence, it was felt necessary to study the time and motion required for producing mango pulp in a mango pulp industry M/s Shree Samarth Foods, Palgad, Tal Dapoli, Dist Ratnagiri. In the study, the time required for each operation was studied. According o the observations, som recommendations were made. Though the factory layout was conventional, there was considerable synchronization in the processing activities. It was observed that the manual peeling operation takes most of the process time and labours, hence use of modified pulper cum refiner was recommended instead of old pulper. The cost of processing mango pulp was found to be 99.47/kg. The body part discomfort faced by the workers due to working in the industry was found out by interviewing them personally. The shoulder, neck and mid back pain is observed in the women workers only who are doing the manual sorting. The arm and palm pain was observed in women workers doing peeling operation. In general, it is observed that the body part discomfort starts with ageing as young labours don't show any body part discomfort.

■ **KEY WORDS :** Mango pulp industry, Time, Motion study, Layout, Palgad

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Mango covers an area of 4946 thousand ha with a production of 37.12 million tons in the world during the year of 2010. India occupies top position among mango growing countries of the world and produces 40.48 per cent of the total world mango production. China and Thailand stood at second and third position among mango producing countries in the world with 4,366 and 2,551 thousand tons, respectively. The

other major mango producing countries in the world during 2010 were Pakistan, Mexico and Indonesia, respectively (FAO).

Mango is grown in almost all the states of India. Uttar Pradesh tops the list of mango producing states. Other major mango producing states are Andhra Pradesh, Maharashtra, Karnataka, Bihar and Gujarat. Rest of the states has quite less production. (Indian Horticulture Database, 2010-11).

Mango is one of the important horticulture crop in the Konkan region. The Alphanso variety of mango is widely grown in this area due to its sweetness, richness and flavour acceptance by the consumer. Alphonso mango is also called "King of fruits" on account of its nutritive value, taste, attractive fragrance and health promoting qualities (Anonymous, 2013). The growers can fetch a good market value as this variety of mango is having a great demand during the season *i.e.* from March to May end *i.e.* before monsoon. But after May month, the rates of the mango fall down so much that it becomes unprofitable to sell the mango in the market. The alternative for this is to sell the half ripened mangos to the canning industries for mango pulp production. Mango Pulp is the concentrated mango juice obtained on processing of various varieties of mangoes. The processed mango pulp has enhanced shelf-life and has significant export potential. The mango pulp can further be used to produce downstream products like mango jelly or can be consumed as fruit juice. The canned mango pulp has about 2 years of shelf-life without using a cold storage. The mango pulp processing industries starts when production of mangoes surpluses the demand for direct consumption. The industries are operational for nearly 30 to 40 day (nearly from 15th of May to 15th of June). Which enables surplus production of fruits of one season for can be used in another season or place. The canning industries pickup the mango lot at a glance, which reduces the effort of the growers to sell the mango on retail basis. Canning industries also make the profitable business because of the availability of the mango. The canning industries in this area are scattered. Most of these industries are set up as per the availability of the space without much planning. The availability of space and the convenience of the owner are the constraints for setting such industries. Same trend is observed in cashew processing industries.

Time and motion study is the important thing in order to determine the success and performance of an industry. This happen because, time is the measurement tool that affects the level of company's performance. The measurement of the product or service success would be known through the time study and time standard by work sampling and workers complaint (Lawrence, 2001). The term time and motion study refers to a broad branch of knowledge dealing with the systematic determination of preferable work methods, with the determination of the time required for the use of human or machine to perform the work by the stipulated method and with the development of materials required to make practical use of these data (Mundel and Danner,1994). Time and motion study have the objective to eliminate work that is not required. It is the design method and the most effective procedure, which requires little effort and in accordance with the individuals who use them. Moreover, it provides a method to measure job performance or to determine the production index for the individual or group work, each section, or entire factory (Meyer, 1994). The space used for any operation represents an investment. Proper utilization of space is an important source of cost reduction, particularly when an enterprise is expanding and needs an increased working area. Furthermore, a proper layout reduces wasted movement, time and effort. There are many ways *i.e.* quality control (QC), total quality management (TQM), standard time, plant layout to solve the problems concerning productivity. The plant layout of the manufacturing process for valve and metal parts production was changed to comply with the international standards through SLP method (Khansuwan and Poowara, 1999). Zhu and Wang (2009) studied the general plane of long yards using SLP which the best layout showed the good workflow and practical significance. Plant layout analysis and design for multiproduct line production has been studied by Jaturachat *et al.* (2007). Wisitsree and Watanapa (2010) designed the plant layout of iron manufacturing based on SLP for increased productivity, the result showed the new plant layout significantly decrease the distance of material flow from billet cutting process until keeping in ware house. There are some characteristic of good quality factory layout, as follow: Travelling time of workers and material is decreasing, minimum operational cost, zero accident in the factory, employees could work efficiently and effectively, optimize empty space, communication among employee are well organized

