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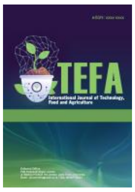

Article

Developing Coffee Cherry Skin and Coffee Husk by Products as Sustainable Novel Food and Fuel

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Abstract: Coffee plantations can potentially support an integrated sustainable coffee production (SCP) system, particularly through the expanded utilization of by-products. Smallholders mostly manage coffee plantations in Indonesia. Coffee processing cannot avoid waste entirely. However, poor processing will increase waste. This research aims to utilize by-products (coffee skin) to create novel food (cascara) and potential fuel. The raw materials from Cherry skin (CS) and Husk skin (HS) are obtained from wet and dry coffee processes. This research conducts the process of sorting raw cascara and roasting it. TDS and pH are examined to measure the level of extraction, while a group of panelists assess the aroma, taste, and mouthfeel using a series of scaling points for justification. CS does not require sorting. However, HS is sorted into three sizes: 7.5mm, 6.5mm, and 5.5mm, respectively. In this study, 1,000g HS has an approximate size distribution of about 25% 7.5 mm, 15% 6.5 mm, and 20% 5.5 mm; the rest is dust and green beans (GB) coffee pixels. In conclusion, CS and HS were roasted to produce food products (cascara). About 2.5kg of raw HS is needed for 1kg feed HS (7.5mm and 6.5mm). HS measuring 5.5mm or below, and the remaining fraction of dust makes up about 54% of the raw feed and can be used as fuel (briquettes).

Keywords: Cascara, cherry skin (CS), husk skin (HS), food, fuel

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1. Introduction

The coffee plant offers more than just a drink made from roasted coffee beans; various by-products are produced during cultivation and production [1]. Cherry skin and silver skin coffee by-products have the potential to produce cascara [2], but the coffee husk is also a type of waste that arises from dry method coffee production. Cascara has become an important opportunity to reduce environmental impact [3]. Cascara produced from Arabica or Robusta coffee has different taste and aroma profiles. Samples with a sour taste and fruity aroma were most dominant in the Arabica cascara samples. In contrast, bitter flavors and aromas (such as floral, black tea, and hay-like) dominated the Robusta cascara samples [4] (cascara was not roasted in this case). Cascara contains polyphenols [4] and antioxidants, and has a low caffeine content [5].

The typical cascara process only consists of drying the raw material in the sun until the water content is between 10-12%, then it can be brewed [6]. Cascara as a by-product is currently a relatively novel food; with various methods of brewing [7]. Cascara can be drunk by adding lemon and honey [8], and especially by adding coffee blossom. Coffee husk skin is rarely used for cascara production because of dust particles in the feed. So, size sorting and dust cleaning need to be done for this waste. Meanwhile, the tannin content of Arabica cascara tea is superior in yield, pH, ash content, antioxidant activity, and caffeine content. Regarding organoleptic scores, Arabica cascara tea produced from fresh cherry skin was most preferred by panelists [9]. Total dissolved solids (TDS) and pH are used for solubility levels, especially in tea investigations [10] , which also use TDS and pH as references for flavor and volatile compound [11]. Even though this study does not yet examine volatiles, it provides an basis for the author's further research, to outline the impacts and opportunities for processing by-products from coffee skins.

This study uses raw materials from CS and HS for the production of novel food (cascara) and potential fuel (briquettes). In previous research, Cascara processing did not go to the roasting stage to process this waste; therefore the novelty of this study is that the authors identified by-products, carried out roasting with the observation of parameters of time, temperature, and level of cascara roasted towards Sustainable Novel Food (mainly) and the rest Fuel. This study aims to analyse the potential to develop a product from coffee waste skin by considering roasted by-products (CS and HS), which are scored on the parameters cup-test, taste-mouthfeel attributes, and aroma attributes. The remainder of the material is potential fuel (briquettes).

