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# Assessment of wastages in fruit supply chain with respect to fruit processing units in Tamilnadu, India

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**Abstract**

In spite of being a second largest producer of overall fruits, India is wasting around one third of the output due to various reasons. Food losses take place at production, postharvest and processing stages in the food supply chain. Food losses occuring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior. 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. 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 handling during cleaning, sorting and grading 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.



## Introduction

Food and Agriculture Organization of United Nations revealed that around 1.3 billion tons of food are wasted or lost globally in a year (Gustavsson *et al.*, 2011). A reduction in food also improves food security by increasing the real income for all the consumers (International Bank for Reconstruction and Development *et al.*, 2011). According to Alexandratos and Bruinsma (2012), food supplies would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution, and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security (Jaspreet *et al.*, 2013). Indian Ministry of Food Processing Industries (MoFPI) is also working towards minimizing wastage at all stages in the food processing chain by the development of infrastructure for storage, transportation and processing of agro-food produce as one of its goal (Ministry of Food Processing Industries, 2014). 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 (Daily News and Analysis, 2008). Wastage was reported in all stages of supply chain such as post harvest processes, farm gate, transportation, cold storage, processing, trading and retailing. Food losses take place at production, postharvest and processing stages in the food supply chain (Parfitt *et al.*, 2010). Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior (Parfitt *et al.*, 2010). 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 (Planning commission, 2013). Agricultural

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wastage was one of the reasons for high inflation prices. Minimizing wastage would improve the return for both farmers and retail vendors. It also support future food security and fulfills one of the prime goals 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 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.

## Materials and Methods

*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 (Paulrajan, 2010; Jaspreet *et al.*, 2013). But this 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 (Directorate of horticulture and plantation crops, 2014). Processing units in Krishnagiri and Dharmapuri districts were selected as these locations account for 90% of the fruit processing units in Tamilnadu (IL&FS for National Innovative Council, 2012; Karthick *et al.*, 2013; Nita *et al.*, 2013). Similarly, Chennai Koyambedu fruit market is one of the biggest fruits market in Asia in terms of trading and retailing (Tamilnadu Agricultural University, 2013; Wikipedia, 2014). All these locations are also having large number of farmers and cold storage units (IL&FS for National Innovative Council, 2012). 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

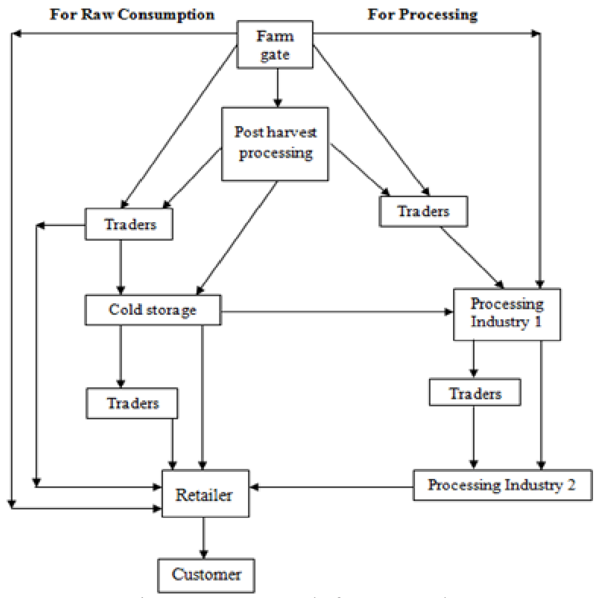

Figure 1. Research frame work

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 (Nita *et al.*, 2013).

*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 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, are called as avoidable waste (Fehr and Romao, 2001). Customary remains after consumption of the fruits that are not edible like banana peel, mango seed etc., were considered as unavoidable waste (Fehr and Romao, 2001). In line with the UN Food and Agriculture Organization'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 and food waste. Food losses occur at the production, post-harvest and processing stages and food waste arises at the retail and consumption stages (Gustavsson *et al*., 2011; Food and Agriculture Organization of the United Nations, 2013). 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 (Food and Agriculture Organization of the United Nations, 2013). 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. 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 value of each range of wastage was calculated and the same was used as weight. Then weighted average was calculated by multiplying percentage of respondents by the weights. 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 by feeding each stage (group) variables manually for identifying the relative importance of factors of wastage in different stages of fruit supply chain.

## Results and Discussions

*Data reliability*

Five broad factors already specified in

Table 1. 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% |

methodology were considered for further analysis. Since ripening factor had single question, there was no possibility for determining the data reliability for the same. Reliability for remaining four factor's variables based on Cronbach's Alpha value was measured by applying SPSS software package. Reliability of all four factors such as farm gate, transportation, packaging and processing was measured as 79%, 88%, 79% and 76% respectively. Since all the reliability value 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. 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 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 reported around 72% of the total fruits and vegetable goes waste in India (Daily News and Analysis, 2008).