(Saerang, 2011). Several factors that must be considered to make a good layout are: material, machine used, employee and material handling (Ailing, 2009).

In short, the time and motion of the processes and the labours in the industries play an important role in the output and commercial benefit of any industry. A study of time and motion of industry is an important tool to evaluate and improve its performance. The properly planned set up can save the human efforts, drudgery and time of the process. Considering this, a study was undertaken for the time and motion study of old and traditionally managed mango pulp canning industry Shree Samarth Foods, Palgad, Tal Dapoli, Dist Ratnagiri. An attempt can be made to improve layout of old factory in order to achieve efficiency in production and improve economy. In addition, the labours were interviewed personally to know about their body part discomforts considering the working manner in the industry.

METHODOLOGY

The Shree Samarth Foods, Palgad, Tal Dapoli, Dist Ratnagiri was selected for the study as the factory is gradually expanded from small processing unit. The owner has expanded the unit for the gradual increase in the capacity as the space available with him. The layout of the factory was studied (Fig. 1). The work flow of the processing was studied through the interview with the owner. The process was split in different events so

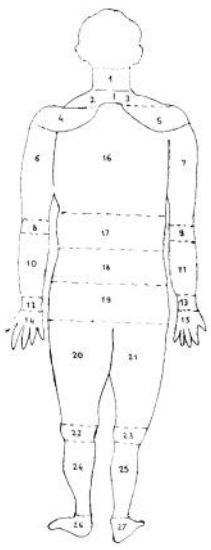
Table 1: Event wise time and motion study along with labour required at Shree Samarth Foods, Palgad, Tal Dapoli Dist Ratnagiri

Sr. No.	Event	Time required, sec	Distance travelled, m	Rate of doing work, qty per hour	No. of labours (M/F)
1.	Inward to ripening yard	14	11.4	--	4 M
2.	Disposal of rotten mangoes	80	54	--	3 F
3.	Sorting of mangoes		--	532.8 kg	2 F
4.	Ripening yard to tip and peel cutting	11	9.6	--	2 M
5.	Rate of tip cutting	--	--	@ 720 Mangoes/labour	4 F
6.	Tip cutting to peeling	3.5	2.6	--	0.5 F
7.	Peel disposal	75	48	--	2 M
	Rate of peeling			@ 4 mangoes/min /labour	4.5 F
8.	Carrying vessels from press peel to cleaning station	10	7	--	1 F
	Time for cleaning	30 min	--	--	0.5 M
9.	Peeling platform to pulper	8	3.2	--	0.5 M
	Capacity of pulper	--	--	@ 864 kg/h	--
10.	Mango stone disposal	70	46	--	1 M
11.	Boiling to can keeping	2.5	3.2		1 M
12.	Can filling to sealing	2	0.5	--	0.5 M
	Can filling rate	--	--	655.7 kg/h	--
	Sealing rate	--	--	@ 5.67 cans/min	--
13.	Sealing to hot water dip	54	2.6	--	1 M
14.	Hot water dip to cold water dip	45	2.2	--	0.5 M
15.	Cold water dip to water draining area	30	1.0	--	0.5 M
16.	Water draining area to storage area	54	15	--	1.0 M
17.	Storage to labeling area	4	2	--	0.5 M
	Rate of labeling	--	--	@ 50 tins/h	--
18.	Packing to dispatch	48	27	--	1.0 M
19.	Fuel storage to boiler	4.5	2	--	0.5 M
20.	Ash disposal	12	7.2	--	0.5 M
21.	Can inward to storage	25	15	--	0.5 M
22.	Can storage to filling platform	11	6	--	0.5 M

