

Fruit Waste Potential, a Weakness or a Potency, Doing Locally Effect Globally

Setyadjit Setyadjit, Ermi Sukasih, and Risfaheri Risfaheri
Indonesian Center for Agriculture Postharvest and Development, Bogor, Indonesia
Email: Pascapanen@yahoo.com

Abstract—Liquid and solid waste are claimed as one of source of Green House Gas (GHG) which cause global warming and climate change. Fruit has a potency producing solid waste. To figure out the local fruit waste potential; we correlated the fruit production, the edible portion of the composition of food, published paper, and also our experience in doing postharvest research. Not all fruit has production data, also not all the production data have edible portion. Some of variation of cultivated variety has also been neglected. The figure shows 8 097 938 tonnes of fruit waste annually produced in Indonesia. This value is bigger than annual production of banana which is the biggest fruit produced in Indonesia *viz* 6 862 567 tonnes. The fruit losses data are unavailable, but this would increase the amount of waste if it the good handling practices failed to be done. The government policy across ministry and across center and local government were produced supporting decree and regulation to preserve the environment. The member of society such as researcher, culinary society, and processor were trying to improve their knowledge to utilize the fruit solid waste. Fruit processing industry both local and abroad facing dynamic pressure and some of them faced difficulty in coping environmental problem. Looking for better solution for potential environmental problem from fruit, it is recommended researching varieties with long storage life; also continuing research on postharvest fruit preservation and transportation, fruit seedless, and continuing to educate small processor, and society to have better understanding of GHG and global warming and how to cope them.

Index Terms—fruit waste, fruit losses, waste utilization, fruit postharvest handling, fruit processing

I. INTRODUCTION

Organic fruit waste which come from fruit after harvest can contribute to global warming. After harvested fruit is sorted, graded, postharvest treated, packed, and stored. Then, it is transported and marketed to reach the destination which is the consumer where they are consumed. The other alternative is transportation the processing unit which is then processed to become various products such as minimally processed fruit, fruit juices and various drinks, fruit crisp, fruit meals. In packing house operation (PHO), storage, transportation and distribution, fruit is still emitting ethylene, and carbon dioxide which also contribute to Green Houses Gas [1].

Green House Gases (CHG) is a gas that provide a trap to heat, normally it is stay at earth surface. This is a result of human activity. The most abundant gases is CO₂ which is 95% come from the burning of fossil fuel. However, the other 2 gases *viz*. methane (CH₄) and nitrous oxide (N₂O) are more effective in entrapping the heat. Carbon dioxide has GWP (Global warming potential) to 1, methane to 23 and nitrous oxide to 296 [2], [3]. However, the atmospheric life time for CO₂ is 50-200 years, methane 12+3, and nitrous oxide 120 years.

Carbon dioxide is produced by the fruit both in the form of whole fruit and waste which are a type of GHG whist the ethylene is close related to methane which probably is also a GHG gas. The question is then “is ethylene then give the same effect GHG to methane [1]-[3].

The aim of make this paper was trying to understand the potential waste of fruit in Indonesia and try to relate to the potential GHG, what regulation is available, what is done by society, and recommendation of the applied research and development for fruit.

II. FRUIT

Indonesia classified a horticultural crop into fruit, vegetable and bio-farmaca. Other classification is refer growth habit, physiological character, life span of plants, climatic requirements, seasonal basis, and use of horticultural plants [4]. The example of a classification physiological character are a Temperate: small fruits: grape, strawberry; tree fruits: apple, pear, cherry; nuts: peach, walnut. b Tropical and Sub Tropical: herbaceous perennials: pineapple, banana; tree fruits: mango, papaya; nuts: cashew nut, araca nut. The other type of class is deciduous and ever green. A Deciduous Tree: fig., guava, apple, karvanda, berry, sweet cherry, pomegranate, grape, mulberry, phalsa, almond. b Evergreen trees: araca nut, dates, coconut, pineapple, banana, jackfruit, avocado, sweet orange, mandarin orange, k. lime, mango, chicku, papaya, passion fruit, cashew nut. In this paper we use temperate and tropical-subtropical type of classification.

III. METHOD TO CALCULATE FRUIT WASTE

The available data on the fruit waste potential is on the national fruit production which also can be broken down into every provinces production data which is provided by Indonesian Statistics Bureau through a “sensus” activity. Thus to get the potential waste data a publication

being used *i.e.* food composition data. This data was compiled by Indonesian community of food nutritionist. The book was firstly published in 1964, 2005 the publication was updated become DKBM (“Daftar komposisi bahan makanan”/List of food composition) [5]. In the table there are data on percentage of edible portion, or using available data from other publication if the data not available in the book, then the waste potential can be calculated. In 2009 this book title was revised which no longer presentation of the edible portion.