2. Materials and Methods

Experimental and observational methods were applied in this study. This study used two types of coffee skin waste: Cherry Skin, produced from the wet method of coffee processing and Husk Skin produced from the dry method. The raw material is from the Andungsari Arabica variety. CS is obtained after pulping (separating the skin and pulp of the beans), while HS is obtained after hulling. HS has mixed particles (fine (dust), medium, and coarse). Sorting is selected for the advanced stage of HS. Next, the roasting stage is chosen to determine the profile; we refer to SCA profiling [12][13][14]and apply it to cascara as a color profiling consideration. The roasting stage uses medium roasting. The roasting temperature applied here is the typical tea roasting temperature of 80 – 120^o C [15][16][17]. We conducted the cup test for aroma attribute parameters: floral, sweet, and roasted; and taste and mouthfeel attributes: bitterness, astringency, and sweet aftertaste [17]. The water content of the material is around 7% ± 0.5, then it is roasted like tea until the maximum water content is between 2 and 5% [16][18]. The panel for sensory evaluation was composed of 10 panelists (six men and four women, 30 – 38 years old), all of whom were from the Coffee Science Institute (CSI) and Vilos Laboratory, Jember, Indonesia. Figure 1 shows the flow of processing by-products into coffee tea (cascara). The sample is 1,000g CS, and sorted HS. We evaluate cascara brewing with TDS and pH of Cherry Skin Roasted Ground (CS R G), Cherry Skin Roasted (CS R), Husk Skin Roasted Ground (HS R G), Husk Skin Roasted (HS R), Husk Skin Raw (HS Raw), Husk Skin Raw Ground (HS Raw G), CS Raw Ground (CS Raw G), and CS Raw. A ten-point scale was used for grading the six flavors in which 0 – 2 was "very weak," 3-4 was "weak," 5-6 was "neutral," 7-8 was "strong," and 9-10 was "very strong" [19].

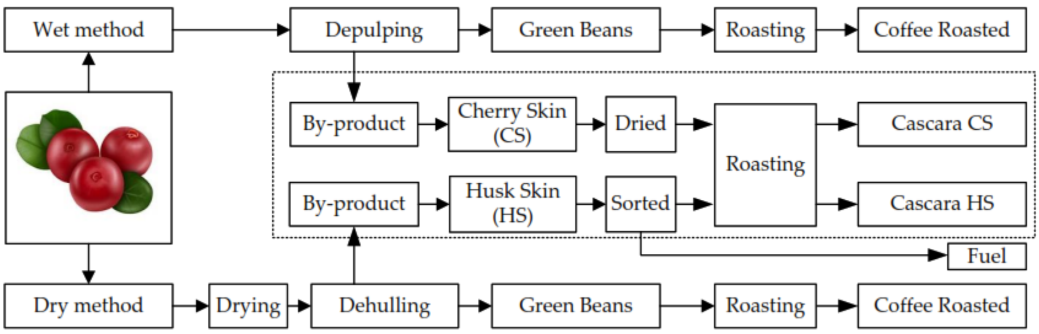

Figure 1. Limitation study by-product cascara

3. Results and Discussion

Wet and dry coffee methods are adjusted to market or commodity demand and conditions of excess raw materials and specialty coffee requests. There are two ways of wet processing: full-wash and semi-wash. Both require large quantities of water. Full-wash and semi-wash, through the de-pulping stage, produce CS by-products and water, while full-wash from fermentation produces wastewater (potential biofuel feedstock). There are various dry processing methods, with the most common being the "natural" process. This method is environmentally friendly, but the taste of this process is difficult to control. Alternatives include the Anaerobic methods, with options including: anaerobic without the addition of other ingredients; anaerobic with an injection of fruit material (Inoculant); anaerobic with an injection of lactic acid bacteria (LACTIC); anaerobic with CO_2 injection (Carbonic Maceration) and, anaerobic with pulp injection of wastewater inoculant (Mosto). The choice of method is adjusted to demand, but generally, the dry methods, such as anaerobic and natural, are chosen.

This study used anaerobic HS and full-wash CS samples. We set the roasting temperature between 90 and 100^{o} C for 10 minutes. Samples were taken from each stage and weighed to calculate the roast yield distributions cascara. Figure 2 shows the weight loss during roasting. Various products are roasted in addition to coffee, including tea, and tartary buckwheat. Weight loss during roasting can be used as a reference for roasted coffee color, taste, aroma and quality [20], and when brewing as an antioxidant reference [21]. Similarly, roasting is used to change the content of volatile compounds, chemical content, profiling, etc [22][23], even tarty buckwheat can be roasted to improve its antioxidant profile [24]. The authors` have not found any references about roasted cascara, although several varieties of cascara in Aceh have the same characteristics as tea [25], cascara in the European market is sold as a novel alternative beverage [26].

