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Fruit Wastages from Farm Gate to Retail Outlets in Tamilnadu, India-With Specific Focus on Fruit Processing Units

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Abstract: Government of India focuses on the agricultural sector with the objective of ensuring higher income to the farmers by minimizing supply chain wastages. Though India is second largest fruits producer in the world, around one third of the output goes waste due to various reasons. Hence this study is focused to identify the major stages of wastages in fruit supply chain from farm gate to retail end by dividing this into five different stages such as farm gate, traders, cold storage, processing and retailing. This study is confined to wastages in fruit processing units since it was one of the major wastage stages in fruit supply chain next to retailing. As there are a number of detailed studies about wastage in the retail stage and very few studies are available with regards to wastage in processing stage, this paper is focusing on processing wastage only. Fruit processing units are playing major role in preserving the perishable fruits with long shelf life by adding value through processing. If such sources (Processing units) realized more wastage, then value loss could be very high for farmers, processors and consumers. This study was conducted in four locations of Tamilnadu such as Dharmapuri, Krishnagiri, Chennai and Sub-urban areas of Chennai since these places fulfill the scope of study requirements. This study identified major sources of wastages in fruit processing industries and their root causes viz., long travel distances, lack of labor, poor packing methods, damage due to pest attack and removal of damages parts of fruits, as significant sources of wastages. Processors were expecting support and amended policies from the government to minimize wastage, improve their productivity and income so that farmers and consumers too could benefit with more income and less price respectively.

Key words: Farm gate to Retail · Fruit processing · Food wastage · Supply chain · Transportation wastage

INTRODUCTION

Prime goals of Indian Ministry of Food Processing Industries (MoFPI) are better utilization and value addition of agricultural produce for enhancement of income of farmers and minimizing wastage at all stages in the food processing chain by the development of infrastructure for storage, transportation and processing of agro-food produce [1].In spite of being a second largest producer of overall fruits, nearly 72% of the total production is wasted in India due to poor facility or absence of storage, logistics and processing support [2]. Wastage was reported in all stages of supply chain such as post harvesting processes, farm gate, transportation, cold storage, processing, trading and retailing. Quantum of wastage in each stage varied based on type of fruits and handling methodologies. Wastage of fruits (apart from hoarding) results in inflation-driven prices between farm gate and retail outlet. India has achieved the average annual growth rate of 3.7% of GDP in agriculture and allied sectors during the eleventh five year plan, against the target of 4%. High inflation prices of food and other primary commodities was one of the reasons for failure to reach the targeted growth [3]. Agricultural wastage was one of the reasons for high inflation prices. Minimizing wastage would improve the return for both farmers and retail vendors, which fulfill the first goal of MoFPI as well as keep inflation prices under control. Hence this study is focusing to identify the major sources of wastages in fruit supply chain from farm gate

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to retail end, in order to determine value loss and minimize the same. By minimizing the value loss, the farmers would be able to sell more quantity and get increased sales revenue.

Research frame work: This study is formulated with five different stages from farm gate to retailer end comprising farm gate, cold storage, processing, traders (Wholesale) and retail stage. All these stages involve transportation and middle men who are traders. These stages are customized based on type of business and people involving in them. These customized stages are shown in figure 1 in which entire fruit supply chain is shown in two flow directions viz. (1) Raw consumption and (2) Processing for consuming without value addition and with value addition respectively.

Another study has given the model from farmers to customers with respect to retail supply chain for vegetables [4, 5]. But this above model explains both retail and processing along with cold storage supply chain from farmers to customers for fruits.

Scope of the Study: This research is confined to selected fruits such as Mango, Banana, Grapes, Sapodilla [Sapota] and Guava as these were major fruits produced in Tamilnadu [6]. Processing units in Krishnagiri and Dharmapuri districts were selected as these locations account for 90% of the fruit processing units in Tamilnadu [7-9]. Similarly, Chennai Koyambedu fruit market is one of the biggest fruits market in Asia in terms of trading and retailing [10,11]. All these locations are also having large number of farmers and cold storage units [7]. Hence this study is confined to Krishnagiri and Dharmapuri districts, Chennai and it's sub-urban locations like Tambaram and Poonamallee. Both organized and un-organized retail outlets and their distribution systems were considered in this study. More than 80% of fruit processing units are processing mango as main fruit during season (May to July) and during the off-season they process various other fruits depending on their availability [9].