The percentage distribution details of total wastage in fruit processing units were determined. Traders realized very less wastage since they only mediate between farmers and processing and retail stages 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. Other research reported that 93% of farmers screen their produce before it leaves the farm (Fehr and Romao, 2001) 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. Maheshwar (2006) 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. 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. Another similar study also reported that farmers in both traditional and modern chains incurred the loss of 12.5% on average mainly due to pre-harvest causes, i.e. fruit immaturity, insect damage and diseases/rotting. In the modern chain, collector-wholesalers or distributor and supermarkets incurred an average loss of 5% each due to physical injury, decay/rotting, over-ripening and weight loss which almost the same as that in the traditional chain (Buntong *et al*., 2013). 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 (Arivazhagan *et al*., 2011; Arivazhagan and Geetha, 2012).

Based on the Table 1, it is clear that processing units and retail outlets realized more wastage than the other stages. Hence this study is focusing to analyze only the causes of wastages and its sources in fruit processing units. 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 (Arivazhagan *et al*., 2012) and 44% as processing wastage (including all stages wastage from farm gate to processing units) (Arivazhagan *et al*., 2011; Arivazhagan and Ravilochanan, 2012). Though other stages are the root causes of wastages, traders and other middlemen

Table 2. KMO and Bartlett's Test of factor analysis

| 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 | 231 |
| | Sig. | 0.000 | 0.000 |

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 by reducing numbers of factors, using factor analysis. Sampling adequacy and significance was tested through KMO and Bartlett's test. Table 2 shows the Sampling adequacy and significance value of processing variables and all remaining variables. KMO value justified that factor analysis can be applied for the data, i.e. 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 3 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 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 in five different stages through the factor analysis. Considering avoidable waste as the dependent factor, and the 21 variables of five different factors as independent factors, stepwise regression was done. This was given the following result.

Five different factors such as farm gate, packing, transport, ripening and processing factors along with

Table 3. Total variance explained in factor analysis

| Component | Initial Eigen values | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | 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 | .816 | 3.710 | 80.704 | | | | | | |

their variables were entered manually in to the model in sequential order. Table 4 shows both $R^2$ along with statistical significance of the above five factors. It clearly revealed that all five factors together explained in the final step 72.8% of the variation in avoidable waste.

However, at each step the influence of the variables entering into the solution explained the percentage variation in the dependent variable. In the first step wastage at farm gate level explained 19% of variation in avoidable waste. When wastage during packing was added in the second step, the explanation of variation in avoidable waste improved by another 8% and it became 27%. Entry of the next stage transportation in the third step alone explained around 30% of variation in avoidable waste (Total value of explained variation being about 56%). Wastage during ripening as a factor of avoidable waste, incorporated in the fourth step, explained another 2% of variation (The total being 58%). The addition of wastage during processing, explained about 15% of variation, and as already spelt out all five factors together explained around 73% of the variation in avoidable fruit waste.

Table 4 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 4, very few independent variables in each stage turned out to be statistically significant. This implied that these variables are important. Each factor was made to enter one by one along with their variables in each step. In step 1, farm gate variables were made entered. Out of all farm gate variables, handling during cleaning, sorting and grading alone was turned out to be significant. A unit decrease in cleaning, sorting and grading would increase the wastage by 0.467 units. In the second step packing variables were made entered along with farm gate variables. Unfortunately no packing variables were become significant, whereas same handling during cleaning, sorting and grading was become significant in the second step too. In this stage a unit decrease in cleaning, sorting and grading would increase the wastage by 0.406 units. Transportation variables were made entered in the third step along with previous farm gate and packing variables. A new variable called wastage due to long travelling distance was turned out to be significant along with previous handling during cleaning, sorting and grading variable. This resulted in increased influence on avoidable waste of one unit by 0.303 unit for every increase in unit of distance travelled and 0.372 unit for every decrease of cleaning, sorting and grading.

The fourth stage witnessed the inclusion of ripening variable along with the other three variables till third step. Again in this step too, no ripening variable was become significant, whereas previous two variables such as handling during cleaning, sorting and grading and wastage due to long travelling distance. This resulted that one unit of wastage on avoidable waste by 0.299 unit for every increase in unit of distance travelled and 0.348 unit for every decrease of cleaning, sorting and grading. Final key variables called processing variables were made entered in fifth step along with last four mentioned variables such as farm gate, packing, transportation and ripening variables. Surprisingly, previous stage (packing) variable called poor packing method were turned out to be significant in this stage along with previous variables such as handling during cleaning, sorting and grading, wastage due to long travelling distance and current processing variable called lack of labor. Final stage resulted that every improvement in poor packing method would bring down the avoidable waste by 0.274 unit. This underscores the importance of packing method for transporting such

