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MATERIAL FLOW ANALYSIS OF VEGETABLES WASTE CAUSED BY HORTICULTURAL ACTIVITY (CASE STUDY: BANDUNG CITY)

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Abstract: Material Flow Analysis was used to assess the amounts of vegetables that introduced into Bandung City and become wastes in every trnasaction chain; grower, supplier, wholesale market, retail, consumer and finally collected into final disposal. A huge amount that produced by the peeling processes raised an idea from Mayor of Bandung to apply a policy „peeled vegetables“ before intoduced into Bandung City. Boundary of the mass flow in this study is Bandung City and functional unit used is a unit of weight (tons). Input data used in this research is the data amount of vegetables that go into Bandung City which is calculated based on the level of consumption of vegetables per capita population of Indonesia, adjusted for the population of Bandung City and the number of people around Bandung City who obtained the distribution of vegetable wholesale market in Bandung. Percentage of waste generated in each transaction chain obtained by observation and experiment in the field, the experiment are artificially at the household level and interviews with actors distribution. The resulting output is the number of vegetables waste in every transaction chain vegetables in Bandung City, either through modern markets and traditional markets. From the analysis it can be seen that the amount of vegetables waste in Bandung is 1,252.38 tons / week or 9.54% of 13,126.02 tonnes of waste generated in Bandung City each week.

Keywords: material flow analysis, waste, vegetables, post harvest losses

INTRODUCTION

Every year the population of Bandung City was increased. According to Badan Pusat Statistik (2013), the population of Bandung City in 2012 reached 2,455,517 people. Along with the increasing of population, the need for food was increased too. According to Murthy et al., (2014) vegetable is one of the food sources that rich in fiber and vitamins which are important for the human body. However, in addition to adding nutrition, vegetables also created new problems in the form of waste generated from the sorting process prior to sale. Based on research conducted by Wadhwa and Bakshi (2013) of the FAO, the number vegetables and fruits wastes resulting from the process of sorting, grading and others reached 31.98 million tons in China and 14.95 tons in the USA. Based on the US Environmental Protection Agency (EPA), the amount of junk food in it include vegetables and fruits resulting from the process of sorting, grading, processing and others estimated at 31.75 million tonnes or 12.7% of the 250 million tons of waste solid in the United States in 2008 (EPA 2010a in Buzby et al., 2011). Similar cases have not been investigated in Indonesia, both national and regional scale as in Bandung. Research on material flow analysis has been carried out on plastic polypropylene (PP) glass, as did Nareta and Damanhuri (2014), but has not been conducted on organic waste such as vegetables waste.

Data on the amount of vegetables waste of every chain of production-distribution-consumption in Bandung uncharted thoroughly, whereas vegetables is one of the products which are consumed and accounts for a significant litter. Data on the number of vegetables waste in the process of sorting, processing and others in developed countries has been widely publicized, but in Indonesia has not been done. As an initial overview, based on data from PD Pasar Bermartabat Kota Bandung, every day of the markets in Bandung produced 162.66 m^3 of waste and some of which are biodegradable waste consisting of leftover food, vegetables and fruit. According to Faramita and Rahardyan (2007), waste generation in Bandung every day reach 7,500 m^3. Of these, according to the survey conducted in 2005-2006 by Damanhuri (2008), the composition of organic waste in Bandung by 52% of the total litter, while the rest (48%) in the form of inorganic waste. In the boundary of this study, namely Bandung City, which produces a lot of vegetables waste like Andir Market every day can produce a litter of up to 14 m^3, while markets such thematic Jatayu Market, Cihapit, Cikapundung and others who sell goods -Items non-biodegradable waste only produces less than 1 m^3 per day. From this categorization (thematic and non-thematic) can be estimated that the largest contributor to the waste in the markets in Bandung derived from food losses and food waste, in the form of raw materials, the rest of the food to the food processing former being discarded.