MATERIALS AND METHODS

Sampling Design: This study is descriptive in nature. Data were collected from Farmers, traders, cold storage owners, processing unit owners and retailers. Totally 335 samples were collected adopting convenience sampling method. In order to select the sample respondents, in the first stage, 30 out of 62 processing units located in Krishnagiri and Dharmapuri districts along with 5 processing units at Chennai suburban area were selected. Totally 75 farmers and 75 traders (dealing in

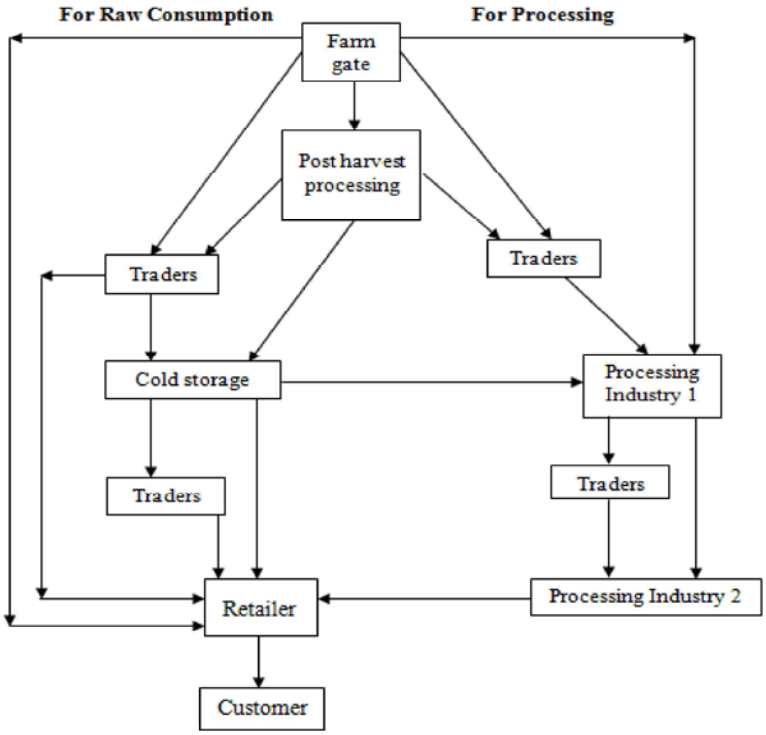

Fig 1: Flow chart for channels of distribution for fruits from farm gate to retailer end.

procuring and supplying mangoes) in all the locations specified above constituted the sample of farmers and traders. Farmers and traders who were supplying raw materials (Fruits) to these processing units alone were chosen for survey. The wholesale market at Koyambedu, Chennai, provides cold storage facility for traders and retailers. Apart from these, there is a few more cold storage facility available in the suburban areas of Chennai. Such a facility is also available at in and around Dindigul and Coimbatore locations. Tracing the arrival of selected fruits in cold storage in all the above places, totally 25 cold storage units were included for the study. Retailers were essentially fruit vendors and they are located closer to consumers. To get an insight in to the wastage problem at the retail stage, 125 retailers were selected in and around Chennai and its suburb.

Definition of Avoidable and Unavoidable Waste: Determining total wastage of fruits selected for this study is challenging since each fruit has different proportion of edible and non-edible part. For example, in mangoes and sapodilla [Sapota], peel and seed are not edible and only the flesh part is edible. In the case of banana, peel alone is non-edible. In guava the entire fruit is edible. In grapes except the seed the rest is edible. Hence only avoidable wastage of all the fruits was considered in this study.

Entire fruit like whole banana, whole mango etc., that does not serve their purpose and they are thrown away without being considered for consumption for whatever reasons there might be, [12] are called as avoidable waste. Customary remains after consumption of the fruits that are not edible like banana peel, mango seed etc., [12] were considered as unavoidable waste. In line with the UN Food and Agriculture Organisation's (FAO) definition, food wastage is the decrease in edible food mass that was originally intended for human consumption, which defined as avoidable food waste which includes both food losses, which occur at the production, post-harvest and processing stages and food waste, which arises at the retail and consumption stages. Whole fruit in all stages of supply chain except processing stage and edible portion in processing stage was defined as avoidable wastage and the same was considered as fruit wastages in this study. This study determined the quantity of wastage at each of five stages (Figure 1) initially and taken only the one of top two stages (processing stage) for in depth analysis.

