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Irsyadillah, M. N., Priadi, C. R., Tjahjono, B., Fitri, M. & Islami, B. B.

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Analysis of Number of Fruit Loss in The Fruit Distribution Process: Case Study of Banana Fruit

Muhammad Noval Irsyadillah[1], Cindy Rianti Priadi[1, a)], Benny Tjahjono[2], Maulida Fitri[1], and Brilyana Bela Islami[1]

[1]Environmental Engineering Study Program, Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Indonesia
[2]Faculty Research Centre for Business in Society, Coventry University, United Kingdom

[a)] Corresponding author:
cindy.priadi@eng.ui.ac.id

Abstract. Banana fruit has the highest production rate in Indonesia with a total production of 7.01 million tons/year. However, the amount of fruit waste from the supply chain that supports the production is still uncertain. This study is aimed to analyze the production of fruit waste from the distribution process and to provide some suggestions in optimizing the its process. Data were obtained through direct sampling on three stages i.e. farmers, wholesalers, and retailers. The parameters analyzed temperature, humidity, and waste generation. The results showed that farmers did not produce waste because all the postharvest fruits were sold to the wholesalers. The wholesalers generated average waste 1.98% per total inventory. The retailers produced 2 types of waste from transportation with the average waste generation of 0.67% per total inventory, and daily waste with the average generation of 2.53% per total inventory. Based on this study, improvement in handling systems at distribution process are needed to prevent waste generation. The implementation of countermeasures is also needed by applying the circular economy to improve the efficiency, minimize the waste generation, and improve the profits. The potential actions than can be implemented are utilizing the waste for animal feed and composting.

INTRODUCTION

Indonesia is one of the largest agrarian countries in the world with most of its population works by utilizing natural resources such as farming. The agricultural sector has the highest growth rate of 9.93% of Indonesia's GDP [1]. However, waste production in Indonesia reaches by up to 64 million tons/year with the largest composition being organic waste by 60% [2], including waste from fruits production from agricultural activities. Previous study showed that the food loss at each step of the food supply chain is 15%, 9.0%, 25%, 10% and 7.0%, respectively for agricultural storage, post-harvest and storage, processing and packaging, distribution and consumption in South and Southeast Asia [3]. Therefore, the focus of the agricultural sector in Indonesia is still limited to maximize the efficiency by produce as many products as possible with considering other factors such as waste generation and the potential utilization the by-product. With mainly generates organic waste from the process, the unmanaged can cause of problems for the environment such as groundwater pollution, as well as interfere the biological and chemical components in the soil [4]. Accordingly, this study is aimed to analyze the fruit loss from each stage at each process. Additionally, the analysis of the estimation of the economy loss incurred due to the waste generation, the identification of waste generation factors, and the potential solutions supporting circular economy are also elaborated.

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METHODOLOGY

Research Location

The three stages observed were farmers, wholesalers, and retailers. Each stage was represented by 3 different locations, where data was collected through the direct sampling method. The location for farmer and wholesaler stages were determined at Cianjur, West Java, Indonesia. Cianjur is the second largest banana production in Indonesia after Lampung [5] and Cianjur is the biggest contributor for West Java Banana Production. Meanwhile, the location for retailer stage was determined at Depok, West Java, Indonesia. The retailers linked with Cianjur Banana Production Supply Chain. Each location was determined to have the same production capacity, which is <1 ton/process. The determination was applied, because the number of samples depends on the area of agricultural land that produces fruit [6].

Sampling Method

At each location, data were collected 10 times at different times, adjust to the processing carried out by the parties concerned. Data collected were waste generation, related factors (i.e. air temperature, humidity, as well as distribution time and distance), existing conditions around locations related to opportunities for applying circular economy. Waste generation data were obtained through direct sampling, as well as air temperature and humidity at the storage room using thermohygrometer. In this case, storage was the most important step of the postharvest process which aimed to maintain the quality of the banana [7]. Meanwhile, distribution time and distance obtained through interview with parties concerned, and conditions around location obtained through direct observation.

The novelty of this study was the waste generation data obtained were analyzed along with the related environmental factors, such as temperature and humidity. Those data will be tested through the correlation statistics test to qualitatively and quantitatively analyze the relevancy with the waste generation. The data will be compared to the total banana inventory from stakeholders in each process to assess the efficacy. Then, the waste generation and the related factors obtained will be plotted to box whisker plots and will be statistically analyzed to validate the analysis results through an IBM SPSS Statistics 24.0. Additionally, the economic loss was also calculated at each stage by multiplying banana's selling price with waste generation.

