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Horticultural Loss Generated by Wholesalers: A Case Study of the Canning Vale Fruit and Vegetable Markets in Western Australia

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Abstract: In today's economic climate, businesses need to efficiently manage their finite resources to maintain long-term sustainable growth, productivity, and profits. However, food loss produces large unacceptable economic losses, environmental degradation, and impacts on humanity globally. Its cost in Australia is estimated to be around AUS$8 billion each year, but knowledge of its extent within the food value chain from farm to fork is very limited. The present study examines food loss by wholesalers. A survey questionnaire was prepared and distributed; 35 wholesalers and processors replied and their responses to 10 targeted questions on produce volumes, amounts handled, reasons for food loss, and innovations applied or being considered to reduce and utilize food loss were analyzed. Reported food loss was estimated to be 180 kg per week per primary wholesaler and 30 kg per secondary wholesaler, or around 286 tonnes per year. Participants ranked "over supply" and "no market demand" as the main causes for food loss. The study found that improving grading guidelines has the potential to significantly reduce food loss levels and improve profit margins.

Keywords: food loss; sustainability; food supply chain; food security; loss management; productivity

1. Introduction

Food loss is a serious global problem that needs immediate action [1]. The loss begins at the farm and continues throughout the food supply chain [2,3]. Fruits and vegetables are delicate products that are subjected to a number of natural and physical sources of deterioration during the marketing process that leads to food loss [4–10]. The high loss levels reported (typically ~35%) are serious threats to food security and the long-term economic sustainability of the food supply chain for present and future generations [1,11–13]. In addition, fruit and vegetable shortages resulting from loss can also contribute to commodity price increases [14–16]. Furthermore, food loss has a negative environmental impact on land usage, water resources, and the use of non-renewable resources such as fertilizer and energy that are utilized to produce, process, handle, and transport the food [17]. Because of the impact of food loss, government, industry, and community groups need to collaboratively work together to achieve policy and cultural change towards the prevention of loss at all levels in the food supply chain [18].

Food supply chains are complex networks consisting of several stages that begin at the farm and end on the proverbial plate of the consumer. Research into the various stages of a food supply chain concerned with fruit and vegetable loss have focused on producers [5,13,16,19–21], retailers [22–27], and consumers [19,28–31]. An often overlooked and rarely studied stage in the food supply chain is the wholesale sector and, as a result, very little reliable data is available. According to Cadilhon et al. [32], wholesale markets can be defined as physical places where supply chain actors (such as producers, processors, retailers, grocers, caterers) come together to buy and sell products to other professionals. Recently, Stenmarck et al. [33] discussed both retail and wholesale trade loss produced in several Nordic countries (Denmark, Finland, Norway, and Sweden). However, their study was based on a review of currently available literature and produced no new data quantifying the amounts of fruit and vegetable loss in the respective Nordic countries. The study did indicate that food loss amounts tended to vary depending on the individual characteristics of the respective retail and wholesale sectors in each country. The study also highlighted the need for further research into establishing the levels of loss in both the retail and wholesale sectors in the respective Nordic countries.

Like many other countries, the fruit and vegetable sector is an important component of the Australian economy. In 2015, Australia's fruit and vegetable production was estimated to be 5.77 million tonnes and valued at AUS $10.59 billion [34]. Most large Australian cities have wholesale markets to distribute fresh fruits and vegetables to a variety of retailers who will in turn supply smaller retail outlets in the surrounding regions [2]. The wholesale market investigated in the present study is located at Canning Vale (south of the states' capital, Perth, as shown in Figure 1) and plays an important role in the Western Australian economy. The present study, for the first time, identifies causes for and extent of food loss at the wholesaler stage for a major food value chain in the state of Western Australia. An innovation of the study is its examination of several approaches that can be applied to reduce and utilize food loss by wholesalers. Among the wholesalers, 53% were primary wholesalers (buy produce directly from growers) and 47% were secondary wholesalers (buy produce in bulk from primary wholesalers and supply to the local retail market, caterers, and customers with specific requirements). The study consisted of a ten-question survey that was distributed to all wholesalers, and their responses were recorded. The questions were designed to: (1) determine quantity of produce (fruits and vegetables) received and supplied; (2) estimate the level of fruit and vegetable loss; (3) quantify the ratio between supply and loss; (4) identify the key reasons for loss generation; and (5) identify loss reduction and innovations currently being applied or under consideration for future food loss reduction and utilization strategies.