Variables Taken for the Study: Avoidable wastage of fruits was considered from farm gate to processing units [i.e., through processing channel in research framework diagram (Figure 1)]. Production losses, post harvest, handling, storage, processing, packaging, distribution, retail losses were considered as major variables in this research. At every stage, there are a variety of reasons for the losses. In this study, the focus is only on avoidable waste. Around 29 variables were identified under five major wastage categories such as Farm gate wastage, Transportation wastage, Packaging wastage, Ripening wastage and Processing wastage. Data were collected for all these types of wastages. Among these 29 variables, six were dropped based on the response in the pilot survey. Pilot study was conducted among 23 processing units [15]. Based on the opinion from fruit processing unit owners, questions relating to those six variables evoked limited response warranting their removal. Respondents pointed out that situation relating to three of these six variables, was not experienced in reality. As per experts' opinion in pilot study, expected situation never arises since they were taking more care for controlling those wastages. All the respondents reported nil wastage on two variables. One more variable on ownership of ripening chamber was also dropped as more than 80% of the respondents did not own ripening chamber. So this study considered only 23 variables. Total avoidable processing wastage was considered as dependent variable and remaining 22 independent variables were considered under 5 major groups of variables (Farm gate wastage, Transportation wastage, Packaging wastage, Ripening wastage and processing wastage) for analysis.

Data Collection Method: Structured questionnaire was prepared for each five stages and data were collected through survey method. Avoidable fruit wastage data were collected from processing unit owners by meeting them in person. Same data were collected from farmers and suppliers, who were supplying raw materials to the processing units through interview and questionnaire. Out of total supply, more than 80 to 90% of the raw materials (fruits) were supplied by farmers and the rest by traders. Farm gate variable data were collected from farmers, transportation variable data were collected from traders and all other variable data were collected from processing unit owners.

Analysis Methods: Master table was prepared in SPSS package and the same was utilized for analysis. Frequency analysis was performed to get percentage of wastage at each stage of fruit supply chain from farm gate to processing units. Weighted average was also used to find out exact quantity of wastage at each stage. Weighted average was calculated by using percentage of response as weights and mean value of given range in questionnaire as wastage values. For example, A%, B% and C% of the respondents indicated different range of wastage viz., 0 to 5%, 6 to 10% and 11 to 20% of fruit wastages respectively. The mean of each range of wastage was calculated which was used as weight. Then weighted average was calculated by multiplying percentage of respondents by weighted average. Then this was divided by 100.

Key variables found through factor analysis by using principle component extraction and varimax rotation methods along with KMO and Bartlett's test for testing sampling adequacy and significance respectively. Relationship between the variables was determined through regression analysis by using avoidable wastage as dependent variable and all other variables as independent variables. Stepwise regression method was adopted for identifying the relative importance of factors of wastage in different stages of fruit supply chain.

RESULTS AND DISCUSSIONS

Data Reliability: Five broad variables already specified in methodology were considered for further analysis. Since there was only one question on ripening in the questionnaire, there was no possibility for determining the data reliability for the same. Table 1 shows the data reliability for remaining four variables based on Cronbach's Alpha value applying SPSS software package. Reliability of all four variables was more than 75%, these data were very suitable for further analysis.

Quantum of Wastage from Farm Gate to Retail: A simple frequency analysis and weighted average were used to determine the total quantity of wastage in all stages of fruits supply chain.

5 to 10%. And 72% of cold storage recorded less than 5% wastage. About 74% of processing units lose 11 to 20% of its total fruits and 62% of retailers reported 21 to 30% of wastage in their total procurement. Table 1 shows the weighted average for identifying exact quantity of every stage. This study reveals that around 61% of total fruit production was getting wasted from farm gate to retail end. This value would increase if study includes unavoidable wastage at processing level and kitchen waste at consumer end. Daily News and Analysis (DNA) reported around 72% of the total fruits and vegetable goes waste in India [2].