RESULTS AND DISCUSSION

Results showed that the farmer stage did not generate waste because all farmers do not carry out the storage and elimination process after harvest, but immediately sell their postharvest to wholesalers. In fact, farmer generated waste such as banana leaves and banana tree pieces which was not include as waste. However, wholesaler stage generated waste from banana selection before sold to retailers with the average of 1.98% of the total inventory. The retailer stage generated two types of waste, such as from transport with the average of 0.67% of the total inventory and from daily selling and storage process with the average of 2.53% of the total inventory.

In the storage process at the wholesaler stage, the temperature range was 22.1–29.8 ^{o}C and the humidity range was 82–98% which resulted correlation value of 0.455 with the production of wholesaler waste. Meanwhile, the temperature range was 19.3–29.2 ^{o}C and the humidity range was 56–99% in the storage process at the retailer stage which resulted correlation value of 0.637 with the production of daily retailer waste. Based on these statistical tests, it was proven that temperature and humidity during storage can affect the waste generation. Next, based on interviews, the value of the transport distance range between 113–305 km and the transport time range between 5–12 hours from all retail traders. These data were then statistically analyzed which resulted correlation value of 0.580. So, it was proven that the distribution time and distance can also affect waste generation during transport.

Fruit waste and loss also caused economic loss with the average of IDR 0 for farmers, IDR 40,617 for wholesalers, IDR 208,880 for retailers due to transport waste, and IDR 114,000 for retailers due to daily waste, respectively. The small percentage of waste generation which resulted low price of loss did not guarantee the total economic loss suffered will be a little because the determination was by the quantity of waste produced. Fig. 1 below are the results of waste generation and the related factors.