As a food product transaction center, activity in the markets in Bandung City also annually increased along with the increasing population. According to the last census, the number of markets in Bandung City, which is under the management of PD Pasar Bermartabat Kota Bandung in Bandung in 2012 reached 37 markets (Badan Pusat Statistik, 2013). Vegetables waste is one of the types of waste that dominate solid waste in these markets, particularly in markets such as Pasar Caringin parent, Gedebage Market, Market Ciroyom and others. This occurs because the vegetables are imported directly from agricultural production centers around Bandung like Lembang, Cisarua, and others are not directly sold to consumers, but through the process of sorting again-after sorting done at the level of farmers and collectors. Parts of rotten vegetables and not worth selling directly disposed in place and become waste. The total volume of waste and waste into these need to be assessed through the material flow approach (Material Flow Analysis, MFA).

To reduce the burden of waste which is increase every day, the Mayor of Bandung City in 2014 initiated a program to reduction the vegetables waste, in particular by requiring every vegetable that goes to Bandung City to be packed in plastic packaging that is expected to reduce the volume of waste of vegetable origin. Perpetrators of packaging in this case is the supplier of vegetables which are in the upstream chain of transactions before entering into Bandung (Kompas, 2014).

According to research by Sharma and Singh (2011), the number of vegetables fractions become due process of sorting waste in the farm, to the hands of the consumer market could reach 23.19% with an average loss of (food losses) amounted to 14.6%. The main cause of the high levels of litter due to post harvest handling based research Osman et al. (2009) is inadequate knowledge about good handling practices (36.7%), treatment is less efficient (50.3%), poor infrastructure (51.9%), and less funding for technological applications (38 , 8%).

This study has the objective to determine the contribution due to the vegetable waste sorting process (sorting) of the amount of waste generated in the markets holding in Bandung.

The purpose of this study was to obtain details of the production of vegetables in the upper level (the farm) and the amount of waste generated from the process of segregation of the various stages of the transaction chain and downstream (markets). The hypothesis in this study is that the waste generated from the process of sorting vegetables in every transaction chain has a major contribution to the amount of waste generated in the markets holding in Bandung.

RESEARCH METHODOLOGY

This study uses the approach of Material Flow Analysis (MFA). Boundary of MFA system in this study is Bandung. The waste were analyzed only in the form of the number and type of vegetables waste derived from vegetable production (olerikultura) resulting from production centers around Bandung City, such as Kertasari, Pangalengan and Ciwidey which are located in Bandung. Market which is used as the location of the study is only a legally recognized market and is under the management of PD Pasar Bermartabat Kota Bandung, in terms of which have been 6 markets Gedebage Wholesale Market (wholesaler), Andir Market, Kiaracondong Market, Cihaurgeulis Market, Ciroyom Market and Cijerah Market, and market that are under management of *Badan Pengelola Pusat Perdagangan Caringin* (BP3C) ie Caringin Wholesale Market. Collection of data related to waste management from relevant agencies.

Data collection was performed by means of surveys, field trials and interviews with farmers, collectors/suppliers (middlemen), merchant wholesale market, traditional market traders, hypermarkets, supermarkets and for the final stages of the sorting is done in artificial vegetable consumers to perform 5 attempts for each types of vegetables. The survey was conducted by taking samples from each population. Sampling for farmers conducted by random sampling method.

Data processing approach flow of vegetables waste material is done by analyzing the input and output to the amount of vegetables and vegetable waste generated in Bandung and surrounding areas, taking into account other variables, such as the amount of vegetables that come from outside Bandung City. Other data used for the benefit of the description made by descriptive statistical analysis approach, such as the total number, mode, median, mean, standard deviation, distribution curves, and so forth. This analysis is not used for the conclusion of the population, but only to explain the data alone.

RESULTS AND DISCUSSIONS

The types of vegetables studied were the vegetables which are consumed regularly by people in Bandung City, and statistically recorded in West Java Provincial Agriculture Office. The types of vegetables are as listed in Table 1. The vegetables that go to Bandung previously have undergone various stages of sorting and grading, both at farm level (the farm), city, until before entering into Caringin Wholesale Market. The amount of variation varies depending on the type of vegetable sorting. However, to determine the waste generated from the sorting process is not only based on the percentage of sorting, but based on the level of consumption of vegetables. Average sorting for various types of vegetables from upstream to downstream is shown in Figure 2 and Figure 3.