IV. INDONESIAN FRUIT WASTE

Total Indonesian fruit waste potential is 8 097 938 tonnes in 2014, most waste probably in the city. As comparison per day in Jakarta metropolitan city produce 6000 ton per day, 2 190 000 tonnes per year. But the metropolitan city the waste is not organic only. The most wasted fruit is durian (79%), mangosteen (71%), rambutan (60%), and water melon (54%) (Table I and II). Mangosteen peel is more expensive than flesh because xanthone content [6].

TABLE I. POTENTIAL OF FRUIT WASTE OF SELECTED FRUITS

Type of Fruit	Fruit type	Edible portion (%)	Waste (%)	Production (tonnes)	Waste Potential (tonnes)
Jack fruit (PS)	B-TF	75	25	644 295	161 074
Papaya (PS)	B-TF	71	29	840 119	243 635
Lanzones (PS)	B-TF	64	36	208 426	35 033
Durian (PS)	B-TF	22	78	859 127	670 119
Guava (PS)	B-TF	82	18	187 418	33 735
Citrus Pamelo (PS)	B-TF	62	38	141 296	53 692
Citrus Tangerine(PS)	B-TF	71	29	1 785 264	517 727
Mango (PS)	B-TF	65	35	2 431 329	850 965
Mangosteen (PS)	B-TF	29	71	114 760	81 480
Rambutan (PS)	B-TF	40	60	737 246	442 338

ASF; Temperate Small Fruit

ATF: Temperate Tree Fruit

BHP: Tropical/Subtropical Herbaceous Perennial

BTF: Tropical/Subtropical Tree Fruit

PS: Peel and Seed

PH: Peel and heart

P: Peel

S: Seed

TABLE II. POTENTIAL WASTE OF SELECTED FRUITS

Type of Fruit	Fruit Class	Edibel portion (%)	Waste (%)	Production (Tonnes)	Potential Waste (Tonnes)
Soursop (PS)	B-TF	68	32	53 068	16 982
Pineapple (PH)	B-HP	53	47	1 835 490	862 680
Avocado (PS)	B-TF	61	39	307 326	119 857
Star Fruit (P)	B-TF	86	14	81 663	11 433
Rose Apple (S)	B-TF	90	10	91 983	9198
Sapota (PS)	B-TF	79	21	138 209	29 024
Bread fruit (PH)	B-TF	84	16	103 491	16 559
Passion Fruit (PS)	B-HP	36	64	108 144	69 212
Rock melon (PS)	B-HP	46	54	150 356	343 437
Water melon (P)	B-HP	46	54	653 995	353 157
“Blewah” (PS)	B-HP	46	54	38 665	559 481
Snake Fruit (PS)	B-HP	50	50	1 118 962	559 481
Banana (P)	B-HP	75	25	6 862 567	1 715 642
Apple (PH)	A-TF	89	19	2 260 337	429 464
Grape	A-SF	100	0	218 811	0
Total					8 097 938

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Among the biggest producer of waste are banana, pineapple, mango, durian and tangerine. The other fruit only produce small portion of waste. The fact of fruit

waste are still contain useful material such as starch, sugar, pectin, vitamin, mineral, and bioactive compound. Second, it is difficult to collect because they are readily

only in processing unit such as canning factory, juice processing factory, fruit drying (“sale”), banana crisp factory. However some of fruit waste can be easily collected from household waste such as peel of durian and jack fruit.

The processing unit that produce collectible waste are as follow. The dried banana processing unit almost available almost in every province, banana crisp (the biggest in Lampung), banana crisp small and medium in Java, banana fried vendor also provide peel of banana that easily be collected. Puree and juice company normally processed fruit such as apple, guava, mango, star fruit, pineapple, passion fruit, durian. Fruit candy is producing candy normally from mango, passion fruit, durian, guava, soursop. There are also fruit soup and fruit ice shop which selling fresh prepared mixed fruit.

Society already use of fruit waste for producing processed products such as using seed of salacca to make “coffee “ powder. Seed of avocado is to be used in manufacturing traditional medicine. Peel of pabello for producing sugarised dried candy. Peel of jackfruit food meals by introduction of salt. Seed of jackfruit, durian, can be boiled and eaten as a starchy snack.

Conversion of the whole fruit waste into CO₂ is difficult to perform because some waste is in the form of peel, seed and core. Thus the conversion from wet to dry is also difficult to predict. Some waste is already used for feed stock. Some are used for production of traditional medicine, and food.