2. Materials and Methods

2.1. Survey Methods and Questionnaires

The study collected primary data via a structured questionnaire aimed at businesses that receive and sell fresh fruits and vegetables at Market City Canning Vale, Perth, Western Australia. The market facility consisted of refrigerated warehouses throughout, including packaging and a number of open display areas, as seen in Figure 1b,c. Produce handled was largely domestically sourced (94%), with a small volume of imported crops (6%). Research in this field has shown that estimating the levels of fruit and vegetable loss is often difficult and in many cases not reliable. Historically, two main approaches have been used to measure food loss. The first approach actually measures what has been lost, but this implies knowledge of what was present at the outset and this is usually not the case [35]. The second approach uses an Investigative Survey Research Approach (ISRA) to elicit loss estimates from those involved in the food supply chain [36]. In the second approach, a structured questionnaire enables the collection of various information from respondents [37]. The questionnaire used in this study considered: (1) produce sold; (2) the amount of received produce in a week; and (3) the amount of produce loss per week. In addition, to assist wholesalers, all questions had multiple answer choices based on an extensive background literature review. Respondents were asked to choose the "most" or

"least" preferred answer choice. In this survey, loss was defined as the portion of fruits and vegetables that do not reach their natural destination. In this case, human consumption and losses result from spoilage, decay, or any other kind of deterioration. Furthermore, participants were not requested to provide information regarding any qualitative fruit and vegetable losses, but were asked their reasons for not selling and their opinions on future loss reduction and utilization methods. The reason behind this approach stems from previous studies that showed qualitative losses were much more difficult to determine than quantitative losses [16,38]. Importantly, poor produce quality attracts little consumer interest since factors such as appearance, taste, texture, and nutritional value are expected for premium quality fruits and vegetables [39]. Consumer dissatisfaction with quality results in lower market values and higher levels of produce loss [40,41]. However, in developed countries, quality management of fruits and vegetables is rigorously maintained, since consumer choice is the key to successful retail business outcomes. Thus, retailers have to know their customers' quality preferences and operate their quality practices accordingly to maintain optimum profitability. The present questionnaire focused on assessing reported fruit and vegetable loss at the wholesale stage, since very little data is currently available. In addition, all participants were provided with an information letter fully explaining the nature of the survey and questionnaire, as required by the human ethics and confidentiality procedures promoted by Murdoch University.

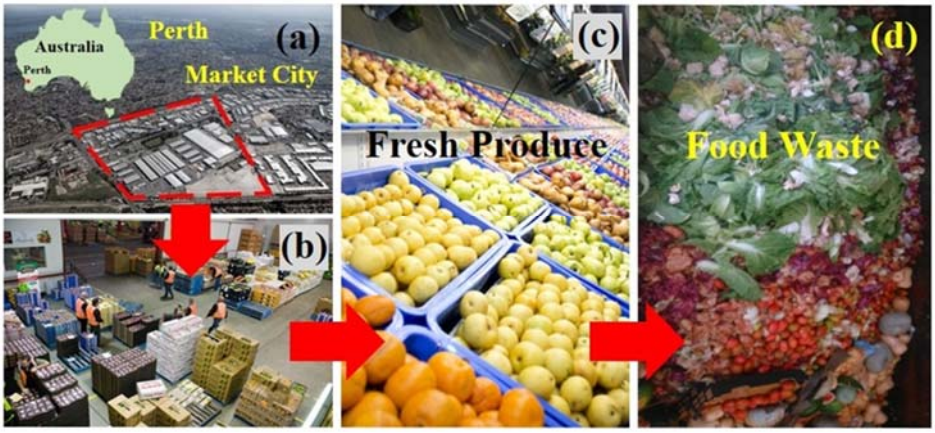

Figure 1. (**a**) Aerial view of Market City Canning Vale, Perth, Western Australia; (**b**) wholesalers at work in the market; (**c**) typical examples of fresh produce sold at the market; and (**d**) a representative view of food loss in a bin.