Traders realized very less wastage since they mediate between farmers and processing and retail stages by facilitating transactions and do not handle the fruits. They accept only good fruits from farmers and supply the same to intermediaries like processors or retailers. M. Fehr reported that 93% of farmers screen their produce before it leaves the farm [12]. Hence, either farmer or intermediaries would realize more wastages than the traders. This lesser wastage realized by traders was due to poor transportation and handling. C. Maheshwar reported in International society for horticultural science, Belgium conference that 30% of fruits loss occurred due to poor management facilities and practices such as poor handling, storage and transportation, whereas 5% occurred due to presence of large number of middlemen [13]. Though both farm gate and cold storages reported same volume of wastages at their level, cold storage would realize very less wastage. On the other hand wastage at farm gate was found to be caused by factors like poor harvesting methods, immature raw materials, different varieties from different climate, large variations in internal pulp temperatures, poor transportation and long travelling. Earlier research of this author revealed around 34% of cold storage wastage, but actual wastage inside the cold storage was just 8.4% based on improper storage conditions, poor maintenance of cold storage and temperature variations. Remaining 25% of the cold storage waste reported due to external factors like transportation, poor packing, handling and ripening [14, 15].

Around 75% of farmers are realizing 5 to 10% of fruits wastage at farm gate level. Around 31% of traders reported less than 5% wastage and 61% of traders realized

Table 1: Reliability values of variables

Sl. No	Variables	Cronbach's Alpha value	Reliability Percentage
1	Farm-gate	0.790	79%
2	Transportation	0.877	88%
3	Packaging	0.788	79%
4	Processing	0.756	76%

Table 2: Total fruit wastages at five different stages of fruit supply chain

Sl. No	Stage in fruit supply chain	Weighted average	Total fruit wastage
1	Farm gate	(20 x 2.5)+(74.7 x 7.5)+(5.3 x 15) / 100	6.9%
2	Cold storage	(30.7 x 2.5) + (61.3 x 7.5) + (8 x 15) / 100	6.6%
3	Traders	(72 x 2.5) + (20 x 7.5) + (8 x 15) / 100	4.5%
4	Processing units	(74.3 x 15) + (22.9 x 25) + (2.9 x 35) / 100	17.9%
5	Retail	(2.4 x 7.5) + (17.6 x 15) + (61.6 x 25) + (18.4 x 35) / 100	24.7%
		Total wastage	60.6%

Table 3: KMO and Bartlett's Test

KMO and Bartlett's Test		For Processing Variables (9)	All variables (22)
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.599	0.478
Bartlett's Test of Sphericity	Approx. Chi-Square	239.232	441.590
	df	91.000	231.000
	Sig.	0.000	0.000

Table 4: Total variance

	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.464	20.291	20.291	4.464	20.291	20.291	3.541	16.093	16.093
2	3.528	16.037	36.327	3.528	16.037	36.327	3.474	15.792	31.885
3	2.912	13.237	49.564	2.912	13.237	49.564	2.917	13.260	45.145
4	2.032	9.237	58.802	2.032	9.237	58.802	1.993	9.060	54.205
5	1.526	6.938	65.739	1.526	6.938	65.739	1.807	8.214	62.419
6	1.331	6.049	71.788	1.331	6.049	71.788	1.716	7.799	70.219
7	1.145	5.205	76.993	1.145	5.205	76.993	1.490	6.775	76.993
8	0.816	3.710	80.704						

Based on the table 2, it is clear that processing units and retail outlets realized more wastage than the other stages. Both retail and processing stages alone realized 3/4th of total wastage in fruit supply chain. Earlier research of the author revealed around 26% as retail wastage [17] and 44% as processing wastage (including all stages wastage from farm gate to processing units) [15, 16]. But in the current study percentage of waste was 24.7 % in retail and 17.9% in processing stage. As there are a number of detailed studies on wastage in the retail stage and very few studies are found with regards to wastage in processing stage, this paper focused on processing wastage only. Though other stages are the root causes of wastages, traders and other middlemen don't own these wastages, but pass these to other channel members in the line. For example, poor harvesting method at farm gate would not realize any wastage at farmers' level, unless there was any physical damage. But such waste product move through the supply chain until it is separated as a waste at the beginning stage of processing. Normally before the processing begins, bad fruits are separated from good ones and the former becomes the waste. This study investigated the sources of fruit wastages at processing stage where a significant part of wastage was reported.