Through this study, the author applies husk-skin sorting to separate alternative streams for co-products. HS selection is determined by sorting into sizes of 7.5mm, 6.5mm, and 5.5mm. Figure 3 shows HS raw materials sorted by size. We use sizes 7.5 and 6.5 for the HS roasts so, the potential fraction of raw HS for use in cascara is 40.6%. Pixel is a small type of coffee used for commercial ground coffee. Meanwhile, the remaining fraction (33.2%) has the potential to be used as fuel in the form of briquettes which can be used as alternatives for wood used in traditional roasting of coffee. The energy potential in HS is calculated based on the resulting combustion treatment, with a calorific value of 30.54Kcal/kg [28]/ The overall heat potential is calculated using equation(1).

Heat potential HS:

$$Hp\ HS = Cap\ Hs\ x\ HHV\ HS \qquad (1)$$

Where :

Hp HS = *Heat Potential HS (kWh/kg).*
Cap HS = *Husk Skin quantity (kg)*
HHV = *Higher Heating Value, 30.54 (Kcal/kg)*

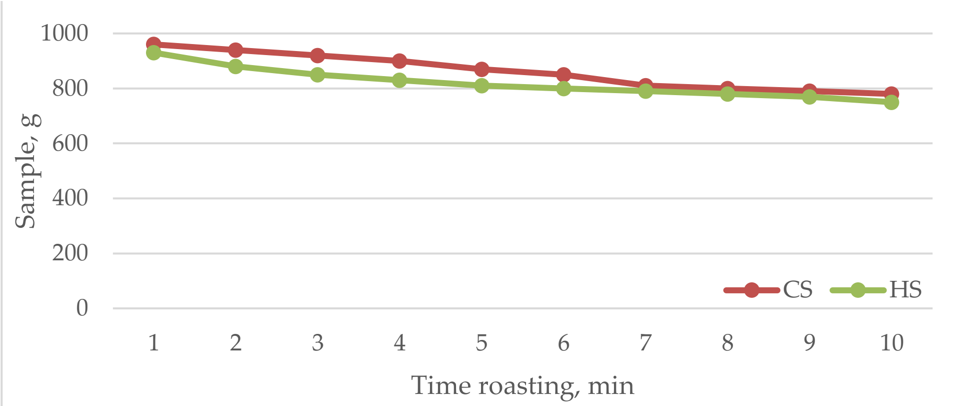

Figure 2. Weight loss of sample during roasting

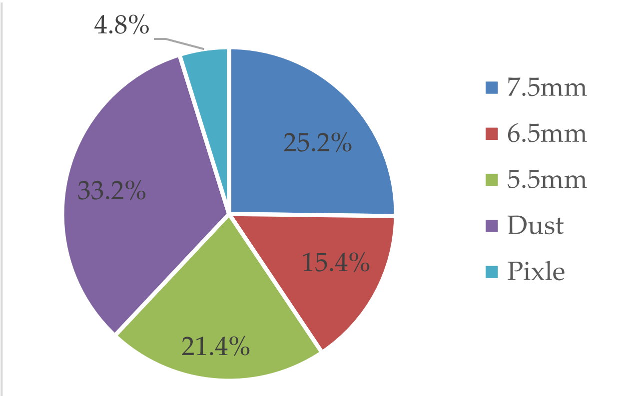

Figure 3. Size distribution of sorted HS and manual sortation screens 7.5mm, 6.5mm, and 5.5mm

Figure 4 illustrates the physical differences of raw HS, 1,000g of raw HS is sorted to produce 252g of 7.5mm HS; 6.5mm size 154g, 5.5mm size 214g, dust 332g, and pixel 48g. Cascara production via HS requires more ingredients than CS, as in the latter 1,000 g can be roasted directly without sorting to produce 780g CS R medium. In contrast, around 2 or 3kg of HS material is required to get around 1 kilogram of roasted HS, as only sizes 7.5mm and 6.5mm are utilized. HS 5.5mm can be used as cascara, but we must adjust the roasting temperature and time to avoid producing a dark roast.