Improper handling in PHO (packing house operation) and other postharvest places will also generate fruit waste. Waste from Improper Handling are at harvest: pest and disease attack such as fruit fly anthracnose in mango and guava, chilling injury during low temperature storage, mechanical injury during transport, rotten during second sortation in wholesale, un-saleable product in retail outlet. However, the losses data is not many provided by researchers. Losses will cause loss of profit and cause waste problem in the city.

Some exporter claimed was lost nearly 95% of product arrived in destination in middle-east in 2003. Anthracnose is believed to be responsible for this since anthracnose infection in the field and the rotten fruit happen during distribution and transportation. Some disease incidence recently also happened caused by *Rhodotorulla* which is a yeast. This is most probably after global warming. Then it is needed a new treatment.

Impact of waste and losses in the rural area does not cause much problem and easier to handle but in the city will cause smell, sanitary problem also ruining view. As an example of the PT Great Giant Pineapple in rural areas in East Lampung can live in harmony with environment whereas PT UJ in Bandung has so much claims by surrounding society.

Ethylene which is naturally produced by fruit waste is considered harmless gas compare to methane for GHG. Thus, many researchers even recommend to convert methane to ethylene. One of the researchers [7], recommends using an oxidative coupling and solid catalyst for producing methane to ethylene.

V. GOVERNMENT REGULATION

Indonesian government is very responsive and active to protect living environment both central and local government by producing ministerial decree or local government decree, also society guide line. As an example is ministry of living environment decree no 5 2014 on the regulation of liquid waste [8], this is a regulation to replace many of previous regulations. Local government decree which is Bali province also produced government regulation no 4 year 2005 [9] on the controlling the contamination and damage on living environment. Ministry of Agriculture 2008 on and good manufacturing practices for plant material processing by ministry regulation no. 35 “Permentan” /OT/140/7/2008 [10]; Ministerial Decree of man power no. 187 2016 [11] for labor competency for how to handle industrial waste. In the field for society there is guideline for CSR (Company Social Responsibility) being use in the field of environment. This includes 3 R (reuse, reduce and recycle) [12]. Similarly also in Australia producing similar document but shorter a guideline to society but not social responsibility [13]. This is only a quick effort to find government regulation, if we go further then of course would find abundant.

VI. RESEARCH AND DEVELOPMENT ON UTILISING WASTE

There are abundant of research result that we can find easily in the internet or library. To make easier understanding, there are required to be classified. Below are some of the examples

A. Food Material and Functional Food

Making a ready to use product such as carbonated drink contain extract of mangosteen peel which is rich in xanthone [6]. Xanthone is natural bioactive compound which is believed and also some research provided, have a cure effect of many disease of human being. There is also study [14] on producing low methoxyl pectin by extraction from lime peel. Some researcher were producing vinegar from banana peel and coconut water [15], then using the vinegar for inhibiting the growth of *Listeria monocytogenes*. There are also efforts in the plate using mangosteen peel extract for preventing microbes of food contaminant [16]. The others are using peel of jack fruit cv. Cempedak [17] as source material of production of bioethanol for energy, and citrus peel with the help of *Aspergillus* spp for producing rhamnosidase [18].

B. Bioactive Compound

Production of antioxidant which is abundant in solid waste including fruit waste [19]; thus it is recommended to extract the antioxidant from solid waste, before further composting process. By doing extraction automatically it is stopped the respiration process, thus there is not anymore production of CO₂ and ethylene. Mango solid waste which is peel; and seed contained bioactive material that has capability to act as natural disease resistant material. By proper extraction, the disease

resistant material can be isolated [20]. The bioactive extract of mango peel was proven to have capability to control *Rhodotorulla* sp which cannot be controlled by benomyl in plate [21]. *Rhodotorulla* is a new mango disease appear after global warming because there is an extension of mango season in Indonesia.

C. Packaging Material

Packaging material is also causing problem to our earth. There are many packaging material which cannot be degraded by microbes which is available in the soil. Thus, they stay in environment for years. There are some research offering the solution by making a material which can be degraded. The peel of durian (the biggest portion is peel), and jack fruit cv. Campedak peel for producing edible film [22]. There is also study in producing polymer by using nano-material from pineapple waste [23].

