

# Analysis of Tropical Fruit Waste Biomass Generation in Indonesia and Its Reuse Potential

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## ABSTRACT

Several The following research focuses on analysing waste biomass generated thru the processing of specific tropical fruits, such as Dragon fruit, Duku, Mangosteen, and Snake fruit. The amount (in %) of produced fruit waste biomass (skin, peel) during fruit processing was monitored, and collected waste biomass was subjected to determination of its basic chemical parameters and elementary composition within its possible utilization as a source of renewable energy. Averaged determined ratio of generated waste biomass of total fruit mass was following: Dragon fruit - 35.83%, Duku - 23.48%, Mangosteen - 69.40% and Snake fruit - 15.16%. Analysis of moisture content  $Mc(\%)$  exhibited unwanted high values of such indicator (44.57 - 61.70%), but satisfactory level of ash content  $Ac(1.15 - 8.23\%)$ , which indicated suitability for combustion purposes. Observed  $Mc$  results may be improved by using solar renewable energy. Elementary composition analysis proved a suitable ratio of  $C:N (\pm 25-30:1)$  in the case of Dragon fruit and Duku fruit samples, which indicated their suitability as a natural fertilizer in the form of the compost. In conclusion, investigated specific fruit waste biomass contributes to the waste production in a significant way. Therefore, their sustainable utilization is necessary and due to the observed data also advantageous (possible highly advanced source of green energy purposes).

**Keywords:** waste biomass, elementary composition, compost

## 1. INTRODUCTION

Agricultural Waste biomass represents all organic waste materials originating from plants, bacteria, cyanobacteria, fungi, as well as from animals. Various kinds of waste biomass originated from agriculture sector, mainly from processing of agriculture crops. Majority of such waste biomass materials can be recycled or reused as a feedstock for production of alternative environmentally friendly biofuels (in liquid, solid or gaseous form) [1]. Mentioned biofuels are offering new possibilities how to ensure the energy demand nowadays and conserve environment at the same time.

Unfortunately, worldwide energy consumption is still ensured by the fossil fuels, whose using causes serious environmental damages; specifically, 31% of produced energy originated from oil, 29% from coal, 21.2% from natural gas and only 10.3% from waste

biomass-based biofuels in 2014, despite the fact that waste biomass has a great potential in energy production sector. The advantage of waste biomass lies in its low carbon and greenhouse gas emissions and mainly in its availability [2, 3].

The oil represents a primary energy source in Indonesia, specifically, a 1.61 billion barrel oil equivalent (BOE) was monitored in 2013. Nevertheless, utilization of waste biomass in its raw unprocessed form (firewood, empty coconut shells or empty fruit bunches) is still common in many regions in Indonesia, thus, the habit of waste biomass utilization is still between the wide public mostly in rural areas. Nevertheless, the amount of energy generated by biofuels achieved only 4% in 2013 in Indonesia [4].

Dragon fruit, also known as a Pitaya, Pitahaya or Strawberry Pear grows on the climbing cactus plant and currently is cultivated in countries like of Southeast Asia, Israel, Australia, China, Philippines, Hawaii, Mexico, Colombia or Spanish. Duku fruit is commonly also called Doekoe or Dookoo and grows on robust tree in Southeast Asia, in Hawaii, Surinam or Rica. Mangosteen fruit, also called Mang-khud or Manggis, grows on the slow-growing tree in Southeast Asia. Finally, Snake fruit, also called Salak or Buahular, grows at short-stemmed palm in Southeast Asia [5-9].

Abundant amount of fruit waste biomass is generated worldwide within the food processing processes. Unfortunately, its subsequent utilization or recycling in not the matter of course; in many cases is such fruit waste biomass left behind without any useful reuse. The impact of such bad waste management can be reduced by reusing of specific parts of the fruit waste biomass (bioactive components converting) for production of biofuels [10, 11].

The main aim of present investigation was to analyse the amount of waste biomass (%) of selected tropical fruit kinds (Dragon fruit (*Hylocereus Polyrhizus*), Duku (*Lansium Domesticum* Correa), Mangosteen (*Garcinia mangostana* L.) and Snake fruit (*Salacczalacca*) generated during the fruit processing (skinning, peeling). Further, the chemical analysis of generated fruit waste biomass was also the subject of the

investigation within the statement of such waste materials potential sustainable reuse or recycling.

2. MATERIALS AND METHODS

Materials and samples used in performed investigation originated from Bandar Lampung, Lampung district, Sumatra, Republic of Indonesia (see Figure 1) and represent fruit waste biomass generated during fruit processing.