Sorting can be interpreted with a separate product that is not in accordance with the market and the products based on quality standards. The purpose of grading is to improve

customer satisfaction (Utama and Antara, 2013). Grading is the term used in the post harvest activities in an industry. Understanding grading is separation or grading of products based on market needs, or can also be defined by the process of sorting and sizing for commercial purpose (Utama and Antara, 2013). Grading for each type of product different from each other because each product has different characteristics, agronomic practices, as well as climatic conditions during production, diversity of products (size, shape, etc.) and the diversity in demand for different markets (Utama and Antara, 2013).

Stages initial sorting is done in the farm. Sorting at the level of the farm is done to separate marketable vegetables and vegetables are not worth selling, as affected by the disease, suffered mechanical damage due to impact, the size is too small or too big. Average sorting at farm level is 7.11%, with the types of vegetables that have the greatest degree of sorting is chinese cabbage (39.21%) and cabbage (34.71%). In aggregate, after adjusting for vegetable production, the level of sorting at the farm level is 11.05%, as shown in Figure 1. According to Salunkhe and Desai (1984 in Utama and Antara, 2013), vegetable crops have been harvested in fact still alive. It is characterized by the process of respiration by the vegetable crops. The process of respiration in plants remodel existing complex carbohydrates in the plant body into simple carbohydrates are sugars and then oxidized into energy. This reform process produces CO2, H2O and heat. Therefore there wilting vegetables when vegetables are long kept and degrade the quality of the vegetables that produce a lot of waste. Besides litter, as described earlier, that H2O produced during respiration also cause weight loss due to loss of water content vegetables with a percentage of aggregate approximately 9.04% of all kinds of vegetables, as shown in the diagram MFA in Figure 1.

At farm level there is no difference between vegetable sorting for traditional markets and modern markets except the 2 types of vegetables, namely scallion and carrot. For scallion and carrot aimed at the modern market, the larger the percentage sortasinya because most of the dirty part discarded, given the modern market of consumer preferences is more complicated than the traditional market. A striking difference for sorting vegetables in the farm located at the level of grading, or sorting by a specific size. Vegetables for the modern market requires a uniform size, so some vegetables that have non-uniform size sold to the wholesale market, both Caringin Wholesale Market, Gedebage or Andir. The vegetables that go into Modern Market experienced two stages of sorting, the first sorting is done in the farm by the supplier 1 and additional sorting at the packing house is done by the supplier 2. Average sorting vegetables for supplier 1 is 10.39% and for suppliers 2 amounted to 12.85%. Based on figures such as sorting can be seen that, if 100 kg is processed by the packing house (supplier 2), it will produce as much as 12.85 kg of waste. Sorting waste generated at the upstream level are generally used as animal feed or as land fertilizer that is left in the ground. After sorting at the upstream level, vegetables for the traditional market will be sent to the wholesale market, while vegetables for the modern market that has been through the stages of packaging (supplier 2) will be directly distributed to supermarkets, hypermarkets and other modern markets in Bandung.

Based on interviews conducted randomized to 8 retailers supermarket / hypermarket in Bandung, it is known that 100% of vegetables that go into a modern market in Bandung, 97% of which will be on display while the remaining 3% will be returned because there are defects or do not qualify for a decent display criteria. Vegetables are returned in general will be waste and losses are borne by the return of packaging or suppliers 2. Vegetables do not

pass the selection which then become waste will be disposed of by the supplier 2, and is often used by people around the location of the packing house as animal feed or processed as ingredients food, because the quality is still decent returns vegetable consumption.