VII. DISCUSSION

Since the attention of world society on the global warming, there were many attention and efforts given by Indonesian society, to understand, also to act. However, the understanding is still vary among member of society and the act is still sporadically. The action on the waste in waste collection situs is already taken by local government, because it is very distinctive and affect people in the city. Thus, we exclude this matter from the discussion. Even though fruit waste is smaller compare to waste produced by fossil fuel, it is necessary to prevent build up, thus, it is necessary to take action from the beginning. We classified discussion follow supply chain system start from farmer in field and orchard; postharvest collection, PHO, transportation and marketing it is called postharvest handling; fruit processing; and others will include idea on company coping with waste and trash.

A. Orchard

The leave, young fruit, branches, rotten fruit in tree such as in mango are sources of waste in the orchard. Flower of durian, small fruit, actually can be processed to food. Fallen young rambutan fruit, can be processed by young society in Malang for making a snack. Flower of durian can be used as vegetables. If not processed it is also can be used as raw material of composting. What we need is to educate farmer, about global warming, our next generation, and how to act and to do it; these beside their main duty which is producing premium quality fruit. In Indonesia there is a system through agriculture extension. Through this system better quality fruit can be produced *i.e.* free from ant fruit. Communication device such as what app can be used to support the activity across the country through smart phone. There are also means for preventing waste are breeding program for seedless fruit, breeding for thinner peel. There many regulation from the government to make a legal activity, but if it is not available, it can be made. Thanks to the extension worker that already acted to the right direction such as doing composting lesson.

B. Postharvest Handling

Postharvest handling can be done in farmer house or orchard but also in small collection trader, fruit ripener normally in banana, also in wholesale market, and supermarket. We exclude the activity in whole sale market because it is normally be handled by local government. The activity should be on the handling procedure for waste, processing the useful material, how to dispose, etc. There are many regulations from the government to make a legal activity, but if it is not available, it can be made. Building wholesale market for fruit outside the city or in city suburb is also an alternative solution. Other solution action is technology in disease resistant fruit, continuing research and development on postharvest storage and transport both for whole fruit and minimally processed fruit.

C. Fruit Processing

There are some companies who already processed the fruits waste to the profit such as xanthone producer, dried soursop leaves, pamelo peel candy, seed of salacca for coffee. There are also eating boiled seed of durian, jackfruit, and banana peel for animal feed. They are actually save farmer effort which is producing fruit for consumption. Thanks to the society who already have a thinking to reduce fruit waste.

There many fruit processor that can be classified into household base, or small processor (street vendor of fried banana, dried banana, banana crisp). The street vendors so far we believed are the most sustainable one, or actually when it is collapsed we do not noticed. For small unit processing there should be an education on how to minimize waste and conserve environment. Education on how to process waste such as seed and peel of fruit are needed to be done. Whilst medium processors (CV. PU) and big company like UJ, UNL, B, GG Pineapple also overseas like G. Circle, and one in east java processing which is apple nectar have to have different approach.

There are 5 examples for fruit processor in dealing with waste such as Great giant pineapple [24], Golden circle [25]-[28], UJ [29], [30], anonymous apple juice processor in east java [30]. The great giant pineapple so far has not face any problem in facing waste. It is a big company, marketed its product worldwide. It is produced juice and canned pineapple. They used zero waste concept such as pineapple peel for cow feed, cow manure for producing biogas for power, after biogas production the manure paste goes to field for pineapple growing. It was built far away from central city of Bandar Lampung, but it is closed to a harbor in Sumatra.

Golden circle have the same reputation, was built in North Gate, Queensland Australia. Golden circle is a multinational company which firstly built in 1947 [28], growing bigger, processed 180 000 tonnes of pineapple annually. In 2009 it was sold out to American company called Heinz. It was perfectly processed its waste. Solid waste for composting [26] and receive admiration from the government [25], and from the researcher [27]. However, the operation of the company was shut down in

2011, Heinz leave for New Zealand because possibly it cannot cope with the cost of production.

CV PU a small to medium, was a champion of ICAPRD (Indonesian Center for Agriculture Research and Development), which is processing of fruit mainly mango, guava, banana, soursop, rock melon, pineapple, and now lemon, for puree and pure juice. This processor is sustainable in their business by also processing many ready to drink product. Since introduction of the juice processing technique in 2003, with liquid waste treatment of 3 pools system, the company is still producing until now. Solid waste such as seed of mango are sold as for seedling but the pulp and peel just dumped in the garden. Now with the growing quantity of processing lemon, the company faced difficulty to process peel waste of lemon because their busy with the main business.