as to study it separately. The time required for each event in the process was recorded using the stopwatch and the distances were measured with a measuring tape. Most of the events were studied in actual practice while for some others, the time was recorded as per the experience of the owner and the experienced labour working there. The motion paths were also recorded during the study to find out the time required and the distance travelled by the person during the event of the process. The number of labours (male/female) and capacity of the labours were found through an interview with the owner of the factory. As per the availability of the machineries and lay out of the factory, the mango pulp canning process was split in the events as enlisted in the Table 1 and 2 to study the time and motion. For these events, the time required, distance travelled, capacity were studied. The workers were interviewed personally to find the strains they are facing due to working in the industry. To study the body part discomfort, a picture (Fig 2) was shown to the workers for easily locating the discomfort body part. The information obtained from the interview is also discussed below.

■ RESULTS AND DISCUSSION

The time required for each operation and the distance travelled by the persons gives the idea about the time and motion for the process. The motion study helps to relocate the units in the industry to curtail the worker' motion so as to save the time and the movement in the industry. The layout of the industry (not to the scale) is shown in Fig. 1.



1. Neck
2. Clavicle left
3. Clavicle right
4. Left shoulder
5. Right shoulder
6. Left arm
7. Right arm
8. Left elbow
9. Right elbow
10. Left fore arm
11. Right fore arm
12. Left wrist
13. Right wrist
14. Left palm
15. Right palm
16. Upper back
17. Mid back
18. Lower back
19. Buttocks
20. Left thigh
21. Right thigh
22. Left knee
23. Right knee
24. Left leg
25. Right leg
26. Left foot
27. Right foot

Fig. 1 : Regions for identifying the body part discomfort

The mango pulp processing in this factory is batch type. One batch contains on an average 300 kg raw mangoes. Time required for each event of one batch is given in Table 2. It is not included the time for the cold water dipping as it takes 24 h and batch dipped in cold water on a day has to be removed on next day from cold water.

Table 2 : Time for each event for processing one batch

Sr.No.	Event	Time required, min
1.	Sorting of ripen mangoes	33.78
2.	Tip cutting	27.77
3.	Peeling of mangoes	74.07
4.	Time for pulping	20.8
5.	Pulp boiling	30
6.	Filling and sealing	8.82
7.	Hot water dipping	45
8.	Labeling	60
9.	Box packing	71.43

The time required for the processing 300 kg ripen mangoes was found to be 381.56 min *i.e.* 1.3 min/kg but if manual peeling operation is avoided by using modified pulper cum refiner it saves 5 labours and 74.07 min of process time. Modified capacity will be 1.0 min/kg. Labour capacity can be increased from 75.8 kg/person to 89.3 kg/person. The man-hour required for processing 300 kg of raw mangoes by machines was found to be 224 *i.e.* 0.75 mah-hr/kg. The man-hour required for processing 300 kg of raw mangoes by manual peeling was found to be 264 *i.e.* 0.88 mah-hr/kg. This shows that the man-hr required in case of manual peeling are much more (17 %) than that of the machine.

It is observed from the table that the 18 jobs are done by the male workers only while the 6 jobs are done by the female workers only. It can be said that the heavy jobs are done by the male workers while the light and critical jobs are done by female workers. The workers starts working at 9 am and work till 1:30 pm. Then after lunch break, they resume duties from 2:30 pm to 6 pm.

