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A Study on Fruit Wastage in Mass Scale Fruit Processing Industries in Sri Lanka and their Potential to Reuse

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ABSTRACT

Process food industry in Sri Lanka has been expanded with the open economy, increase of population, technological development, and the modern lifestyle of people. Meantime, disposal of solid food waste from such industries has become one of the major environmental issues in the country. Although fruits are the leading food waste type generates globally, literature for fruit wastes (FW) generate in Sri Lankan fruit manufacturing industries (FMI) is scanty. Therefore, the objectives of this study were to investigate the types and amounts of FW generates in FMI, waste management practices currently employing in FMI, issues and challenges associated with the implementation of sustainable waste management practices and potentials of reuse and recycle the FW instead of disposal. The study was carried out as a qualitative study using the five leading FMI in Sri Lanka and the data were collected through a questionnaire survey, personal interviews, focused group discussions and personal observations. Gathered data demonstrated that annual fruit wastage of FMI is around 35 to 60%. Pineapple leftovers found to be the leading FW type generates in local FMI. Out of studied industries, only one FMI recycle and reuse the FW by composting and for others FW is a profit loss since they hire a third party to dispose the waste. As such, there is a great potential to reuse and recycle the FW generate in Sri Lankan FMI. However, financial restriction, lack of affordable technologies, difficulty in finding workers and lands, and public protest against the development of waste processing areas were identified as manger issues in the attempt of reuse and recycling the waste.

Keywords

Fruit manufacturing industries, Fruit wastes, Recycle, Reuse.

Introduction

Fruits and vegetables account for the highest food waste (45%) generate globally [1]. In Asia, it is 37% from total agricultural waste [2]. In a study conducted by Adikaram in 1986 [3] it has found that fruit waste generate by only the stalls in Central province of Sri Lanka as 5 to 25% . After 32 years from that study, the post-harvest losses of fruits in the country is lying between 20-40 % [32]. This huge fruit losses cause an economical damage about $800 million annually [5] along with environmental and social problems.

Fruit losses happened in the processing stage causes comparatively high economic damage due to the additional cost for transportation, storage, electricity, machines, technology, labors, etc. [3]. They also contribute to the waste of resources such as land, water, energy and other inputs used in fruit production [6]. Further, this wastes are either land filling, release to natural water ways, or else incineration in the industrial level cause environmental, social and economic problems as a solid waste; contributes to greenhouse gas emission, water pollution, bad odor, harbor for flies, mosquitoes, rats and pathogens, etc. [6,7]. Therefore, manufacturing industries should pay attention on effective management of these losses since economic growth cannot be sustained without environmental protection. Although many researches discussed the functional benefits and reuse applications of industrial fruit losses [2;8-12], it is rare to see the practical implementations.

Knowing the types and amounts of fruit waste generated and the potentials and constrains of current waste management practices will ease the waste management process which is pivotal in achieving United Nations' sustainable development goals in the country [13]. Yet, there is no any published literature on fruit processing losses and their management in the country, to the date. As such this study was conducted to investigate type, amounts,

potential to reuse and the causes of fruit waste generated from large scale fruit manufacturing industries in Sri Lanka and this is the first study conducted on above aspects in Sri Lanka.

Methodology

The study was carried out among the five leading fruit manufacturing industries (FMI) in Sri Lanka and the data collected through a questionnaire survey, personal interviews, focused group discussions (e.g. quality assurance executives, coworkers, etc.) and personal observations.

Types and amounts of fruit wastes (FW) generates in FMI, waste management practices currently employing in FMI, issues and challenges associated with the implementation of sustainable waste management practices and potentials of reuse and recycle the FW instead of disposal are the major areas highlighted in the survey.

Results and Discussion

Industrial based survey on fruit wastes

Though it is imperative to manage the fruit waste wisely, the literature on such waste management applications are not adequately available (Schneider, 2013). Therefore, this survey was conducted among five large scale fruit manufacturing industries (FMI) in Sri Lanka (named as A, B, C, D and E) to gather information.

Background study

Autocracy of the FMI in Sri Lanka is owned by privet sector, so as the five companies selected. Type of production lines of selected industries are semi-automated except 'A', which is a fully automated FMI.