PT UJ is located near Bandung West Java was processing milk, then, widen their business on fruit juice brand Buavita. Finally they cannot cope with complexity of business and sell the juice line to PT Unilever [29]. Still PT UJ is facing difficulty in coping with people close to the plant. People are complaining about the drying of the well, and smell [30]. Koi Fish farmer in Malang, East Java complaining about the dead of the Koi fish, they accused the waste from the apple nectar or juice company's liquid waste responsible for it and smell of the waste spoilt the air [31].

Fruit processing company from small to big require a big land so that far away from the settlement at all time. However, by the time the company growing after 30, 40 and 60 years, surrounded areas become a crowded settlement. The absorption capability of the environment decrease whilst the companies are processing more and more products for consumer and customer. The limit of tolerance of surrounded inhabitant are also decreased because the increase of population. In business, they have more and more competitor with older machine and technology. This one happened to both company like PT UJ and Golden circle.

There are many ways to cope with the problem. One of them is contracting some of "dirty work" to the supply chain partner. This one happened in the company like "Sido Muncul", they are only received dried material from the farmer. This then keeps the plant cleaner. So the big company should keep in their mind for future "environment" problem. We are human being required jobs and employment but we also want cleaner processing activity.

Small to medium enterprises can be helped by government by choosing processing technique with high B/C ratio (benefit and cost) ratio. And let the low B/C ratio which is required high turnover are done by big company. For small to medium unit processing there should be an education on how to minimise their waste and conserve environment. Education is necessary on how to process seed and peel of fruit, and treated liquid waste. The unit processing should consider 'safe' location by predicting the growing inhabitant, building, road and transport after 10 years to 20 years, at site close to their plant.

D. Others

In the system so far we use jargon such as who made the trash should clean it. This one is a bit old model since the farmer, processor, supermarket are normally very busy doing their main business in modern society, with many competitors of their product. By initiation from central and local government we can create a small to big companies that have relation to farmer, trader, collector, ripener, and market close by. These companies would have capability to process the waste to make money. The MoU can be made special such as take the waste first without pay, and sharing the profit and make payment later. If the waste produced is least, farmer and other actors of Supply Chain sustainable. The technology from [6], [14]-[23] can be explored to find the best economically viable.

From waste to waste, the idea given by young researcher to extract the D-limonene from citrus peel, with very low investment, can then add to Styrofoam which is in the form of polymer, which very difficult to degrade. After degradation it becomes monomer which can be used by microbes for their source of metabolism. This idea is great but it is need to define who will pay for the activity, to have sustainable one.

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Setyadjit Setyadjit was born in Blitar East Java, Indonesia on December 12th, 1959. He got PhD in Horticulture, Queensland University, Australia, 2001, Master in Applied Science in food technology, University of New South Wales, Australia, 1989, and teknologi hasil pertanian, Institut Pertanian, Bogor, Indonesia, 1982. Since 1982 to date, he is working as a postharvest researcher in the Indonesian Ministry of Agriculture. There he was working in Central Research Institute for Horticulture until 2002, Indonesian Center for Agriculture Postharvest Research and Development, in Bogor, to date.

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Dr. Setyadjit, MAppSc a member of Indonesian Food Technologist and Himpenindo (Himpunan Peneliti Indonesia). His interest is on postharvest handling, processing and quality of horticulture produce.



Ermi Sukasih was born in Trenggalek, East Java, on November 17, 1973. She is a master's graduate in Food Science at Bogor Agricultural Institute. Until now the author works as a Researcher at Indonesian Center for Agricultural Postharvest Researches and Development. Her publication:

"Effect of ascorbic acid soaking and sodium bisulphite on two varieties of shallot (*Allium ascalonicum* L.Cepa) on physical and organoleptical character of shallot powder," *Agritech*, vol. 36, pp. 270-278, 2016.

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Ermi Sukasih, STP, MSi is a member of Indonesian Food Technologist and Himpenindo (Himpunan Peneliti Indonesia). Her interest is on processing and quality of horticulture produce.



Risfaheri Risfaheri was born in Sawahlunto, West Sumatra, Indonesia, July 1st 1964. He got Doctorate degree from Institut Pertanian Bogor, Indonesia, 2002, teknologi industry (industrial technology). He is working in Ministry of Agriculture since 1987 to date. He obtained a Professor (Riset) in 2010. He is Head of Bangka Belitung Institute for Agriculture Technology Assessment 2011-2013; Head of Lampung Institute for Agriculture Technology Assessment 2013-2014; Head of Research Institute from 2014-2016; Director of ICAPRD since 2016 to date. Prof. (R) Dr. Ir. Risfaheri is now a member of Himpenindo (Himpunan Peneliti Indonesia). His interest is on postharvest of agriculture crop.