Key Variables of Wastage: This part of study is trying to identify key variables determining wastage, using factor analysis. Sampling adequacy and significance was tested through KMO and Bartlett's test. Table 3 shows the significance value of processing variables and all variables. KMO value justified that factor analysis can be applied for the data. Sampling adequacy for processing variables was almost 60% whereas for all variables it was nearly 48%. Since 57% of processing units constituted the sample in the study area, 60% sampling adequacy was justifiable. Similarly KMO value of 48% for all variables was considered justified.

Key variables were extracted through factor analysis using principle component analysis method. Table 4 shows that first seven components explained around 77% of total variance. These variables were extracted using Eigen values.

Variables in these seven components were identified through Varimax rotation. There were five variables such as wastage during loading of raw materials in to the vehicle, wastage during unloading of raw materials from the vehicle, wastage due to long travelling distance for raw materials, wastage due to lack of cold containers during raw material transportation and poor road conditions, belonged to first component. This component

Table 5: Stepwise regression coefficients

		Un standardized Coefficients		Standardized Coefficients			
	Model	B	Std. Error	Beta	t	Sig.	R Square
1	(Constant)	3.357	0.168		19.961	0.000	0.295
	Wastage due to long travelling distance	0.354	0.095	0.543	3.719	0.001	
2	(Constant)	3.185	0.151		21.163	0.000	0.505
	Wastage due to long travelling distance	0.432	0.084	0.663	5.157	0.000	
	Wastage due to lack of labor	0.332	0.090	0.473	3.685	0.001	
3	(Constant)	3.589	0.168		21.374	0.000	0.656
	Wastage due to long travelling distance	0.468	0.072	0.718	6.539	0.000	
	Wastage due to lack of labor	0.344	0.076	0.490	4.503	0.000	
	Wastage due to poor packing methods	-0.278	0.075	-0.392	-3.693	0.001	
4	(Constant)	3.614	0.156		23.166	0.000	0.714
	Wastage due to long travelling distance	0.403	0.071	0.619	5.648	0.000	
	Wastage due to lack of labor	0.397	0.074	0.566	5.365	0.000	
	Wastage due to poor packing methods	-0.292	0.070	-0.412	-4.167	0.000	
	Damage due to pest attack (Whole fruit)	0.189	0.077	0.280	2.463	0.020	
5	(Constant)	3.320	0.185		17.927	0.000	0.766
	Wastage due to long travelling distance	0.388	0.066	0.594	5.865	0.000	
	Wastage due to lack of labor	0.312	0.076	0.446	4.114	0.000	
	Wastage due to poor packing methods	-0.309	0.065	-0.436	-4.766	0.000	
	Damage due to pest attack (Whole fruit)	0.241	0.074	0.357	3.274	0.003	
	Wastage due to damaged part of fruits removal (Removal of pest portion, decay portion etc.)	0.312	0.124	0.277	2.522	0.017	

was named as transportation wastage. It explained about 16.1% of variance in avoidable waste. There were four other variables such as wastage due to lack of labor at farms, mechanical injury to fruits due to poor harvesting methods, harvesting of immature raw fruit and handling wastage during cleaning, sorting, grading, etc., constituted the second component. This component was named as farm-gate wastage and it accounted for about 16% of variance in avoidable waste. Another set of five variables, such as wastage due to pest attack, manual processing, lack of processing labor, damage removal and pilferage at processing stage, were included in third component. This component was named as natural and processing wastage. It explained about 13.3% of variance in avoidable waste. Similarly wastage due to poor packaging methods and poor packaging materials were brought under the fourth component. This component was named as poor packaging. This explained about 9% of variance in avoidable waste. Whereas one and only variable included in fifth component, was named traditional ripening and it explained slightly more than 8% of variance in avoidable waste. Two other variables such as late harvest due to lack of farm labor and pilferage at farm gate level were included under sixth component, named as labor wastage. It accounted for about 7.8% of variance in avoidable waste. One more variable viz., wastage due to lack of skilled labor was included in seventh component explaining 6.8% of variance in avoidable waste. These factors falling in to 7 components highlight the importance of 21 variables explaining in total nearly 77% of avoidable waste in fruits.