Figure 4. Raw HS (a) ; Sorted HS of size 7.5mm (b), 6.5mm (c), 5.5mm (d), and pixel (e).

Figure 5. CS R (a), CS raw(b), HS R (c), HS raw(d)

Figure 5 shows the difference between roasted CS (a) and raw CS (b), roasted HS (c), and raw HS (d). Raw CS and HS are soft (without roasting), and have a water content between 8-10%. Meanwhile, CS and HS harden after roasting. Figure 6 shows the extraction results for each cascara from CS. CS R G samples were ground and brewed at a temperature of 98^{o} C, and TDS and pH measurements were carried out from one minute to eight minutes on multiple samples. We use this parameter as a measurement of solution extraction. The mineral water we use is TDS 152. We can see the difference in Figures 6 and 7; the TDS of cascara from CS differs from HS.

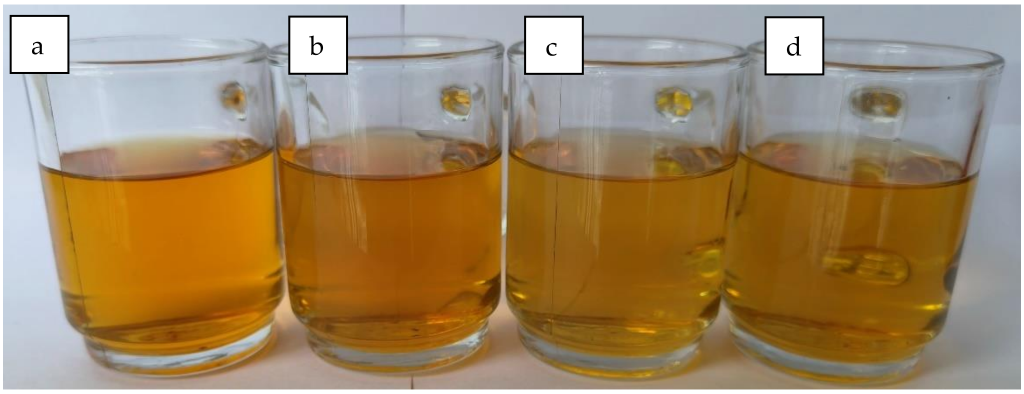

Figure 6. CS roasted ground (a), CS roasted (b), CS raw ground (c), CS raw (d)

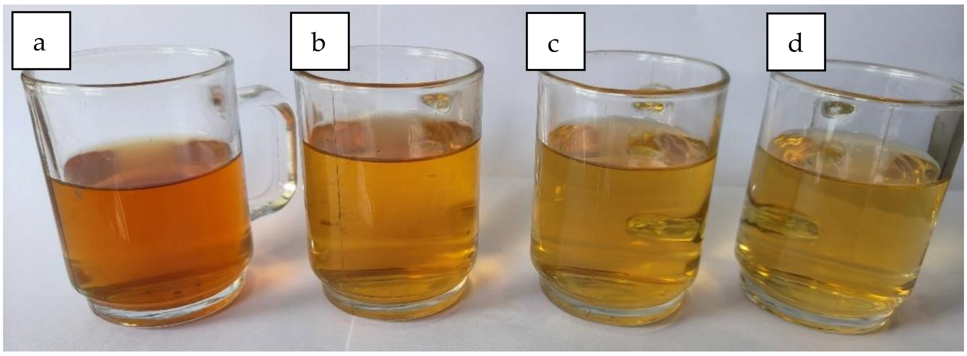

Figure 7. HS roasted ground (a), HS roasted (b), HS raw ground (c), HS raw (d)