2.2. Administration and Data Analysis

The survey questionnaire was circulated to all 55 fruit and vegetable wholesalers, secondary wholesalers, and processors operating in Market City Canning Vale, Western Australia. Both a walk-in hand-out approach and online survey were carried out to obtain maximum participation. Also provided was an information letter detailing the objectives of the questionnaire and the nature of the survey. Once a week, business owners were contacted either by face-to-face meetings or by email to assist and check their progress in completing the questionnaire. After a 12-week period, which started in mid-June 2015, a total of 35 questionnaires were returned from the various wholesale businesses. Data collected in the questionnaires was classified into meaningful categories and captured using a specially designed excel spreadsheet template before applying descriptive statistics of frequency and percentage [42]. The Social Sciences (SPSS) statistical software version 21.0 (IBM Corp, Armonk, NY, USA, 2012) was then used to analyze the data [43]. Analysis revealed three distinct key themes: (1) fruits and vegetables received and reasons for loss generation; (2) loss reduction strategies; and (3) food loss utilization preferences. During the analysis, emergent patterns and relationships amongst the key questions were identified through a process of reduction and rearranging of the data into more manageable and comprehensible forms. Furthermore, qualitative text analysis software program Nvivo (QSR

International Pty Ltd., Doncaster, Victoria, Australia, 2012) was used to analyze open-ended question answers [44]. Participants were also requested to add their own thoughts regarding the reasons behind loss generation, loss reduction, and loss utilization approaches in the 'other section' of the questionnaire. Text analysis was also used to analyze the 'other section' of the questionnaire.

3. Results

The various outcomes of the questionnaire are presented in the following four sections. Section 3.1 presents percentage distribution of participation by the various wholesalers and processors contacted. The weekly tonnages of supplied fresh fruits and vegetables and respective loss levels are also reported in this section. The following section examines the relationship between received fresh produce and the amount of loss with respect to each business type. Section 3.3 examines the causes of loss generation, while the final section lists the various comments received from participants regarding loss reduction and loss utilization strategies.

3.1. Wholesaler and Processor Participation, Received Fruits and Vegetables, and Loss Levels

A total of 55 businesses were contacted and invited to take part in the present survey questionnaire. Figure 2 presents a percentage breakdown of participation from the various businesses (primary wholesaler, secondary wholesaler, and processor) located at Market City Canning Vale, Western Australia, as seen in Figure 1a. There were a total of 35 respondents to the survey questionnaire. Of the 35 participants, 18 were primary wholesalers (51.43%), 13 were secondary wholesalers (37.14%), and the remaining 4 were processors (11.43%). The remaining businesses declined to participate in the survey, citing business confidentiality. Those businesses that responded were found to be sincere and genuinely interested in reporting, since they could see the value of identifying loss and developing loss utilization strategies.

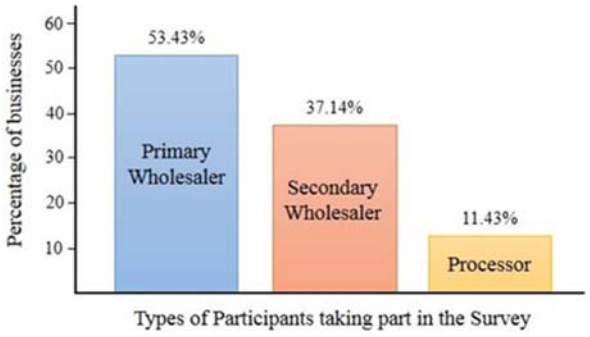

Figure 2. Percentage participation of wholesalers and processors located at Market City Canning Vale, Perth, Western Australia.