The companies are owned quality certificates such as ISO 22000, ISO 9001, HACCP, HALAL, SLS, kosher, BRC, IFS, FDA, fair trade etc. However, only company 'C' and 'D' got the ISO 14000 certificate (Quality standards related to environmental management). Focus group discussions with production managers and quality assurance executives revealed that most of the companies consider on environmental quality standers only if they exporting the products. Less awareness of local consumers on environmental quality standards as well as considerable annual cost for the quality certificates discourage them of applying for such certificates.

When consider the two industries who has ISO 14000 certificate, Industry 'C' has their own waste management system while D get the service of a third party to manage the waste. Other industries also get the service of the third party to manage the waste but in ad hock manner.

Types and amounts of FW generates in FMI

FMI perform both 'fresh pack' and 'processing/value adding' activities. The five selected industries are basically involved in 'processing' activities of jam, nectar, cordial, chutneys, etc. Pineapple, mango, papaw, lime, passion fruit and wood apple are the main raw materials for them. Types and amount of the waste generated by these industries are shown in Figure 1. Soursop, water melon, ash pumpkin, banana, guava, bread fruit and embarella also utilized for the production in these industries in minor quantities. In addition, small scale fruit outlets largely utilized avocado and orange for juice production. Fruit waste can divide into two categories as solid waste (peels, seeds, stones. Shells, fruit pieces, pulp/pomace) and liquid waste (fruit juice). Principal waste part of each fruit type was elaborate in Table 1 in their ascending order as per the data obtain from personal interviews with quality management executives and coworkers. According to the data peels are the leading fruit waste type generated.

Fruit type	Fruit waste types
Pine apple	Crown/stem/cores > peel > pulp > damage fruits > juice
Mango	Seed > peels > Damage fruits > pulp > juice
Papaw	Peel > damage fruits > seeds
Lime	Peel> seeds>damage Fruits> pulp > juice
Passion Fruit	Peel> seeds>damage Fruits> pulp > juice
Wood Apple	Shell > Damage fruits > seeds > pulp > Juice

Table 1: Major fruit waste types generate in local fruit manufacturing industries.

Most of the fruits are seasonal, as such, cost for raw materials is less and availability is high in the season. Therefore, FMI purchased additional amount of fruits in the season and freeze for utilize in the off season. According to the information obtained from FMI 'C' freeze fruit pulps can be store over six months. In contrast, some FMI stop the production of particular product at the off season or import raw materials. Amount of purchasing, production and most importantly waste generation fluctuate with the consumer demand. The consumer demand is varying with, product quality, market competition, weather condition, etc.

FMI are not calculating their fruit wastes separately, except 'A'. Therefore, in the study, the values were calculated using the purchasing and production data. Accordingly, highest wastage percentage acquired by pine apple followed by passion fruit and mango (Figure 1).

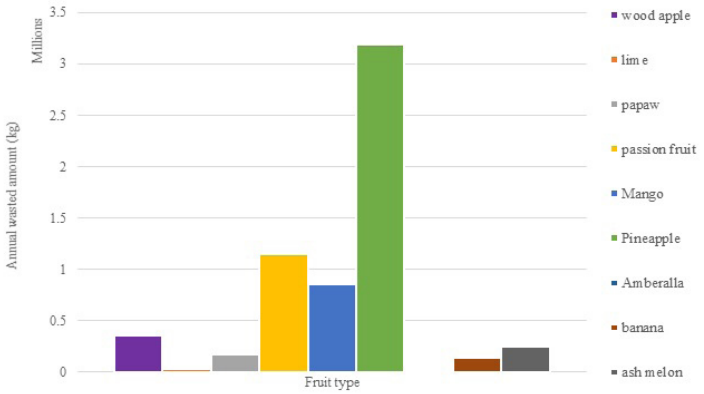


Figure 1: Types of Fruit.

Gathered data demonstrated that annual fruit wastage of FMI is around 35 to 60%. As per the calculations of FMI 'A', their waste percentages for pineapple, mango (kohu), mango (Karthakolomban), papaw, lime, passion Fruit, woodapple, ash pumpkin, and amberella were 55%, 58%, 58%, 52%, 72%, 80%, 58%, 52% and 55%, respectively. Results indicate that, more than half of fruits are wasted.

There are some literature data on postharvest losses of fruits in Sri Lanka. For banana it is about 30% [14]. Highest amount of post-harvest losses observed in papaya [4]. However, present study demonstrated that papaya is not acquired a leading proportion in industrial losses. Pineapple, mango and passion fruit losses are the prominent. Mango and pineapple utilized by all four FMI as raw material (one FMI reluctant to give their purchasing and production data).