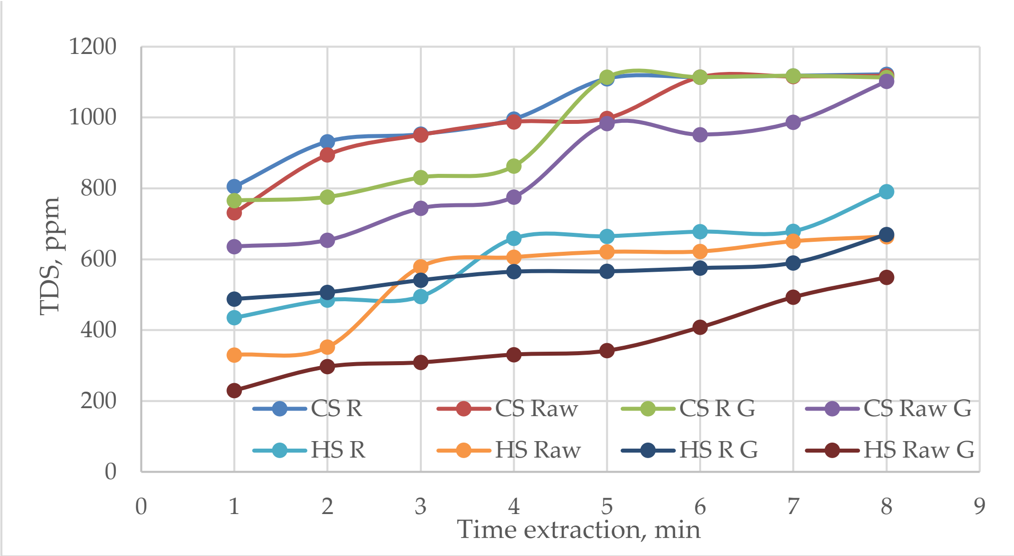

Figure 8. TDS of Cascara samples

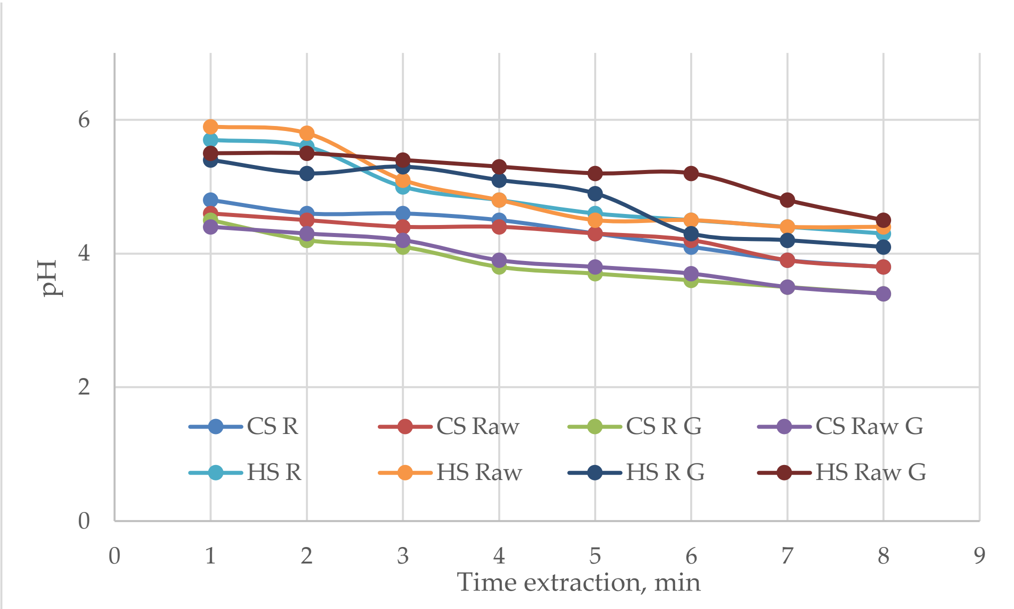

Figure 9. pH Cascara sample

Figure 8 shows the TDS of cascara. The extraction groups are different for each CS and HS type; even though HS consists of parchment and cherry skin, the TDS is still lower than CS. TDS tends to increase from one to eight minutes, showing that extraction progresses across the period time.