Figure 3 reports the weekly tonnage of supplied fresh fruits and vegetables and respective loss levels reported by each respective participant. Figure 3a presents the percentage breakdown of fresh fruits and vegetables received by each participant business each week. Around 31.43% of participants receive between 41 to 100 tonnes of fresh produce each week, while another 25.71% of participants receive between 1 to 20 tonnes each week. This was followed by 23% of participants receiving more than 100 tonnes of fresh produces each week. Figure 3b presents the weekly breakdown of food loss produced by the respective participants, with 31.4% of participants reporting loss levels exceeding 180 kg each week. Surprisingly, 25.71% of participants reported no loss during the week.

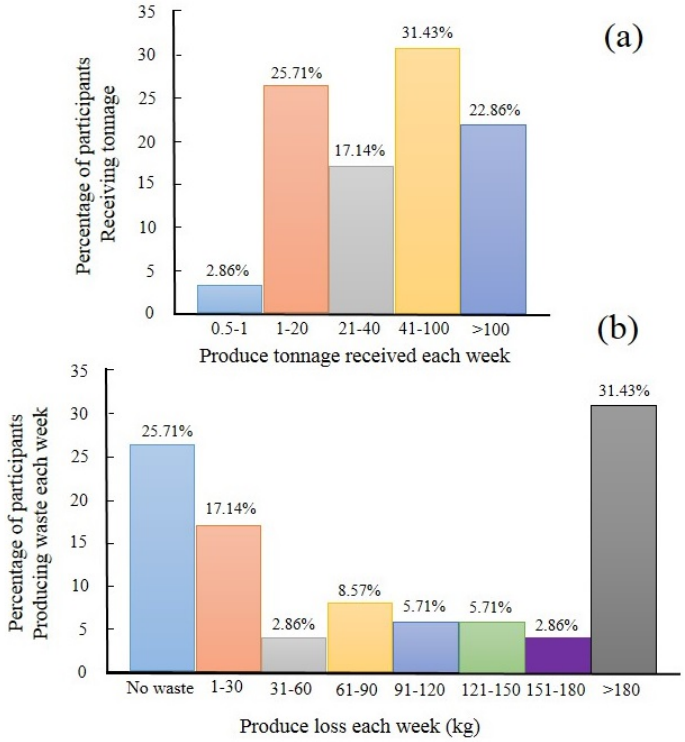

Figure 3. (**a**) Percentage breakdown of weekly tonnage of supplied fresh fruits and vegetables; and (**b**) percentage breakdown of respective loss levels reported by each respective participant.

3.2. Relationship between Received Produce and Loss Level with Respect to Business Type

Three main business categories were considered in this study, namely primary wholesaler, secondary wholesaler, and processor. The reported tonnages indicated that around 75% of primary wholesalers (six) received more than 100 tonnes of fresh produce each week. This was followed by 36.36% of primary wholesalers (four) receiving from 41 to 100 tonnes, and eight primary wholesalers handling between 1 and 40 tonnes of fresh produce. In the case of secondary wholesalers, 25% (two) received more than 100 tonnes and four reported receiving between 41 and 100 tonnes of produce each week. The four processors received between 1 and 100 tonnes of fresh fruits and vegetables each week. Losses were also reported by each of the respective businesses. For primary wholesalers, six businesses (54.55%) reported a weekly loss greater than 180 kg, while eight businesses reported losses between 1 and 180 kg each week. The remaining four primary wholesalers reported "nothing lost" each week. For secondary wholesalers, four businesses (36.36%) reported generating more than 180 kg of food loss each week, four businesses reported losses ranging from 1 to 180 kg, and five businesses (55.56%) reported "nothing lost" each week. For processors, three businesses reported losses between 1 and 180 kg and one business (9%) reported a loss above 180 kg. Further analysis of loss reporting was carried out using a log-linear model that used the "Processors" as the reference level. The model was also used to verify the significance of loss levels by each respective business in the three categories surveyed. The modelling revealed no statistically significant differences in loss levels between the processors and the secondary wholesalers (p-value = 0.81) and between the processors and primary wholesalers (p-value = 0.56).

