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Assessment on Coffee Cherry Flour of Mengani Arabica Coffee, Bali, Indonesia as Iron Non-Heme Source

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Abstract | Coffee Cherry Flour (CCF) of Arabica Coffee Pulp (CP) produced in Kintamani, Bali, Indonesia, has been compared to CCF traded in La Boite, New York. CP samples were picked from the pulper, oven-dried at 80 °C for 15 h, and then grounded using a coffee grinder. Analyses on Mengani's CCF and La Boite's comprised Fe content (Inductively Coupled Plasma Optical Emission Spectrometer) as well as five enhancer agents – vitamin C (Iodimetric titration), beta carotene (UV-Vis spectrophotometer), amino acid (amino acid analyzer), and reducing sugars (colorimetric method). Utilizing descriptive statistics, the research is presented in box-plot, with a *t*-test. It was recorded that Fe content in Mengani's CCF [9.269 mg 100 g^{-1}, ranged (4.717 to 15.686) mg 100 g^{-1}] was lower than La Boite's, although statistically insignificant ($P > 0.05$). On five enhancers agents' side, Mengani's vitamin C [185.45 mg 100 g^{-1}, ranged (143.03 to 227.27) mg 100 g^{-1}] and beta carotene [4.370 g mg^{-1}, ranged (4.367 to 4.587) g mg^{-1}] contents were only slightly different ($P < 0.05$). Noteworthy distinctions were on Mengani's amino acid content [7.571 g 100 g^{-1} ranged (7.222 to 7.920) g 100 g^{-1}], which was much lower ($P < 0.01$), and its reducing sugars content [4 311.10 mg kg^{-1} ranged (3 911.10 to 4 422.20) mg kg^{-1}], which was higher ($P < 0.01$) than LaBoite's. Mengani's amino acid is presumably degraded due to the drying process at the temperature of 80 °C for 15 h.

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Introduction

The International Coffee Organization (ICO) – held in July 2019 – reported that the global coffee production in 2018 had grown up to 10.29 % compared to 2015. However, another note from the same organization was that the world's coffee consumption increased 6.52 % within the same time span (Shahbandeh, 2020). Considering how the consumption rate is lower than the production one, it is obvious that the world has quite a surplus, causing pressure toward coffee prices (Murphy, 2019). Furthermore, Acosta (2019) revealed how Columbia had been losing up to 40 000 ha of coffee plantation within 18 mo (months) in 2018 after its farmers opted to discontinue tending due to sliding prices of coffee.

Further, the COVID-19 pandemic strike impacts a large number of closed cafés due to lockdown and semi-lockdown policies, lowering the sales number of green beans coffee (Al-Fadly, 2020; Kurniawan, 2020). Furthermore, Kevon *et al.* (2021) predicted the decrease of coffee production globally in 2022 – which would go further south as long as the pandemic was still around – since coffee plants could not be properly tended.

Coffee stakeholders need to overcome the above problem and efficiency should be a choice. James and Deswarte (2015) and Stéphane and Thomas (2009) advised applying biorefinery, *i.e.* to process waste and turn it into economical products. Several studies on coffee waste utilization have been done by Padmapriya *et al.* (2019), Pushpa and Naidu (2012), Pushpa *et al.* (2012), and Setyobudi *et al.* (2018). Setyobudi *et al.* (2019) specifically proposed recycling coffee pulps (CP) and coffee husks (CH) into coffee cherry flour (CCF). This process gives double benefits since it is not only to minimize CP and CH pollutants (Elida, 2012; Grisel *et al.*, 2014; Melkayo *et al.*, 2016) but also to generate highly economical products (Ebba, 2015; Hermosa *et al.*, 2014; Sukrisno, 2013).