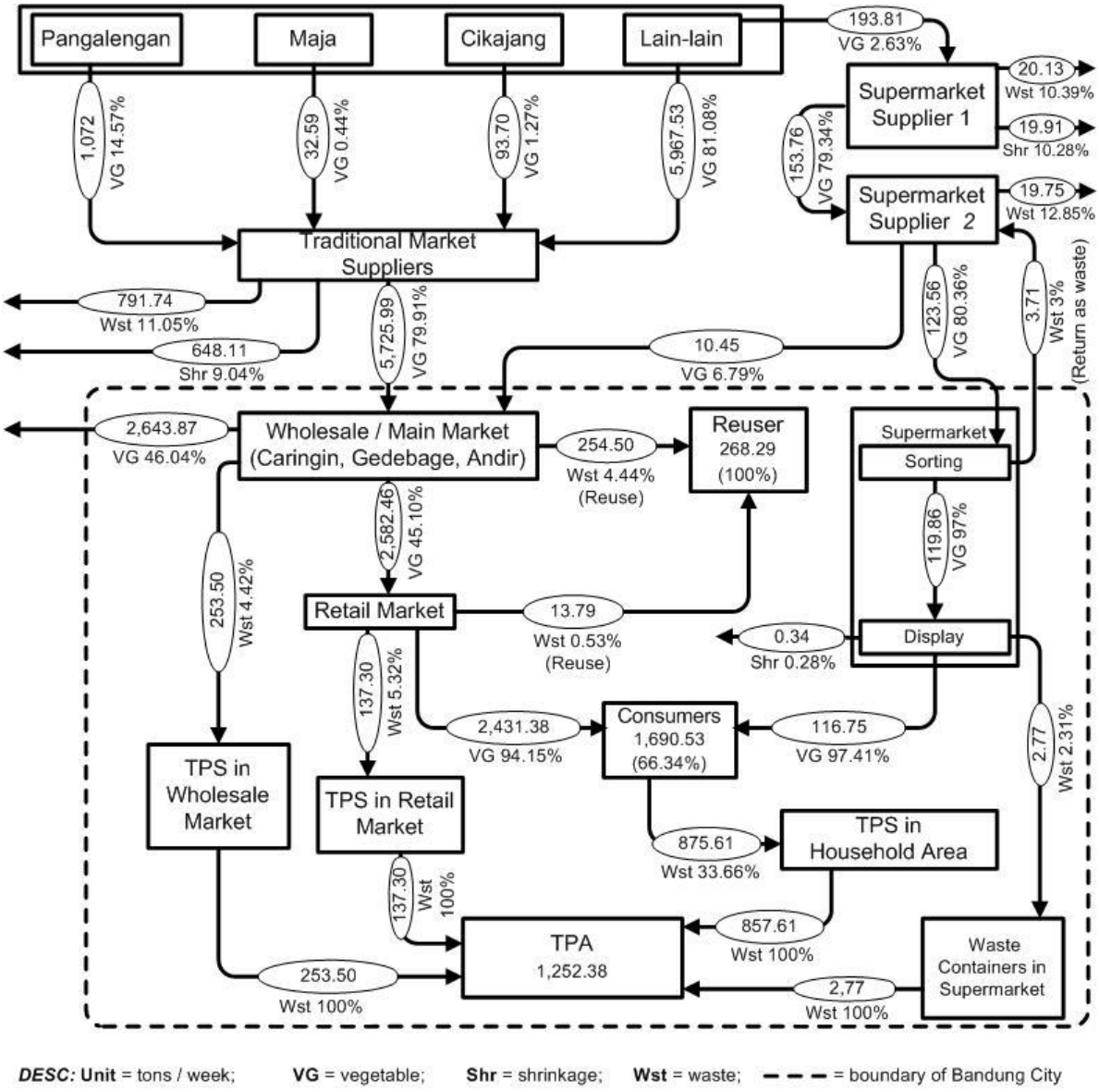

Figure 1. Material flow of vegetables in Bandung City

Based on the above it can be seen that the average percentage of sorting vegetables at the city level or suppliers ranged from 9-13%. In terms of agricultural engineering, the amount of loss due to sorting or grading process is called with post harvest losses. According Tridjaya (2005 in Haryanto and Rochani, 2006) post harvest losses for vegetable products in Indonesia on average about 9.6%. According to Choudhury (2006), some of the causes of the magnitude of post harvest losses are external factors and internal factors.