Table 1 characterizes the association between received fresh produce and levels of loss generated each week by the various businesses surveyed. Only one business (2.86% of total participants) received between 501 and 1000 kg of fresh produce each week and reported no loss. For businesses receiving between 1 and 20 tonnes of fresh produce each week (nine in total, or 25.71% of total participants surveyed), three (33.33% of the nine businesses) produced no loss, while two (22.22% of the nine businesses) reported generating loss levels greater than 180 kg each week. Among businesses

receiving between 21 and 40 tonnes of fresh produce each week (six in total, or 17.14% of total participants surveyed), three (50.00% of the six businesses) generated no loss, while one (16.67% of the six businesses) reported loss levels greater than 180 kg each week. Among businesses receiving between 41 and 100 tonnes of fresh produce each week (11 in total, or 31.43% of total participants surveyed), two (18.18% of the 11 businesses) generated no loss, while four businesses (36.36% of the 11 businesses) reported loss levels greater than 180 kg each week. For businesses receiving more than 100 tonnes of fresh produce each week (eight in total, or 22.86% of total participants surveyed), four (50.00% of the eight businesses) generated loss levels greater than 180 kg each week (Table 1). Furthermore, the log-linear modelling used also examined the association between the dependent variable loss levels and the independent variables of business type and weekly reported amounts of produce received and showed that there were no statistically significant associations between the reported loss levels and the independent variables at $p = 0.05$. Overall, from the information reported by the 35 participants, it was possible to estimate average loss levels for primary and secondary wholesalers. Average fruit and vegetable loss for primary wholesalers was estimated to be around 180 kg per week and 30 kg per week for secondary wholesalers. Based on the reported fruit and vegetable losses, the annual loss was estimated to be around 286 tonnes.

Table 1. Relationship between received fresh fruits and vegetables and weekly loss levels reported by participants at the Canning Vale Wholesale Market, Perth Western Australia.

Produce Received	Fruits and Vegetables Removed Due to Loss (kg)								Total
	No Loss	1–30	31–60	61–90	91–120	121–150	151–180	>180	
501–1000 kg	1 (100.00%) [z]	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (2.86%)
1–20 tonnes	3 (33.33%)	2 (22.22%)	0 (0.00%)	1 (11.11%)	1 (11.11%)	0 (0.00%)	0 (0.00%)	2 (22.22%)	9 (25.71%)
21–40 tonnes	3 (50.00%)	1 (16.67%)	0 (0.00%)	1 (16.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (16.67%)	6 (17.14%)
41–100 tonnes	2 (18.18%)	2 (18.18%)	1 (9.09%)	1 (9.09%)	0 (0.00%)	1 (9.09%)	0 (0.00%)	4 (36.36%)	11 (31.43%)
>100 tonnes	0 (0.00%)	1 (12.50%)	0 (0.00%)	0 (0.00%)	1 (12.50%)	1 (12.50%)	1 (12.50%)	4 (50.00%)	8 (22.86%)
Participants	9	6	1	3	2	2	1	11	35

[z] Values in parentheses are % of total received.

3.3. Causes of Food Loss

Participants were asked to rank "reasons for loss" from four loss categories, with the most applicable (rank 1) to least applicable (rank 5). The four categories included: (1) low market price; (2) no market demand; (3) over supply; and (4) high/low temperature damage. Participants reported "over supply" (rank 1.56) and "low market price" (rank 2.65) as the most and least applicable reasons, respectively, for fruit and vegetable loss each week (Figure 4). Comments made in an "other" box for this section in the questionnaire indicated participants thought poor product quality was the main factor influencing the level of loss.