Cost of processing the mango pulp:

The cost of processing the mango pulp was

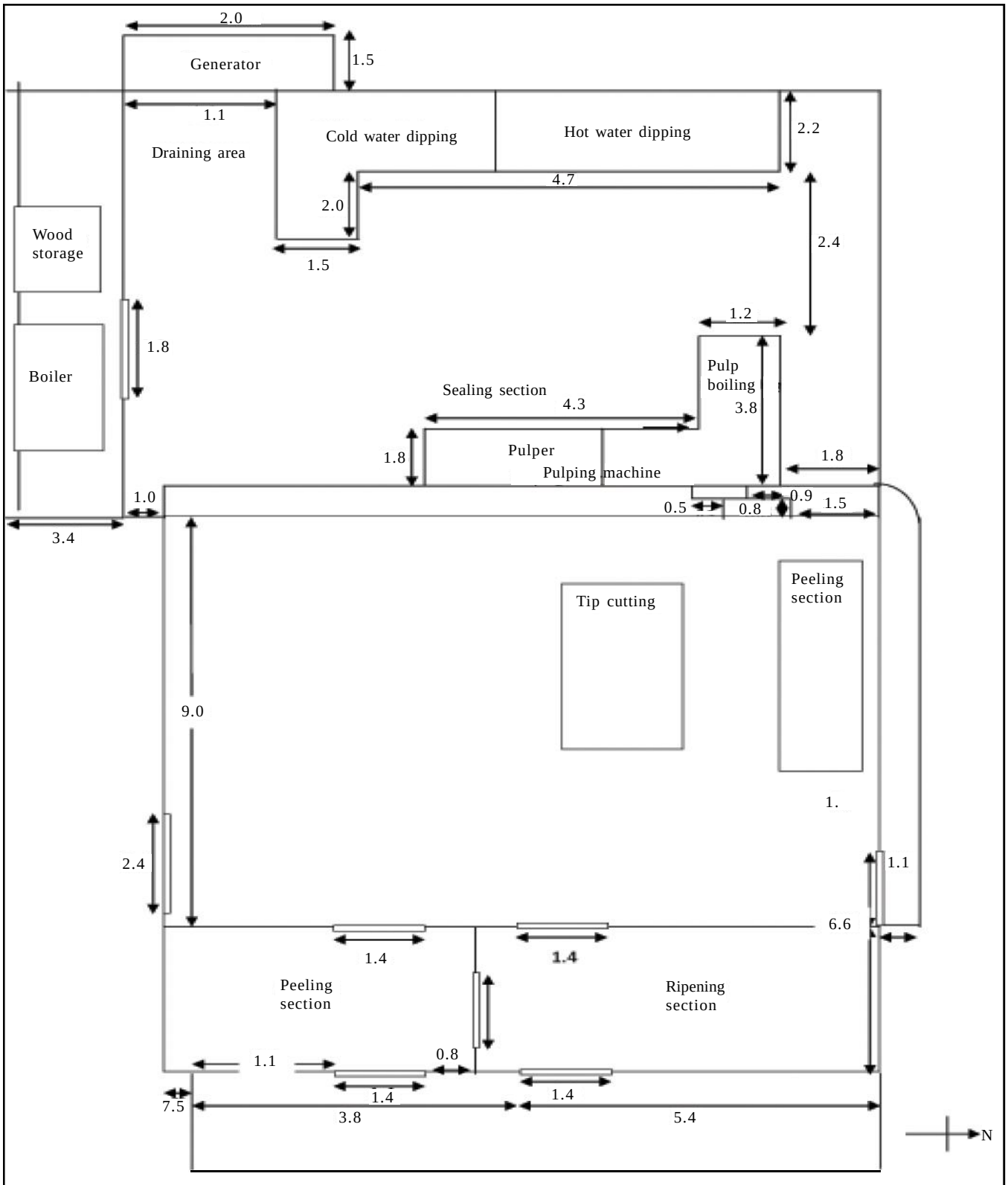


Fig. 2 : Existing 1 layout of Shree Samarth foods, Palgad, Tal Dopali Dist Ratnagiri

calculated by considering the wages of the male and female labour as Rs. 180/day (Rs. 22.5/h) and Rs. 140/day (Rs. 17.5/h) of 8 working hours per day, respectively. The number of hours for which the work was done by male and female workers for processing 300 kg batch of raw mangoes was determined separately. The number of hours for which the boiler, pulper machine and sealing machine used was also determined. Considering the motor capacity (kW) of these units and the tariff for the industrial electricity consumption as Rs. 9 per unit, the cost for use of these machines was determined. Summing the costs, the cost for processing 300 kg of raw mangoes was determined. The total male hours required were 158.76 while female hours required were 267.05 for processing 300 kg of raw mangoes.