External factors such as mechanical injury among (damage due to mechanical factors)

where vegetables and fresh fruit has a soft texture and a high water content. Handling erroneous and improper packaging during transport process causes the product vegetables and fruits become discolored (bruising), cuts (cutting), crushed (breaking), and others. Other causes are diseases caused by parasites (Parasitic diseases). Vegetables infected fungi, bacteria, insects and other organisms causing post harvest magnitude lossess on vegetable products and fruits such. Microorganisms can attack the fruits and vegetables quickly due to weak natural defenses of fruits and vegetables in the tissue as well as the abundance of nutrients and moisture that support rapid growth of microorganisms (Choudhury, 2006).

In addition to external factors there are internal factors that cause waste generation in the process of sorting is physiological damage (Physiological deterioration). Tissue of fruits and vegetables is still alive after harvesting is done and continue its physiological activity. Physiological deviations occur because of a shortage of minerals, the temperature is too low or too high, or inadequate environmental conditions, such as humidity is too high. Physiological damage can also occur spontaneously due to the activity of enzymes that lead to excessive maturity (overripeness) and aging (senescence) (Choudhury, 2006). The level of sorting due to external and internal factors can be seen in Figure 2 for vegetables in traditional markets and Figure 3 for vegetables in the modern market.

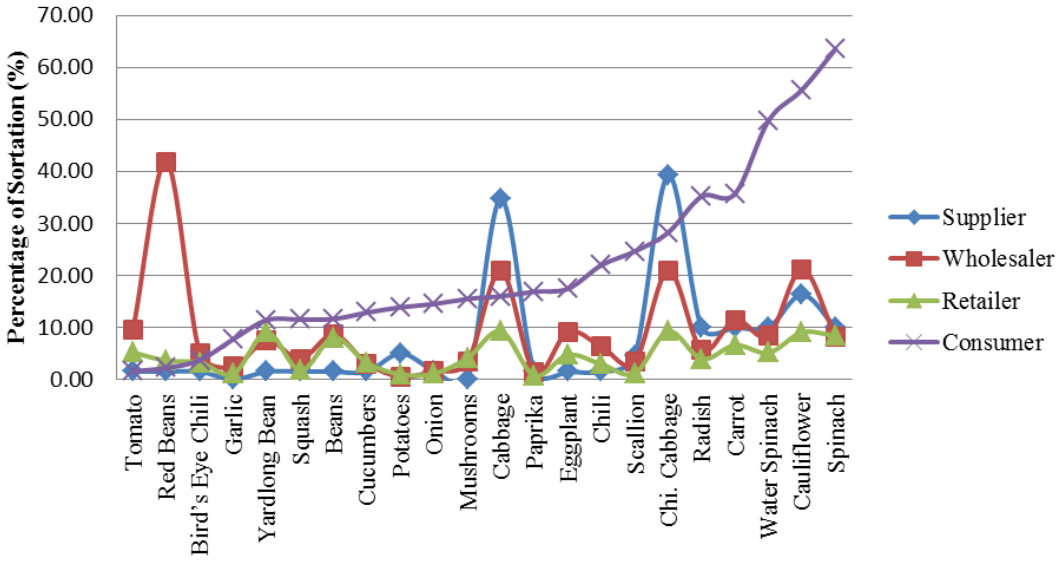

Figure 2. Variation of vegetables sorting from traditional markets, upstream to downstream.