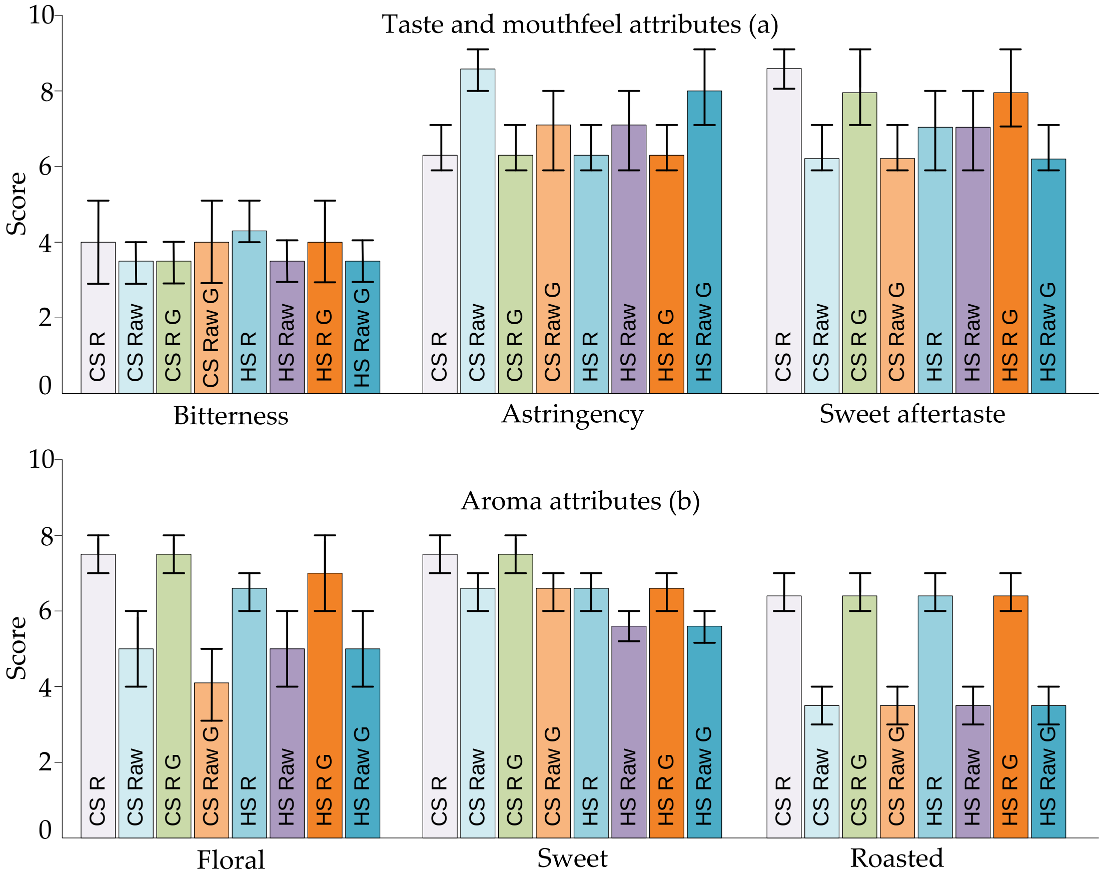

Figure 10. Taste and mouthfeel (a), and aroma attributes (b)

Based on a cup test, panelists evaluated the taste, mouthfeel, and aroma. We brewed cascara with a ratio of 1:15 (cascara: water), with the time of extraction to serving being up to 8 minutes. TDS for CS R was found to be higher than the others. The floral and sweet attributes also represent the panelists' preferences; the scores ranged between 7 and 8. CS R aroma is strong (7-8) showing that the medium roast is suitable for cascara. In contrast, light roast tastes astringent, while dark roast tastes like smoke (roasted). 1kg CS produces 785g of roasted CS, while 2.5kg raw HS produces around 1,015g of 7.5mm and 6.5mm (HS Sized). 1kg HS (7.5mm and 6.5mm) becomes 750g HS roasted. So, 2.5kg of raw HS can produce 830g of dust, 535g of HS 5.5mm, and 120g of GB pixels. The remaining HS sorting dust reaches 33.2% and can be used for combustion in a mechanical dryer. However, if dust and HS 5.5mm are used as fuel, dust + HS 5.5mm reaches 54.6%, or as much as 1.365g from 2.5kg raw HS. By making HS pellets from these materials, the HS calorific value reaches 16,898 kJ/kg [18] and has been reported up to 18.98 MJ/kg in Ethiopia [29]. Making charcoal requires 2.5kg HS to produce 1kg char, with a density of 970kg/m^3 and a higher heating value (HHV) of around 30.54 Kcal/kg [28]. If dust and HS 5.5mm are used as raw pellets, raw HS of around 4.5kg is required to produce 1kg of charcoal. About 1.8kg is the feedstock for cascara (HS 7.5mm and 6.5mm), and 216g GB pixel for commercial coffee. The Indonesian National Standard (SNI) briquette was 5,000 kcal/g, mixing 75% HS + 25% coconut shell. The calorific value was 2.57 x 10^7 kJ/kg [30]. Utilization of this was from HS is a solution for implementing renewable energy (biomass waste), and reducing CO_2 emissions.