Stepwise Regression Model: Stepwise regression analysis was chosen for this study, because, the wastage occurred at different stages due to different factors. To identify the relative importance of factors in different stages, stepwise regression was applied. In this model, the 22 variables were identified through the factor analysis. Considering avoidable waste as the dependent factor and the 21 variables as independent factors, stepwise regression was done. This yielded the following result.

Five significant variables such as wastage due to long travelling distance, lack of labor, poor packing methods, damage due to birds and animals and wastage due to damage removal (Removal of pest portion, decay portion etc.) entered in to the model in sequential order in which the variables are listed. Table 5 shows both R^2 along with statistical significance of the above five variables. It clearly revealed that all five variables together explained totally 77% (R2 = 0.766) of the variation in avoidable waste.

Percentage of Variation Through R Square Value: However, at each step the influence of the variable entering into the solution explained the percentage variation in the dependent variable. In the first step wastage due to long travel alone explained 30% (R2 = 0.295) of variation in avoidable waste. When wastage due to processing lack of labor was added in the second step, the explanation of variation in avoidable waste improved by another 21% and it became more than 51% (R2 = 0.505). Entry of the factor poor packing methods in the third step explained another 15% of variation in avoidable waste [Total value of explained variation being about 66% (R2 = 0.656)]. Damage due to pest attack as a factor of avoidable waste, incorporated in the fourth step, explained another 6% of variation [The total being 71.4% (R2 = 0.714)]. As already spelt out, the addition of wastage due to damaged part of fruits removal, explained about 5.2% of variation in avoidable waste.

Relative Importance of the Independent Variables Through Un-Standardized Coefficients: Table 5 contains both un-standardized and standardized coefficients. It is customary to use the un-standardized coefficients to explain their relative influence on the dependent variable and the standardized coefficients to determine the relative importance of the independent variables. In the regression equation given in Table 5, all the independent variables turned out to be statistically significant. This implied that all the variables included are important. Each independent variable was made to enter one by one in each step. In step 1, the wastage due to long travelling distance alone entered. A unit increase in distance travelled would increase the wastage by 0.354 units. To avoid this proper packing and handling methods need to be adopted. In the second step wastage due to lack of labor entered along with the distance travelled. This resulted in increased influence of distance travelled on avoidable waste by 0.432 units for every increase in unit of distance travelled. A unit increase in lack of labor would add to the avoidable waste by 0.332 units. In the third step, wastage due to poor packing entered and with the rest of the variables till the second step. This increased the influence of both distance travelled and lack of labor on avoidable waste (0.468 and 0.344 respectively). Every effort taken to adopt good packing practice would bring down the avoidable waste by 0.278 units. This underscores the importance of packing method for transporting such perishable products. Depending upon the type of fruits to be transported, appropriate packing method along with right packaging material is need to be used. For example, use of plastic tray with separators or use of recycling paper tray or use of perforated sponge covering could help to minimize physical contact between fruits, with which physical injury can be minimized and also the temperature could be minimized on the outer skin as well as inner flesh of the fruits. Adoption of such good packing practices would help to minimize the waste. The fourth stage witnessed the inclusion of damage due to pest attack by whole fruit along with the other variables in the third step. This resulted in capturing increased influence of distance travelled, lack of labor and poor packing method on avoidable waste to the tune of 0.403, 0.397 and – 0.292 respectively, compared to the third step value of these coefficients. The avoidable wastage goes up by 0.189 units for every additional damaged caused by pest attack by whole fruit. Protection from such damage would help to bring down the avoidable damage to some extent.

An interesting outcome could be noted in the first step. With the addition of wastage due to damaged part of fruits removal as an independent variable, results in reduced influence of distance transported and lack of labor on avoidable waste. This is because, the avoidable waste caused by factors in the four steps is removed in the fifth step, the overall avoidable waste declines. That is, when damaged parts of fruits are removed before the transporting or processing stage start, the overall waste would go down. In order to determine the relative importance of the independent variables the standardized coefficient values were studied. In all five steps wastage due to long travelling distance turned out to be the important variable, followed by wastage due to lack of farm labor. This would imply that if effective steps are taken to minimize the wastage due to long travelling major part of the wastage of fruits could be avoided. For this purpose, apart from using appropriate packing methods, vehicles with cold storage facility alone should be used. The maintenance of internal temperature in the storage space of the vehicle would have considerable effect in preserving the fruits in storage.