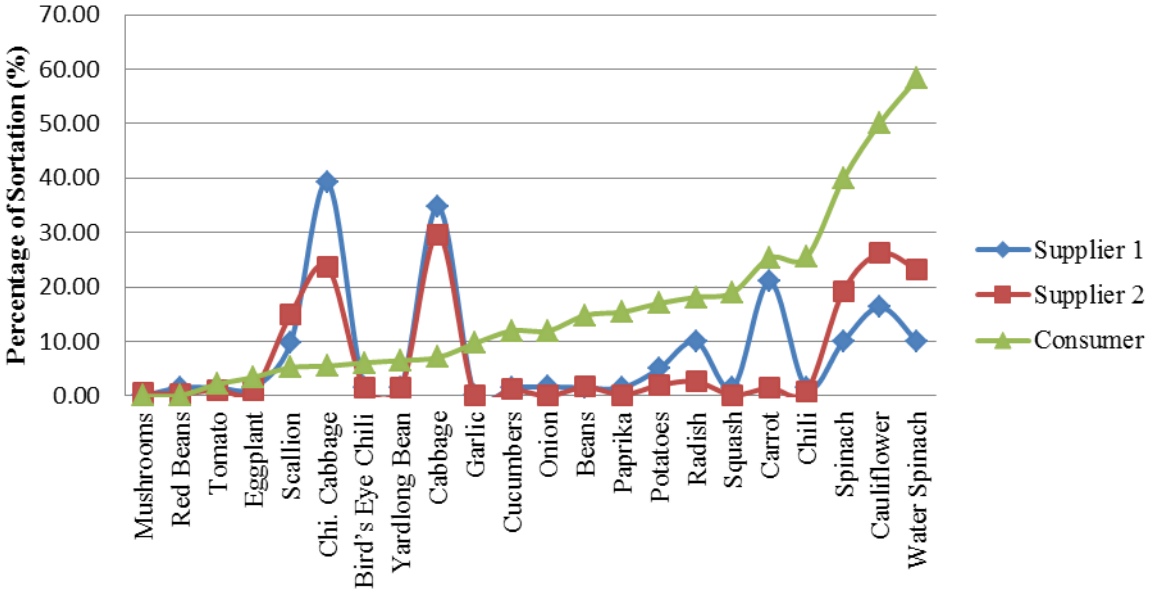

Figure 3. Variation of vegetables sorting from modern markets, upstream to downstream.

After going through various stages of sorting and trade system in the upstream chain, vegetables for the traditional market will be taken to the wholesale market (wholesaler), but the amount of vegetables that go into Bandung City is not recorded in the offices or agencies, both PD Pasar Bermartabat Kota Bandung or Dinas Pertanian Kota Bandung. Therefore, to find out how persentese and the amount of vegetables that go into markets in Bandung then conducted interviews of 100 people of the Bandung. Based on the interview, 95% of the Bandung routinely buy vegetables from traditional markets, while 5% of the modern market. This percentage is used to determine the input MFA in traditional and modern markets. Supporting the input data to determine the amount of vegetables in detail that went into Bandung City based on data vegetable consumption per capita population of Indonesia (Susenas, 2012) were converted into tons / week, after adjusting for the proportion of production - consumption and the number of people in Bandung and areas directly adjacent to Bandung City. The region is that Cimahi City, Bandung Regency and West Bandung Regency, where the majority of the retail market in the region to buy vegetables from Caringin Wholesale Market, Gedebage Wholesale Market and Andir Market, except four commodities namely beans, cucumber, water spinach and spinach.

Based on the data processing Susenas (2012) and interviews, it can be seen that the amount of vegetables that go into Bandung City is 5,845.85 tons / week. Of these, 2,643.87 tons of vegetables will go into the traditional markets outside Bandung City, 2,582.46 tons will go into the traditional market in Bandung City and 119.86 tons will enter through the modern market, such as supermarkets, hypermarkets and other. As we know that the wholesale or main market in Bandung became an intermediary distribution vegetables around Bandung City. Although these vegetables will be brought out to Bandung City, but the impact is sorting the rest of the numbers 508 tons / week will be waste in Bandung City. This number is obtained from the calculation of average sorting for vegetables at a wholesale market in Bandung, which reached 8.86% or be greater in certain seasons when certain types of

vegetable production soared and prices plummeted. From 8.86% of sorting numbers, as much as 4.42% or 253.50 tons will be transported to the landfill, while 4.44% or 254.50 tonnes will be used by reuser, such as; processing plants that process waste seasoning of garlic, red chili and bird's eye chili; as well as ruminant farmers who utilize waste sorting beans, chinese cabbage, cabbage and others, with no continuous retrieval. Vegetables rest of this sorting purchased at the price varies, from Rp 1,000 / kg to 5,000 / sacks. Based on data from PD Pasar Bermartabat Kota Bandung (2013), every day 25.25 m3 of waste generated in the Gedebage Main Market and 14 m3 of waste in Andir Market. Meanwhile, according to the data BP3C (2014) 150 m3 of waste generated from Caringin Wholesale Market. Based on these data, calculation and showed that every third week of the wholesale market produced 331.19 tons of waste. Thus, it can be seen that 76.54% of the waste generated in the three main market is derived from residual sorting vegetables.