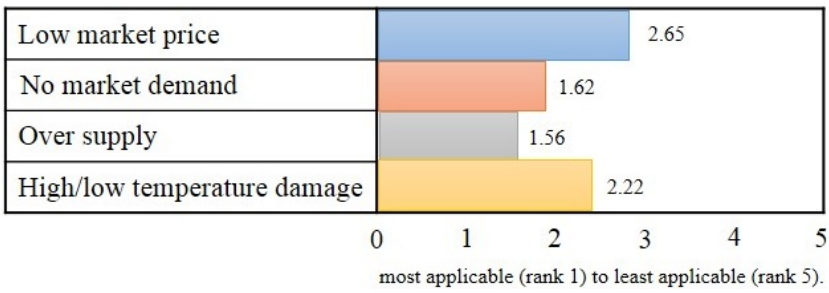

Figure 4. Food loss generation categories and mean rankings produced from participant responses.

3.4. Participant Perspectives of Food Loss Reduction and Loss Utilization

There are two parts to this section. In the first part participants were asked to rank five methods for loss reduction, and then comment on loss reduction strategies. The categories of methods for loss reduction were: (1) Revising visual appearance standards for fruits and vegetables at supermarket; (2) Improving storage facilities, technology, and infrastructure to better connect wholesalers to the market; (3) Engaging trained workers in wholesale to handle fresh produce; (4) Promoting more grower markets to sell produce directly to the consumers; and (5) Changing government policy to promote subsidies for wholesalers and processors. The businesses reported "Improving storage facilities, technology, and infrastructure" more important than either "Revising visual appearance standards" or "Promoting more grower markets" as an effective method for reducing weekly loss levels (Figure 5). Interestingly, "Promoting more grower markets" and "Revising visual appearance standards" produced *p*-values of 0.021, while "Improving storage facilities, technology and infrastructure" and "Promoting more grower markets" gave *p*-values of 0.004. Participants were also asked to add their own comments on loss reduction strategies to the questionnaire in an "other" box. However, very few participants (11) responded and those that did respond reported that if all stakeholders accepted and implemented quality standards there would be much lower levels of loss at the wholesale stage.

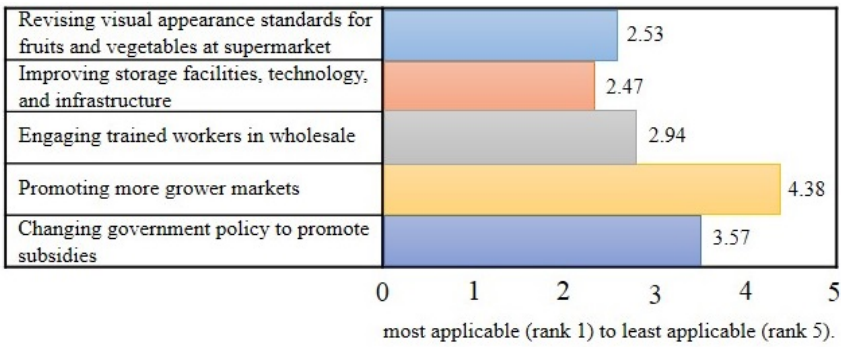

Figure 5. Food loss reduction categories and mean rankings produced from participant responses.

In the second part, participants were asked to rank methods for loss utilization and comment on loss utilization strategies. Loss utilization methods were assigned five categories: (1) Use for bio-energy production; (2) To make value-added compounds; (3) To make fish/animal food; (4) More donations to food bank and increasing tax deduction for food donations to charities; and (5) Increase revenue from selling compost made from crop scraps. The rank values determined from the reported date for the five loss utilization categories were 1.17 for "More donations to food bank and increasing tax deduction for food donations to charities", 2.58 for "To make fish/animal food", 2.94 for "Increase revenue from selling compost made from crop scraps", 3.00 for "To make value-added compounds", and 4.15 for "Use for bio-energy production" (Figure 6). Participants were also asked to add their own comments to the questionnaire in the "other" box stating their views on food loss utilization strategies. Participants expressed the view that "More donations to food bank and increasing tax deduction for food donations to charities" was the preferred food loss utilization strategy.