Seven base variables such as poor raw material transportation, farm gate wastage, processing wastage, poor packaging, traditional ripening, labor wastage and lack of skilled labor wastage were identified from factor analysis. Similarly, five significant variables such as wastage due to long travelling distance, lack of labor, poor packing methods, damage due to pest attack and wastage due to damaged part of fruits removal were found from stepwise regression analysis. In both analyses, long

travelling distance of raw materials plays the predominant role in avoidable wastage of fruits at processing stage followed by lack of labor and poor packing methods.

Wastage Due to Long Travelling Distance of Raw Materials: More than 90% of fruit processing units are located at Krishnagiri and Dharmapuri districts of Tamilnadu. Moreover, all first level fruit processing units are working for just 60 to 90 days in a year due to seasonality of the raw materials. Therefore, competition for the procurement of domestic raw materials within around 50km radius turns out to be very high, escalating the price. Hence processing units were forced to procure the raw materials from long distance to achieve capacity utilization during the season. Most of the units were procuring more than half of raw materials from more than 300kms. It requires 12 to 24 hours of travelling time between raw material source locations to processing unit location. None of the units was using any vehicle with cold storage facility for transporting the raw materials. Mr. Tilak Ram, the treasurer of Krishmaa Cluster Development Society (KCDS) stated that though all the fruit processing units are located within a range of 40 km, yet within this distance 30-40% fresh fruit spoilage occur [8]. About 30% of fruits and vegetables grown in India (40 million tonnes amounting to US$ 13 billion) get wasted annually due to lack of cold storage transportation and cold storage facilities [13]. No proper packaging methods or packing materials were used for the raw material transportation. Simply the fruits were loaded on to the vehicle and carried to the processing units. This affects more the fruits at the bottom due to heavy weight on them and also poor road condition. Fehr reported that intrinsic factors in the stages of storage, transport, packaging, sorting, handling and administration were contributing to fruits losses [18]. Temperature of the fruits also increased due to long distance transportation. One of the articles on supply chains of fruits and vegetable reported that the loss of fruits and vegetables during transportation was said to be in the range of 20 - 30% in countries like China and India [19]. Moreover, most of the first level fruit processing units were operating exactly during peak summer season. This also caused the increase of temperature during long distance transportation. High temperatures and variations in temperature happened to be the root cause for spoilage of fruits during ripening. All fresh produce is subject to damage when exposed to extremes of temperature [20]. One of the major problems of food waste in much of United States' food was transported long distances and as it travels, the temperature often changes dramatically [21].

Wastage Due to Lack of Labor: Lack of labor at processing units was the next major reason for fruit wastages. Professional aptitude of personnel [18] especially absenteeism was prime reason for the labor shortage. People were preferred to work in the National rural employment guarantee scheme of the central government as it provides more income with less work. Further a number of the people go to near industrial locations such as Hosur and Bangalore in search of permanent job, whereas fruit processing units could provide jobs for just two months. Around 60 fruit processing units were located within 50km radius and they could get very few workers in this radius. People were also hesitating to come from long distance, since the job was seasonal. Because of the above reasons, fruit processors experienced challenging situation for getting man power. Few processing unit owners managed to use rural students of just 15 years of age. Though it was win – win situation for both processors and students in terms of generating income to meet their respective needs (This seasonal operation days exactly falls on school summer holidays), yet the regulation relating to use of child labor effectively prevent this option.

Raw data of this study revealed that, maximum wastage limit due to lack of labor was 5%, whereas it was just less than 1% in case of skilled labor shortage. Hence it was noted that there was no need of training labors for working in fruit processing units. Hence using alternative source of manpower could be considered. For example, a number of self-help groups could be approached and involved in the processing stage. As the work is only seasonal, the self help group might be able to add to their earning capacity during the processing season. One more option is to train school children in the processing stage during their vacation period, so that they would benefit learning an occupation and use that to supplement their family income. Training of school children could be considered as a part of the curriculum so that the provisions of Child Labor act would not be a stumbling block. As the scale of commercial production and the distances between the rural producer and urban consumer increase, more exacting requirements will have to be met in regard to training and supervising labor [20].