Labour cost = Male hours × Wages, Rs./h + Female hours × Wages, Rs./h

= 158.76 × 22.5 + 267.05 × 17.5 = 3572.1 + 4673.4 = Rs. 8245.5.

Boiler motor runs for 85 min has rating of 2 hp, pulper motors of 4 hp runs for 21 min and sealing machine of 1 hp power runs for 10 min. As there is natural sunlight during day time electrical lighting is not required.

Hence, the total electricity consumption was 2.119 kWh + 1.034 kWh + 0.124 kWh = 3.227 kWh.

Considering the tariff of electricity consumption as Rs. 9 / kWh, the charges were Rs. 29.04.

Hence, the total processing cost was Rs. 8245.5 + Rs. 29.04 = Rs. 8274.54.

The rate of raw mango was Rs. 20/kg. Out of 300 kg raw mangoes, 150 kg processed mango pulp was obtained.

Total cost of raw mangoes = 20 × 300 = Rs. 6000.

Cost of sugar added in pulp @ Rs. 35/kg = 35 × 12 = Rs. 420.

Wood required for boiler for 85 min is 56.77 kg and cost is 56.77 × 4 = Rs. 227.08.

Total cost for processing including raw material cost = 8274.54 + 6000 + 420 + 227.08 = Rs. 14921.62.

Yield of the pulp is 50 per cent *i.e.* 150 kg.

The processing cost to obtain 150 kg processed mango pulp was Rs. 14921 *i.e.* Rs. 99.47/kg.

Table 3: Body part discomfort faced by the labours working in Shri Samarth Foods, Palgad, Dapoli

Sr. No.	Age (yr) and gender of subjects	Weight, kg	Height, cm	Nature of work in the factory	Body part facing discomfort as per Fig.
1.	18, M	48	144	Unloading	No
2.	30, F	51	154	Unloading	No
3.	35, F	54	148	Sorting	5
4.	40, F	62	156	Sorting	1, 17
5.	40, F	54	158	Tip cutting	No
6.	18, M	48	144	Tip cutting	No
7.	30, F	51	154	Tip cutting	No
8.	40, F	64	156	Tip cutting	No
9.	30, F	52	144	Tip cutting	18
10.	50, F	58	140	Peeling	14, 15
11.	35, F	54	147	Peeling	No
12.	38, F	47	161	Peeling	No
13.	32, F	51	143	Peeling	No
14.	40, F	56	138	Peeling	6, 7
15.	20, M	63	167	Can filling	No
16.	19, M	35	135	Sealing	No
17.	19, M	52	153	Hot water dipping	No
18.	18, M	56	157	Multitasking	No
19.	18, M	40	138	Multitasking	No
20.	18, M	49	157	Packaging	No

Determination of body part discomfort:

The workers were interviewed personally to find out the body part discomfort experienced by the workers in the industry. The picture as depicted in Fig. 2 was shown to the labours to correctly identify the discomfort body part. In all 20 subjects were interviewed out of which 8 were males while 12 were females. The information collected in given in Table 3.

It is observed from Table 3 that the maximum workers are young and they are not feeling any body part discomfort. The females doing sorting facing shoulder, neck and mid back discomfort while peeling operation workers facing arm and palm discomfort. The discomfort increases with the age of the workers in the factory. It is observed that there is no common trend body part discomfort in factory workers. There is not a single male facing body part discomfort. It can be said that mango pulp processing in this industry is comfortable operation for workers.

Conclusion:

– Though the factory layout was conventional, there was considerable synchronization in the processing of mango pulp.

– The peeling operation, which was manual takes most of the process time and labours, hence use of modified pulper cum refiner was recommended instead of old pulper.

– The cost of processing mango pulp was found to be Rs. 99.47/kg of mango pulp produced.

– The body part discomfort starts with aging as young labours don't have any body part discomfort.

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