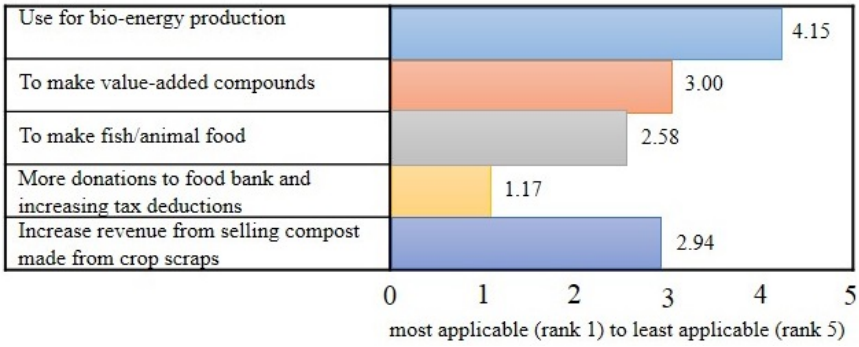

Figure 6. Food loss utilization categories and mean rankings from participant responses.

Another interesting item reported by participants was the relationship between loss levels and produce delivery frequency (daily/alternate days/twice a week or weekly). The reported data revealed that 95% of participants received produce daily, while the remaining 5% of participants received produce twice a week. Analysis of the data indicated that there was no association between produce delivery frequency and the amount of food loss generated.

4. Discussion

The volume of fruit and vegetable loss resulted from the relationship between the amounts of produce received, the quality of the produce, and market forces that influenced the amount of produce sold. Currently, there is very little data available about wholesale marketing of fresh fruits and vegetables in Australia. Although loss audits regularly take place in Australia, the respective audit sources are often inconsistent and present conflicting data [45]. This makes analysis difficult and, as a result, comparative studies are not performed. The present study has identified fruit and vegetable loss levels not previously reported for wholesale markets in Australia. Food loss levels can be derived from both qualitative and quantitative auditing at each stage in the wholesale marketing of fruits and vegetables. These types of losses within a food supply chain can be difficult to determine [16,38]. Generally, losses associated with quality are usually identified by a decrease in the market value of the produce [40,41]. For example, fruits or vegetables with some visual imperfections or that are misshapen, despite having similar taste and nutritional value, will not attract customers and will remain unsold. In the present study, loss was defined as the total amount of unsold produce going to loss each week. The survey contacted 55 businesses, but 20 declined, citing business confidentiality. The 35 businesses that participated in the survey were generally interested and were conservative in reporting loss levels.

Analysis of reported data revealed that 25.71% of participants received between 1 and 20 tonnes of fresh produce each week. Larger tonnages ranging from 21 to 40 tonnes were reported by 17.14% of participants, while 31.43% received between 41 and 100 tonnes and 22.86% received more than 100 tonnes of fresh produces each week. Interestingly, the survey also revealed that around half of the businesses (54.29%) receive more than 41 tonnes of produce each week, indicating larger and smaller wholesalers/processors were equally split in terms of business composition at the market, as seen in Figure 3a. Similarly, Table 1 summarized received fresh produce tonnages of and the weekly breakdown of loss levels produced by each respective participant. Moreover, only 31.4% of participants reported producing more than 180 kg of loss each week and, surprisingly, 25.71% of participants reported producing no food loss, as presented in Figure 3b. Estimation of average weekly loss revealed that primary wholesalers produced 180 kg and secondary wholesalers generated 30 kg. Based on the data, this would yield 286 tonnes of food loss each year by the 35 participants operating at the market.