Waste management practices currently employing in FMI

AIG introduced five major benefits of reducing wastes in FMI as;

- Reducing the purchasing cost (e.g. through avoiding disposal of damaged products)
- Minimizing waste treatment and disposal costs
- Generating alternative income by finding secondary markets for 'waste' products
- Reducing environmental impacts and resources consumption
- Improving the business' reputation and employee satisfaction [15]

Current study showed that the local FMI have not successfully achieving these benefits though they have several waste managing practices.

Categorization of waste is an important aspect of waste management. According to the study of Balasuriya et al., 2015 [16], 28.6% of small scale food industries in Sri Lanka are not categorizing their waste. However, all the five selected FMI are categorizing the major wastes into two types as fruit losses and packaging waste. In addition, waste water also there. Among them amount of fruit losses is always higher than packaging wastes. This is in accordance with the fact sheet of Australian Industry Group which mentioned 'The major waste streams of FMI are organic waste (including fruit and vegetable rejects, peel and pomace) and other raw material wastes' [15]. However, in depth categorization of losses for each fruit was not observed in present study. Better segregation of fruit losses is a suggestion made by AIG for effective waste management [15].

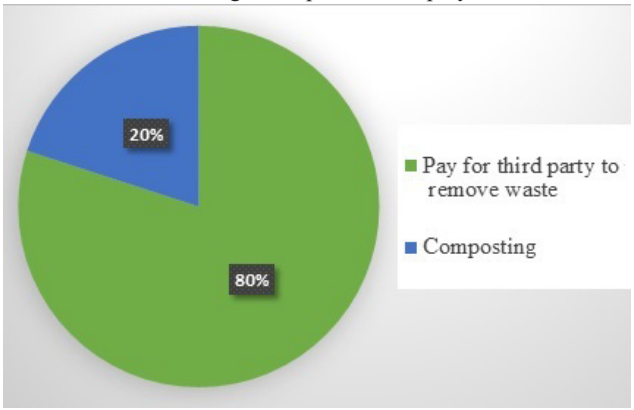
To manage the generated waste, the selected industries are using one or more of following methods;

- Reduce waste generation by importing pulp (without seed/ peel)
- Reduce the waste by rejecting the damaged fruits during purchasing
- Get the service of third party to manage waste
- Production of compost using the generated waste
- Continuous supervision and awareness programs to reduce unnecessary waste

All the FMI purchase their samples from local farmers. FMI 'C' imports the fruits from foreign countries at the off season while 'B' import mango pulp all the time. When purchase as pulps, insight fruit waste generation is mitigate. FMI returned the damaged fruits to avoid insight fruit waste accumulation. Further, food quality and safety practices like first in first out (FIFO), clean in place (CIP), etc. also reduced waste generation. The practices are ensuring with ISO 9001 and ISO 22000 quality standards.

Most of the FMI hired a third party to take away the fruit waste from manufacturing premises which is a profit loss. Purchased fruit wastes are ultimately buried or use as an animal feed. Rarely, mango seeds were given to nurseries. Only FMI 'C' maintained a composting plant and for them fruit waste also profitable in near future as they plan to sell the compost (Figure 2). FMI 'C' cultivated the fruits which needed to their production by using that compost.

Figure 2: Fruit waste management practices employed in five FMI.



Processing is the one single step which generate highest fruit wastage. Peeling, sorting, deseeding, cutting and pulping was identified as leading fruit waste generating processing steps. Hence, all the FMI were continuous supervise and conduct awareness programs to reduce unnecessary waste generate by workers.

Plate 1: Some steps of compost plant in FMI 'C' (a) Fruit waste collected into bins, (b) Fruit waste chopping machine, (c) Allowed to ferment fruit waste (d) Compost, (e) Plant grown by using the compost.

Issues and challenges associated with the implementation of sustainable fruit waste management practices

According to Hui, 2008, the main factors to be consider on waste management of a FMI are age, scale, geographical location of the processing plant, product portfolio and type of process. If a recycle option of the fruit losses take higher cost than the profit from the main products that is useless. Therefore, the reuse and recycle options should tally with the FMI nature. According to Chongrak [17], by product utilizations and waste free technologies are most sophisticated in developed countries, where food production also in mass scale. In developing countries, the options are depending with the financial resources. Reusing fruit losses as food/food additives is the most expensive option due to the requirement of advanced equipment and energy to ensure food safety and quality (e.g. pectin production from fruit losses) [18].