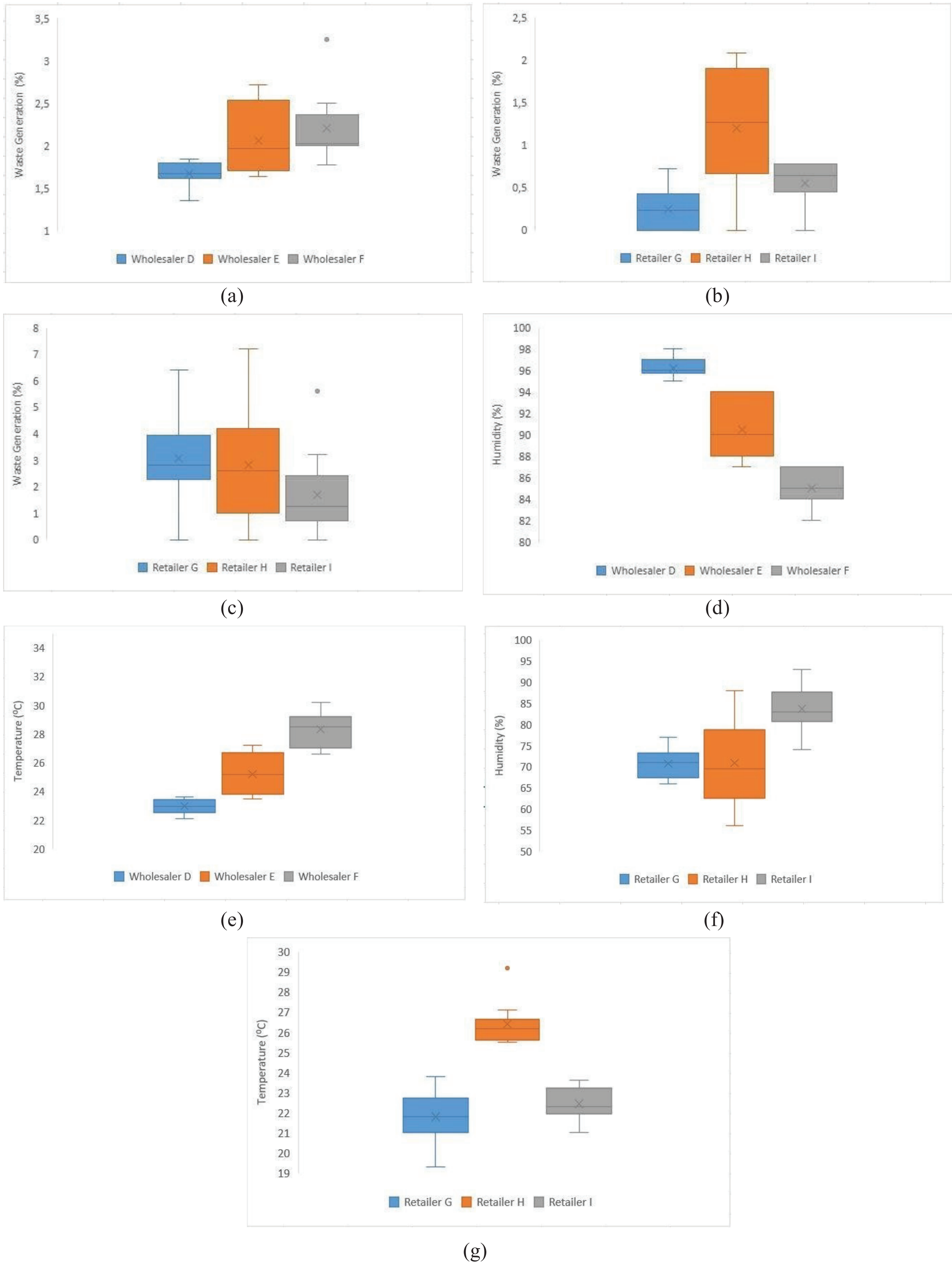

FIGURE 1. Waste generation of (a) storage processing at wholesaler stage; (b) transport at retailer stage; and (c) daily waste at retailer stage. The (d) humidity and (e) temperature of storage room at wholesaler stage. The (f) humidity and (g) temperature of storage room at retailer stage.

Compared to previous studies on banana waste using interview and questionnaires methods. This study obtained the waste generation by up to 7.7%, 8.6%, and 3.2% for farmers, wholesalers, and retailers, respectively [8]. However, the results of this study were like previous study which used the same sampling methods. One of its was research on food loss assessment in Kenya (2014), that obtained the waste generation data by up to 0%, 3%, and 3% for farmers, wholesalers, and retailers, respectively [9]. The two methods can result different data depend on the sources and ways. Interview and questionnaires method get the data from the estimation of the parties involved that could lead to subjective opinions and less accurate data. However, the data from direct sampling method in the field was quantitatively representative to the real condition. Another thing that should be noted the percentage of waste generation is indeed low compared to the total production.

For example, the wholesaler stage used in this study with the average total production of 500 kg/process and was multiplied by 2% as the average waste generation, the amount of waste generation at 10 kg. This amount can be even greater if it is included in the national production of bananas in Indonesia, which has a production rate of 7.01 million tons/year. The banana waste can generate by many factors, such as temperature and humidity during storage.

The optimum temperature and humidity in ripening process of bananas were 16–22 °C 85–95% [10,11]. Based on these studies, all the wholesalers and retailers did not meet the optimum temperature and humidity. The change of the colour of ripen banana with green skin to yellow was due to the decomposition of chlorophyll [12]. Therefore, all retailers must keep the temperature lower than the optimum ripening temperature to prevent the breakdown of chlorophyll.

Based on these findings, there are some ways to tackle the banana waste issue in order to prevent negative impacts on the environment and to enhance economic value. The priority scales of waste management can be determined based on the resource, economic value, and technological capabilities. At the wholesaler stage, the most ideal waste management are animal feed and composting which potentially can support other business activitiy such as farming or even the use of local. At the retailer stage, the tackling of waste issue can be done by feeding hungry people by selling eatable banana, especially waste from transport, with cheaper price (around 10–20% of the normal price). This has been proven to provide additional income to the workers, even though it was not too large. Another option is by selling the waste to fertilizer industry based on the location and the level of business. However, this implementation needs more effort, especially in finding fertilizer business partners who accepts banana waste.

CONCLUSION

The highest waste generation during postharvest stage was from daily waste at the retailer stage, with the average of 2,53% with economic loss of IDR 114,000. However, the highest economic loss was from distribution due to higher total inventory than daily waste, with the economic loss of IDR 208,880. The total fruit loss (in kg) and economic loss will depend on inventory or total production. However, the loss can be tackled by some ways, such as feeding hungry people, animal feed, and composting.

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