Figure1 Target place of investigated samples growth, processing and collection

Specifically, the fruit components as an exocarp, mesocarp, endocarp (outer skins, peels) of Dragon fruit, Duku fruit, Mangosteen fruit and Snake fruit. Table 1 describes taxonomical origin of selected fruit.

Table 1. Taxonomical characterization of investigated fruit kinds

Fruit	Latin name	Family	Origin
Dragon fruit	<i>Hylocereus Polyrhizus</i>	<i>Cactaceae</i>	Central America
Duku	<i>Lansium Domesticum</i> Correa	<i>Meliaceae</i>	Western Malaysia
Mangosteen	<i>Garcinia mangostana</i> L.	<i>Guttiferae</i>	Sunda and Maluku islands
Snake fruit	<i>Salacczalacca</i>	<i>Arecaceae</i>	Southwest Java, South Sumatra

All samples were collected during rainy season from February to May 2019 within the local markets or small processing plants in Bandar Lampung. Investigated fruit kinds were chosen because they represent popular, well-known and widely consumed agriculture crops in

Indonesia, thus, the generation of fruit waste biomass during their processing was ensured. The form of collected fruit waste biomass sample sis expressed in Figure 2 below.



**Figure 2** Investigated samples (skins, peels) before experimental measurements: a) Dragon fruit, b) Duku fruit, c) Mangosteen fruit, d) Snake fruit

First monitored parameter was the amount (in %) of waste biomass of total fruit mass generated during fruits processing. Experimental measurement was following; each of fruit sample was independently weighted before processing (skinning, peeling) and after processing, as well as the generated waste biomass was weighted. Observed data were subsequently used for calculation of percentage of waste biomass generated of total fruit mass by using of following formula (see Equation 1):

$$FWB = \frac{m_2}{m_1} \cdot 100 \quad (1)$$

$m_1$  - mass of fruit before processing (g),  
 $m_2$  - mass of fruit after processing,  
 FWB - amount of fruit waste biomass (%)

Subsequently, a chemical analysis of collected fruit biomass samples was performed within the statement of its possible subsequent utilization as a source of renewable energy. Determination of fuel parameters contained of determination of moisture content  $Mc$  (%), ash content  $Ac$  (%), total solids  $TS$  (%), volatile solids  $VS$  (%) and of elementary composition as a Carbon  $C$  (%), Nitrogen  $N$  (%) and Hydrogen  $H$  (%). All experiments were performed directly after the samples collection and were conducted to mandatory technical standards related to the determination of biomass parameters and its utilization for direct combustion processes; namely, to Standards EN ISO 16948 (2016), EN ISO 18123 (2016), ISO 18122 (2015), EN 18134-2 (2015). Determination of moisture content  $Mc$  (%) was performed by using of laboratory oven Memmert, type UN55 (Schwabach, Germany); the investigated samples

were dried for 24 hours at 102°C until their constant weight. Determination of  $A_c$  (%), total solids  $TS$  (%) and volatile solids  $VS$  (%) was performed by using of laboratory muffle furnace oven ISUZU, type EPTR-13K (Sanjo, Japan); the investigated samples were dried for 6 hours at 600°C until the weight of ash was constant.

### 3. RESULTS AND DISCUSSION

Main objective of performed research was to analyse the amount of fruit waste biomass (%) generated during the specific fruit kinds processing (skinning, peeling). Detail data of such observation are noted in Table 2 below.

**Table 2.** Waste biomass analysis of investigated fruit kinds

Sample	$m_1$	$m_2$	$m_w$	$FWB$
	(g)	(g)	(g)	(%)
Dragon fruit	588.95 ± 120.50	381.43 ± 98.17	207.52 ± 37.63	35.83 ± 5.75
Duku	17.78 ± 4.30	13.68 ± 3.75	4.20 ± 0.77	23.48 ± 5.14
Mangosteen	89.24 ± 27.39	28.03 ± 12.31	61.21 ± 17.72	69.40 ± 9.04
Snake fruit	74.10 ± 8.94	62.88 ± 7.85	11.22 ± 1.77	15.16 ± 1.78

$m_1$  - mass of fruit before processing,  $m_2$  - mass of fruit after processing (g),  $m_w$ - mass of generated waste biomass,  $FWB$  - amount of fruit waste biomass, ± - standard deviation

As is visible, the greatest amount of fruit waste biomass was proved in case of Mangosteen fruit (69.40%), while lowest ratio of waste biomass to fruit was monitored in Snake fruit case (15.16%). Nevertheless, the amount of generated fruit waste biomass of all investigated fruit kinds occurred at high level, thus, production of great amount of waste biomass material within such fruit products and by-products production can be indicated. In consequence, subsequent utilization for some of the environmentally friendly purpose should be highly supported.