Wastage Due to Poor Packing Methods: Poor packing methods for raw materials transportation was another key source for the fruit wastages. All the fruit processing industries were receiving their raw materials in crude manner without any package during transportation. Tractor trucks, mini trucks and lorries were used for

transportation from farm gate to processing unit locations. Crude transportation, long distance on poor road conditions causes heavy damage to fruits internally and externally. Internal damage could cause spoilage of raw materials during ripening process. Moreover, when vehicles were not supported by cold storage facility, heat gets generated affecting both inside pulp/flesh and external skin. This resulted in precocity and lack of freshness in the raw materials and lead to spoilage of fruits before and during ripening. Vehicles need to use plastic crates so that wastage could be minimized. Most of the fruit processors were also pointing out that productivity improve with good quality raw materials and suppliers would also get higher profit. For this suppliers need to use cold storage vehicles. In this case also, both suppliers and processors were expecting that government could help them by providing some support through subsidy or low interest on vehicle loans, improved infrastructure etc.

Wastage Due to Damage: Regression analysis shows that damage due to pest attack and removal of wastage portions from the fruits also significantly impacts the total avoidable fruit wastages. For example, long distance travelling with poor packing methods causes the spoilage of fruits during ripening. This spoilage portions could be removed before starting the process. Another major source of wastage in the processing units was lack of labor especially during sorting process in the ripening process. Experienced processors were stating that, lack of sorting labor for one day was causing around 5 to 10 % of total fruit loss during ripening. Careless handling of fresh produce causes internal bruising, which results in abnormal physical damage or splitting and skin breaks, thus rapidly increasing water loss and add to the wastage. Skin breaks also provide sites for infection by disease organisms causing decay. All living material is subject to attack by parasites. Fresh produce could become infected before or after harvest by diseases widespread in the air, soil and water. Some diseases penetrate the unbroken skin of produce; others require an injury in order to cause infection. Damage so produced is probably the major cause of loss of fresh produce [20].

Wastage Due to Traditional Ripening: Fleshy fruits undergo a natural stage of development known as ripening. This occurs when the fruit has ceased growing and is said to be mature. Ripeness is followed by ageing (often called senescence) and breakdown of the fruit [20]. This study also discovered through raw data that, traditional ripening was one of the major wastage causing sources. To avoid this, processors were suggesting use of ripening chambers. Small processors argued that constructing ripening chambers were challenging task since it involves huge initial cost. Hence again processors were expecting some support from government for constructing ripening chambers through subsidy or provision of ripening chambers at reasonable rent. These chambers could be used for storage of other grains during off season [15, 16].

CONCLUSION

Out of all stages in fruit supply chain, wastage at processing stage is the second major source of wastage, first being retail stage. As only few Indian studies are about wastage at processing stage, this study confined to identifying major sources of wastages at the processing stage and strategies required to minimize the wastage, which would add to the income of farmers and profit of processors. Long travelling distance of raw fruits with poor packing methods and transportation were found to be the major sources of wastage in the processing stage. Lack of labor and damage removal also plays the significant role in wastage. Raw materials transportation with good packaging methods and materials in refrigerated environment will minimize the wastage. Similarly, aseptic and automatic process with the support of ripening chambers also would reduce the wastage level. All these strategies are still on paper for most of the fruit processing units as implementation warrants heavy initial investment. Hence government could extend its support to build infrastructure in terms of transportation in refrigerated environment with good packaging methods and materials and facilitate manpower through amendment governing use of subsidies and manpower in the rural areas.

Scope for Future Research: Since this study was confined to only Tamilnadu state, similar type of studies could be undertaken in other locations where fruit cultivation is undertaken in large areas. As geographical and temperature conditions differ in different locations, appropriate changes in processing and preservation technology, methods of manpower use coupled with detailed research on fruits resistance to infection could go a long way to benefit the farmers and processers.

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