After going through the sorting stage Caringin Wholesale Market, Gedebage Wholesale Market and Andir Market, 2,582.46 tons of vegetables that go into traditional retail markets in Bandung will experience the advanced sorting, but the sorting is not performed on all types of vegetables, but only to certain vegetables such as cabbage and chinese cabbage. Both types of vegetables are often external and internal damage after going through the distribution chain transfer or after a one-day storage period. The amount of sorting numbers for the retail market is 5.85% or 151.09 tons / week. According to FAO (2011), the percentage of vegetables waste at the distribution stage by an average of 10% for South Asia and Southeast Asia. Thus, the rate of 5.85% to 8.86% and the wholesale market for the wholesale market is still below the range of the numbers predicted by the FAO (2011). As a wholesale market, not all the waste in the retail market will end up at the polling station, because some vegetable bins will be used for reprocessing or direct use. The level of reuse vegetables waste in the retail market is 0.53% of the total vegetables that go into the retail market, or approximately 13.79 tons / week. The rest of the vegetables, amounting to 137.30 tons / week (5.32%) will end up in the TPS. Based on this amount can be seen that of 215.97 tonnes of waste generated in the retail market in Bandung City, 63.57% of which is vegetables waste.

In contrast to the traditional market, vegetables are on display in supermarkets and hypermarkets are no longer experiencing additional sorting, but during storage in the refrigerator occurred severe shrinkage due to respiration process the amount of about 0.28%. This amount is insignificant compared to loss weight loss in the wholesale market and the retail market, but the magnitude of weight loss in both traditional markets are not recorded and are difficult to measure the exact amount, so it is ignored in this study. Assumed loss does not occur in the wholesale market and retail as it has reached equilibrium moisture content (EMC) when the transport from the wholesale market to the retail market, but it is also due to their short shelf life in the traditional market in general no more than 2 days. Meanwhile, the shelf life of vegetables in the supermarket / hypermarket can reach 4 days for certain types of vegetables. Although sorting does not happen, at the end of the deadline for the sale is not all vegetables are on display in a supermarket will sold out, the remaining unsold vegetables will usually be sold cheaply to catering or food processing industry. If after low sales, there are still remaining vegetables, the vegetables will be discarded and should be categorized as wastage. The amount of wastage is based on interviews ranged between 2-5%, with an average of 2.31% or 2.77 tons / week for all supermarkets and hypermarkets in Bandung City.

At the end of the chain of transactions, both traditional and modern markets, all kinds of vegetables will end up in the consumer. Based on interviews it is known that 95% of consumers of vegetables in Bandung buy vegetables from traditional markets and the remaining 5% of the market to buy vegetables such as supermarkets and hypermarkets modern. Vegetables from the traditional markets in general have a greater percentage of waste compared to vegetables from the supermarket. From the calculation of the percentage of waste sorting vegetables from traditional markets by 21.43%, with the highest percentage of waste derived from spinach, as shown in Figure 2. Meanwhile, in Figure 3 shows that the percentage of waste vegetables from the supermarket result sorting process at the household level reached 16.05%. Based on data from FAO (2011), at the level of consumption (household), the average percentage of vegetables waste and fruits to South Asia and Southeast Asia an average of 7%. When referring to the FAO data (2011), then the percentage of vegetables waste at the household level in Bandung relatively high (above average) due to the range of percentage of vegetables waste ranged between 14-22%. In aggregate, in Figure 1 can be seen that the percentage of waste sorting vegetables at household level reached 33.66% or 875.61 tons / week. When compared with the waste generation of settlements in Bandung, which reached 4951.98 m3 / day or 8665.97 tons / week as the data PD Kebersihan Kota Bandung (2012), then the vegetables waste accounted for 10.1% of the total waste generated in settlements Bandung City. Details of the amount of waste generated by the chain vegetables vegetable trade system as a whole can be seen in Table 1. At the end of the flow in Figure 1 shows that the total amount of waste vegetables in Bandung City is 1252.38 tons / week. Meanwhile, the total amount of waste in Bandung City amounted to 7500.58 m3 / day or 13126.02 tons / week (PD Kebersihan Kota Bandung, 2012). Thus, the proportion of the total amount of vegetable waste in Bandung City is 9.54%.