Laboratory experimental measurements focused on the basic chemical parameters of obtained fruit waste biomass (see Table 3) primarily expressed the level of

moisture content  $Mc$  (%). As was expected, the level of moisture content  $Mc$  (%) occurred at high level in case of all investigated fruit waste biomass samples, which is directly related to the taxonomical origin of fruit kinds. Obtained result can be considered as a limitation within subsequent reuse of such waste materials, due to the fact, that its conversion into the biofuels or its components commonly contain of drying process, which represent an energy investment. Nevertheless, countries as an Indonesia dispose of great potential of solar drying sustainable technologies (renewable source of energy), which can be easily applied and can solve the energy demand issue.

**Table 3.** Chemical parameters and energetic potential of investigated fruit biomass samples

Sample	$Mc$ (%)	$A_c$ (%)	$TS$ (%)	$VS$ (%)
Dragon fruit	61.70 ± 0.98	1.36 ± 0.04	38.30 ± 0.98	36.94 ± 1.02
Duku	74.64 ± 0.46	1.89 ± 0.02	25.36 ± 0.46	23.47 ± 0.44
Mangosteen	59.45 ± 0.29	8.23 ± 0.22	40.55 ± 0.29	32.32 ± 0.19
Snake fruit	44.57 ± 0.06	1.15 ± 0.05	55.43 ± 0.06	54.28 ± 0.01

$Mc$  - moisture content,  $A_c$  - ash content,  $TS$  - total solids,  $VS$  - volatile solids,  $CV$  - calorific value, ± - standard deviation

Analysis of ash content  $A_c$  (%) proved satisfactory level of such chemical quality indicator in case of all investigated samples. Great results (comparable with wood biomass) were achieved by samples of Dragon fruit, Duku fruit and Snake fruit; the results of Mangosteen fruit occurred at higher level, but it is still

acceptable result. Such observation proved that investigated fruit waste biomass samples are suitable for process of direct combustion, which indicated that they can be used as a feedstock material for production of solid biofuels like bio-briquettes or bio-pellets.

Finally, the elementary composition of samples was performed in effort to state their suitability for recycling purposes, specifically, to be used as a natural fertilizer in the form of the compost. For production of high quality compost the proper Carbon-Nitrogen ratio must be achieved, approximately 25-30:1 (*C:N*). Regarding to

observed data, expressed in Table 4, the proper ratio of *C:N* was observed in case of Dragon fruit and Duku Fruit samples. In case of Mangosteen and Snake fruit the ratio of *C:N* was too high (excess of Carbon), which would in practice results in unrequired slow decomposition of compost components.

**Table 4.** Elementary composition of investigated fruit biomass samples

Sample	<i>N</i> (%)	<i>C</i> (%)	<i>H</i> (%)
Dragon fruit	1.76 ±0.02	37.23 ±0.49	5.33 ± 0.04
Duku	1.57 ±0.06	50.63 ±0.15	7.24 ± 0.09
Mangosteen	0.69 ±0.04	49.98 ±1.70	6.14 ± 0.23
Snake fruit	0.88 ±0.02	46.08 ±0.06	6.23 ± 0.06

*N* - Nitrogen, *C* - Carbon, *H*- Hydrogen, ± - standard deviation

#### 4. CONCLUSION

In conclusion, performed research proved production of great amount of fruit waste biomass from processing of investigated tropical fruit kinds, while greatest amount of waste biomass was monitored in case of Mangosteen and Dragon fruit, specifically, 69.40% and 35.83% of total raw fruit mass (in order). Thus, subsequent reuse of such waste materials within specific environmentally friendly purposes was highly recommended. Chemical analysis proved undesirable high level of moisture content in case of all samples, but it can be easily improved by using of solar energy. Moreover, determination of ash content expressed extremely good result values (comparable with wood biomass), which proved the suitability of samples for processes of direct combustion (solid biofuel production). Elementary composition proved the efficiency and advantage of Dragon fruit and Duku fruit waste biomass in production of natural fertilizer, while they proved their suitability within being a suitable component of high-quality compost. In the end, It is important to realize and understand the fact that such fruit waste biomass materials are produced

every day in great amount and they do not represent useless waste, but commodity with high potential, which can be valorised, reused or convert into specific type of biofuel or fertilizer. In all cases should be treated according to the sustainable steps of proper waste management.

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