Table 4. Stepwise regression coefficients and model summary

| | Model | Un standardized Coefficients | | Standardized Coefficients | t | Sig. | F | R Square |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | | |
| Farm gate | (Constant) | 3.467 | 0.250 | | 13.868 | 0.000 | 7.97 | 0.194 |
| | Handling during cleaning, sorting and grading | -0.467 | 0.165 | -0.441 | -2.822 | 0.008 | | |
| Farm gate and packing | (Constant) | 3.606 | 0.272 | | 13.250 | 0.000 | 3.76 | 0.267 |
| | Handling during cleaning, sorting and grading | -0.406 | 0.167 | -0.384 | -2.425 | 0.021 | | |
| Farm gate, Packing and Transport | (Constant) | 4.206 | 0.287 | | 14.659 | 0.000 | 4.2 | 0.563 |
| | Handling during cleaning, sorting and grading | -0.372 | 0.143 | -0.351 | -2.602 | 0.015 | | |
| | Wastage due to long travelling distance | 0.303 | 0.125 | 0.464 | 2.417 | 0.023 | | |
| Farm gate, Packing, Transport and Ripening | (Constant) | 4.473 | .445 | | 10.059 | 0.000 | 3.29 | 0.578 |
| | Handling during cleaning, sorting and grading | -0.348 | 0.160 | -0.329 | -2.180 | 0.039 | | |
| | Wastage due to long travelling distance | 0.299 | 0.134 | 0.458 | 2.234 | 0.035 | | |
| Farm gate, Packing, Transport, Ripening and Processing | (Constant) | 4.173 | 0.374 | | 11.159 | 0.000 | 5.61 | 0.728 |
| | Handling during cleaning, sorting and grading | -0.286 | 0.132 | -0.271 | -2.172 | 0.040 | | |
| | Wastage due to poor packing methods | -0.274 | 0.119 | -0.387 | -2.297 | 0.031 | | |
| | Wastage due to long travelling distance | 0.444 | 0.117 | 0.681 | 3.798 | 0.001 | | |
| | Wastage due to lack of labour | 0.304 | 0.085 | 0.433 | 3.568 | 0.002 | | |

perishable products. Similarly, increase of one unit on avoidable waste influenced by 0.444 unit for every increase in unit of distance travelled and 0.286 unit for every decrease of cleaning, sorting and grading. Finally, a unit increase in lack of labor would add to the avoidable waste by 0.332 units.

*Wastage due to handling during cleaning, sorting and grading*

Careless harvesting and handling of fruits would be a major cause for avoidable wastage. Mechanical injury during harvesting, throwing of fruits, mechanical cleaning, removal of immature, over mature, pest attack fruits, decay and damaged fruits were the major reasons for avoidable wastage. Proper harvesting methods, right time harvesting, smooth cleaning, training and development of fruit handlers would rescue these type of wastage. 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 (Food and Agriculture Organization of the United Nations, 1989).

*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 50 km 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 300 kms. 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 (Karthick *et al.*, 2013). 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 (Gustavsson *et al.*, 2011). 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. Other research reported that intrinsic factors in the stages of storage, transport, packaging, sorting, handling and administration were contributing to fruits losses (Fehr and Romao, 2010). 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 (Articles Base, 2010). 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 (Food and Agriculture Organization of the United Nations, 1989). 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 (World food program of United Nations, 2013).

*Wastage due to lack of labor*

Lack of labor at processing units was the next major reason for fruit wastages. Professional aptitude of personnel (Articles Base, 2010) 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 just15 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 (Food and Agriculture Organization of the United Nations, 1989).

*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., (Buntong *et al.*, 2013).

## Conclusion

While hunger is the world's number one health risk (Forbes, 2012), about one third of food for human consumption is lost or wasted globally each year (World food program of United Nations, 2013).

Fruits are very nutritious at the same time very low shelf life goods. Since production of many perishable food crops is seasonal, they are produced in greater quantity than the market can absorb, so the surplus of many of these crops must be processed and preserved to avoid wastage of the food and loss of income to the grower (World food program of United Nations, 2013). Fruit processing units were the main sources for adding value and providing extended shelf life for the fruits by converting fruits in to pulp and other value added products. Such a main source is one among the fruit supply chain. Out of all stages in fruit supply chain, this source is experiencing second major source of wastage next to retail. Hence this study was conducted with the objective of identifying major sources of wastages and its minimizing strategies with which the income of farmers and profit of processors could be maximized. Long travelling distance of raw materials with poor packing methods and transportation were the major sources of wastage in the food processing units. Lack of labor and damage removal also plays the significant role in wastage. Raw materials transportation with plastic crates in cold environment will minimize the wastage. Similarly, automatic process with the support of ripening chambers also would reduce the wastage level in fruit processing units. All these strategies are still on paper for most of the fruit processing units. Hence government could extend its support to build infrastructure and facilitate manpower through amendment in existing policies. Though policy changes are highly challenging, Renee Kim (2013) stated that developing effective risk management in the food supply chain is important not only in particular country's context, but also in global context. Since India is one among developing country in the global level, it could develop effective management system in fruit supply chain by introducing policy amendments in order to minimizing the level of fruit wastages.

Since this study was confined to only Tamilnadu state, similar type of studies could be undertaken in all states of India. 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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