Figure 10 illustrates the mass flows of by-products from two processing methods: full-wash and anaerobic. The estimated CB requirement is between 4.8 and 5kg to produce 2.4 – 2.5kg CB wet or around 1.2kg CB dried. Through the medium roasting method, around 1kg of roasted CS is produced. Meanwhile, in the anaerobic method, 1kg roasted

HS, requires around 2.5kg raw HS and 9 – 10 kg CB. The potential fuel from this process is 0.5kg char [28].

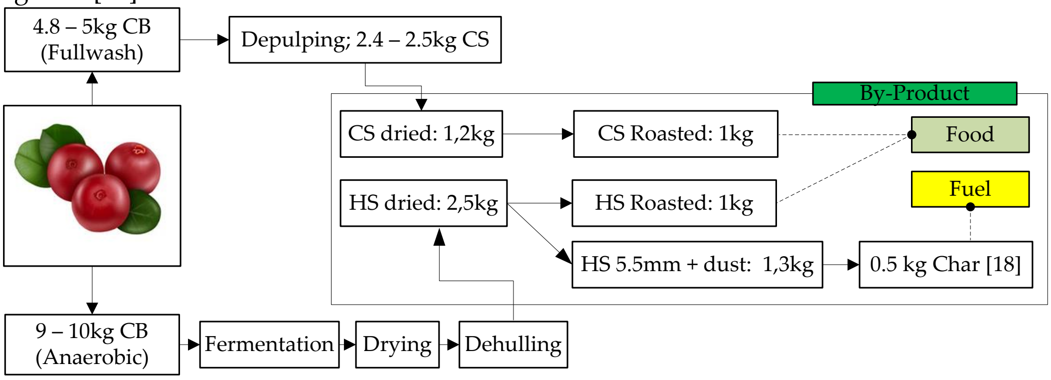

Figure 11. Sustainable novel food and potential fuel from by-products.

4. Conclusions

This study describes the potential use of CS waste as a food product for sustainable coffee production (SCP). From cherry beans (CB) we can produce roasted CS 18% -20 % and roasted coffee (CR) between 15% -16 %. So, in total this reaches 36% as food products, when CS or HS Cascara are used for novel sustainable foods. One kg CS produces 785g of roasted CS, one kg HS produces 406g of 7.5mm and 6.5mm sizes, 214g of 5.5mm sized material, 332g of dust, and 48g of Green beans Pixle (for commercial coffee powder). One kg of HS is mixed (7.5mm and 6.5mm) to produce 750g of roasted HS. To get 1kg HS (7.5mm and 6.5mm) requires at least 2.5kg raw HS, raw HS 5.5mm + dust of 1,365g potentially for fuel. The wet and dry coffee processing methods produce solid and liquid waste which can be turned into by-products to provide novel sustainable food from CS and HS, while an additional fuel (briquette potential) stream is produced from HS dust or HS sized 5.5mm.

Author Contributions:

The team contributed through experiments, observations, measurements, and data validation. Direct observation and sample test assessment involved the CSI laboratory and Vilos, and the assessment panelists. Manuscript contributions are described; first author: idea, conceptualization, test flow, experimental, data measurement, data validation, data interpretation, manuscript writing. Second author: conceptualization, data validation, manuscript writing. Third author: experimental, data measurement, sample testing, sample scores, observation panelist.

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Conflicts of Interest: The authors declare no conflict of interest; we declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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