Literature in the field has indicated a wide range of factors that result in loss generation, and many of these factors vary between developed countries, and between developed and developing

countries [46–48]. The present study also identified major factors contributing to food loss generation. The participants taking part in the present study were all experienced operators in the local West Australian market place and were aware of the causes behind loss generation. The questionnaire revealed that participants ranked "over supply" and "no market demand" as the main factors contributing to loss generation. Participants were also encouraged to add their own comments in the "other" section of the questionnaire and by follow-up conversations. Follow-up conversations tended to target and blame growers for not following proper growing practices and guidelines. Thus, a large proportion of produce reaching the market was not premium quality and could not be ranked as Grade 1 produce. However, from the growers' perspective, there was a need to harvest and deliver to meet prospective market demand. Thus, the need to meet potential market demand often meant immature produce may be harvested, adding to larger levels of loss. These losses resulted from immature fruit becoming moldy or decaying, leading to shorter shelf lives. For example, a number of participants commented that, if growers strictly followed grading and packaging guidelines for cherry tomatoes, loss levels could be dramatically reduced. Importantly, most participants reported that visual appearance should not be the only parameter used in grading and more importance should be given to the nutritional value of the produce.

Furthermore, although estimating loss generation by wholesalers was the aim of the study, there was a contributing factor to loss resulting from poor quality produce arriving at the market. This outcome suggests that further research is needed to fully examine the levels of immature and poor quality produce being delivered, and this contribution to food loss in the market. In terms of loss utilization, participants preferred option was "More donations to food bank and increasing tax deduction for food donations to charities" followed by "To make fish/animal food" (Figure 6). This reported preference is important for policy makers and the private sector, since it indicated that increasing tax deductions for donations to food bank was the preferred option of wholesalers. Alternative strategies that involve further processing of food loss were not well-received by wholesalers, as they did not believe "To make value-added compounds" and "Use for bio-energy production" were effective loss utilization strategies.

5. Conclusions

Average weekly fruit and vegetable losses reported by primary wholesalers was estimated to be 180 kg, with 30 kg of loss generated by secondary wholesalers/processers. This equated to around 286 tonnes of fruit and vegetable loss annually by the participants. Causes for food loss generation were identified, and preferred options for loss utilization strategies recommended by participants were examined and discussed. Wholesalers reported a number of important issues affecting loss that included: (1) Over supply and poor market demand; (2) Lack of adherence to proper growing practices and guidelines for producing high quality produce, with a tendency to harvest regardless of market demand by growers; (3) The need to improve infrastructure and promote better business practices to reduce loss levels; and (4) Revising visual appearance standards for produce and highlighting the importance of nutritional value to increase sales. From the grower's perspective, being able to deliver the right crop with high quality, in the right quantity at the right time to meet prevailing market demand, is difficult. Moreover, forecasting future demand is influenced by many factors, and market volatility exacerbates the difficulty. Thus, balancing supply and market demand will have an impact on food loss levels. The current imbalance could be alleviated by more effective on-line based market information being made available to all stakeholders. Furthermore, an increased supply of higher quality produce resulting from improved grading guidelines has the potential to significantly reduce food loss levels and improve profit margins. However, the size of the sampling pool used in this study was small and only enlisted 64% of wholesale businesses operating at the market. The number of non-participating wholesalers (36%) does influence the statistical significance of the findings. Nonetheless, considering the highly competitive nature of wholesalers and their general reluctance to reveal any businesses related information, the 64% participation was considered

a good outcome. Thus, by addressing the reported food loss and possible loss utilization strategies discussed in this study, it should be possible to reduce loss levels and promote a more profitable business environment for all stakeholders.

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Author Contributions: Purabi Ghosh and Shashi Sharma planned and designed the survey; Purabi Ghosh coordinated with Market City wholesalers, implemented the survey and collected data, traveled to conduct interviews with all stakeholders, and transcribed interviews. Purabi Ghosh, Derek Fawcett, and Devindri Perera worked on analysis; while Gerrard Poinern coordinated project activities and developed the framework for the paper. All authors substantially contributed to writing the paper.

Conflicts of Interest: The authors declare no conflict of interest.

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