Major two barriers which were identified by this survey that discourage effective fruit waste management are time consumption and labor consumption. In addition, high cost and lack of technological knowledge for advance reuse applications are also were identified. The composting plant of FMI 'C' also faced several problems as difficult to find workers for work with waste, neighbors are complaining about the bad odor of wastes, etc.

Some other FMI also willing to recycle or reuse fruit waste. But they stated that they are not practice that due to lack of adequate space for such waste management. All this FMI located around western province. Placing their branches in country side is a good option to acquire space. That reduce the transportation cost of raw materials as well. FMI 'C' have large and isolated area in Polonnaruwa, Sri Lanka to process their waste.

Fehr et al. [12] emphasized importance of education, training, and information spreading among general population on the importance of industrial food waste management. There are not such practices in local contest.

Potential of reuse and recycle the FW instead of disposal

Reuse of food wastes for human use grab less attention worldwide [20]. Majority of food industry wastes (plant origin) are used as animal feeds [21]. Only 2-3% is marketed for human use [18].

Number of studies have been conducted by researchers from universities and industries at selected FMI and have suggested different methods mentioned in Table 2 to manage waste. However, none of them are practice at those industries due to different reasons mentioned in section 3.1.4.

Company	Suggestion
A	Animal feed, compost and recycle
B	Pineapple sludge – culture media for nata de cocoa Pectin extraction, composting
C	Composting, oil from mango seeds
D	Vinegar from acidic fruit waste
E	Composting

Table 2: Suggestions of the value addition of fruit wastes (Based on the researches did in FMI).

In global perspective there are some examples on fruit losses utilization as by products. According to Hui [18], six main products were produced from fruit losses as; candid peels, oils, pectin, re-formed fruit pieces, enzymes, vinegar or wines. Candid melon peels were used to substitute the sultanas in baked goods. The stones from mango, apricot and peach as well as seeds from grape, passion fruit and papaya can use to extract oils. Oil extracted from palm kernel is a popular cooking oil. Commercially, the three most important enzymes from fruit are papain (from papaya), bromelain (from pineapple), and ficin (from figs). However, the process is not economic since biotechnologically synthesized enzymes are comparatively cheaper. The juices drained from peeling/cutting tables can collect into separate drum and produce wine/vinegar. In addition, commercial pectin is extracted from citrus and apple pomace.

Further, fiber, coloring agents, gelling agents, biogases, etc. can produce from fruit losses. Number of researches discussed on such applications as active carbon from waste cherry stones [22], polygalacturonase production from apple, cranberry, and strawberry pomace [23], potential to produce preserved products such as pickles, tutti-fruiti, vadiyams, and cheese using the white portion of watermelon rind (44% of fruit is peel waste) [24], pineapple, mixed fruit, and maosmi wastes as possible substrates for citric acid production by solid-state fermentation using Aspergillus niger [25], ethanol production potential from banana waste [26] and pineapple peels [27], enrichment of fruit products with beneficial substances (e.g., antioxidants) extracted from processing waste, e.g., fruit peel [28], antioxidant, antimicrobial agents and phytochemicals from fruit wastes [29], pectin from mango peels [30], tomato waste [31] and passion fruit peels [32], citrus waste as substrate for microbial protein production [33], etc. Antioxidant enrichment and antimicrobial protection of fresh-cut fruits using their own by-products also studied by Ayala-Zavala et al. [34] and Vega-Vega et al. [35].

Selected FMI stipulated that they are willing to invest or else sell fruit waste if a novel product produce from them. According to the survey, most of the fruit wastes accumulated in large scale local FMI are unexploited. Therefore, innovators have great potential to value adding this fruit wastes and go for novel economic opportunities.

Conclusion

More than half of purchased fruits are annually wasted in local fruit manufacturing industries. Among them, pineapple, passion fruit and mango leftovers acquired the leading proportions. Out of studied industries, only one FMI recycle and reuse the FW by composting and for others FW is a profit loss since they hire a third party to dispose the waste. As such, there is a great potential to reuse and recycle the FW generate in Sri Lankan FMI. However, financial restriction, lack of affordable technologies, difficulty in finding workers and lands, and public protest against the development of waste processing areas were identified as manger issues in the attempt of reuse and recycling the waste.

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