Table 1. Number of vegetables and vegetables wastes in Bandung based on the transaction chain.

No.	Vegetables	The amount of introduced vegetables to Bandung		The amount of vegetables to consumer				Percentage of waste vegetable Total	
		Traditional Market	Modern Market	Traditional Market		Modern Market			
		(tonne)	(tonne)	(tonne)	(%)	(tonne)	(%)	(tonne)	(%)
1.	Onion	402.51	6.38	24.74	1.67	0.86	2.47	25.60	1.69
2.	Garlic	152.61	2.52	7.59	0.51	0.29	0.82	7.87	0.52
3.	Scallion	326.02	4.15	35.22	2.37	0.30	0.85	35.52	2.34
4.	Potatoes	329.98	5.66	16.29	1.10	1.04	2.96	17.32	1.14
5.	Cabbage	501.73	5.46	133.19	8.98	0.49	1.39	133.68	8.80
6.	Chi. Cabbage	216.92	1.98	63.46	4.28	0.15	0.42	63.61	4.19
7.	Carrot	225.28	2.69	49.82	3.36	0.70	2.01	50.52	3.33
8.	Yardlong Bean	255.10	11.32	65.07	4.39	0.95	2.71	66.01	4.35
9.	Chili	328.48	5.25	43.33	2.92	1.38	3.95	44.71	2.94
10.	Tomato	241.33	3.49	27.21	1.83	0.15	0.42	27.36	1.80
11.	Eggplant	534.18	6.63	79.95	5.39	0.36	1.04	80.31	5.29
12.	Beans	202.72	2.96	27.98	1.89	0.48	1.38	28.46	1.87

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		Traditional Market	Modern Market	Traditional Market		Modern Market			
		(tonne)	(tonne)	(tonne)	(%)	(tonne)	(%)	(tonne)	(%)
13.	Cucumbers	103.66	5.36	18.88	1.27	0.73	2.07	19.60	1.29
14.	Water Spinach	521.56	30.37	294.01	19.82	17.40	49.73	311.41	20.50
15.	Spinach	689.73	19.58	478.27	32.23	7.81	22.32	486.07	32.01
16.	Red Beans	47.21	0.43	20.22	1.36	0.01	0.03	20.23	1.33
17.	Squash	172.43	2.98	13.29	0.90	0.60	1.72	13.89	0.91
18.	Radish	88.17	1.06	14.46	0.97	0.21	0.59	14.67	0.97
19.	Cauliflower	152.71	1.64	53.94	3.64	0.81	2.32	54.75	3.61
20.	Bird's Eye Chili	204.95	3.24	14.42	0.97	0.26	0.74	14.68	0.97
21.	Mushrooms	22.74	0.30	2.02	0.14	0.01	0.02	2.03	0.13
22.	Paprika	5.97	0.10	0.39	0.03	0.02	0.05	0.41	0.03
	Total	5,725.99	123.56	1,483.7	100	34.99	100	1,518.72	100

CONCLUSIONS

The vegetables that go into Bandung City through two distribution channels or 2 chain trade system, namely traditional market distribution and modern market distribution. Based on the analysis of material flow to the 22 main types of vegetables consumed in Bandung can be seen that from the input of 5725.99 tons / week of vegetables through traditional markets and 123.56 tons / week of vegetables through modern market generated total vegetable wastes 1252.38 tons / week in Bandung, or 9.54% of the total waste generated 13126.02 tons in Bandung City each week from various sources.

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