Andrew Fedak and Dan Belliveau introduced the pulp and husk-based Coffee Flour at TED Conference 2015, Vancouver, Kanada (Deborah, 2021; Emily, 2015), later they patented it as Coffee Cherry Flour (CCF) (Rachel, 2019; WIPO–PCT, 2014). CCF is registered in Trademarkia dated August 9, 2015, under Serial Number of 86245457 and Registration Number of 4806487. Global Holdings, Inc. (2015) stated that CCF contains 84 % lower fat and 42 % higher fibre than coconut flour, 38 % higher antioxidant than pomegranate (*Punica granatum* L.), more than three times than iron (Fe) in fresh spinach (*Spinacia oleracea* L.), five times higher than fibre of wheat flour, more than three times than protein in kale (*Brassica oleracea* var. sabellica L.), and more than twice than potassium of banana (*Musa paradisiaca* L.). In 2014/2015, CCF has been made in Nicaragua, Guatemala, Mexico, and Vietnam, and more will be produced in Brazil, Columbia, and El Salvador (Global Holding, Inc., 2015). As the fourth biggest coffee producer globally, Indonesia (Rahardjo *et al.*, 2020; Van Der Schaar Investments, 2019) was overlooked by Global Holding regarding the CCF production base plan.

Damat *et al.* (2019), Elba *et al.* (2017), Mindarti *et al.* (2020), Moreno *et al.* (2019) and Rosas-Sánchez (2021), has discussed CCF's positive impacts on the fibre content; however, the study on CCF as Fe source has not yet been discovered. Coffee Cherry Co. (2021) reported that about 49.6 mg 100 g^{-1} (Figure 1a), while, Global Holdings, Inc. (2015) found that the content of Fe in CCF was about 13 % (Figure 1b). The Fe content is higher than one in *S. oleracea*, ranging from 2.7 mg 100 g^{-1} to 3.9 mg 100 g^{-1} (DKBM Indonesia, 2017; USDA, 2018).

The possibility of finding Fe sources from CP and CH as inexpensive haemoglobin booster is beneficial to research (Marín-Tello, 2020) due to the relatively high chance of anemia (Milman, 2011; Nurbadriyah, 2019), particularly in Indonesia (Bukhari *et al.*, 2020; Ellie *et al.*, 2012). Das and Das (2020) and Petek *et al.* (2020) highlighted how anemia impacted COVID acuteness. Several research on haemoglobin boosters have been studied, *i.e.* S. *oleracea* (Dheny and Umarianti, 2017; Nasution *et al.*, 2021), *Moringa olifera* Lam. (Indriani *et al.*, 2019; Tri and Sunarsih, 2021), and *Phoenix dactylifera* L. (Nur and Maulany, 2021; Resti *et al.*, 2021). This study aims to determine whether CCF made in Indonesia can meet the quality standard of commercially available products as Fe source.

Materials and Methods

Coffee pulp

Coffee Pulp (CP) as fresh solid waste was obtained from *Pabrik Pengolahan Kopi* (PK) Arabika, Mengani, a coffee processing company in Kintamani, Bangli, Bali (coordinate 8° 17' 16.63" S 115° 15' 0.61" E). Kintamani, Bali was appointed as research site due to two reasons: (i) Arabika Kintamani Bali is first Indonesia's Geographical Indication goods registered in 2005 and enlisted on December 5, 2008, therefore numbered ID G 000000001 (Nizar, 2018); and (ii) PK Arabika, Mengani is one of Indonesian coffee processing companies awarded the Gold Gourmet Agency for the Valorization of Agricultural Products (AVPA) in the World Roast Coffee Competition 2018 in Paris (Ferry, 2018).

THE COFFEE CHERRY CO.

Nutritional Highlights

Amount per 100g of Coffee Cherry*:

Calories	**144.9 kcal**
Dietary Fiber	**51 g**
Calcium	**425 mg**
Sodium	**15.7 mg**
Magnesium	**333 mg**
Iron	**49.6 mg**
Caffeine	**530 mg**
Antioxidants (total phenolics)	**22 µmol values/gram**

*typical values across varietals

(a)

Nutrition Facts

Serving Size 1 Tbsp (10g)
Servings Per Container

Amount Per Serving	
Calories 34	Calories from Fat 0
	% Daily Value*
Total Fat 0.056g	**0**%
Saturated Fat 0.037g	%
Trans Fat 0.019g	
Cholesterol 0mg	**0**%
Sodium 1.8mg	**0**%
Potassium 310mg	**7**%
Total Carbohydrate 6.5g	**2**%
Dietary Fiber 5.2g	**21**%
Soluble Fiber 1.8g	
Insoluble Fiber 3.4g	
Sugars 0.3g	
Protein 1.5g	

Vitamin A 2% • Vitamin C 0%
Calcium 4% • Iron 13%

* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

(b)

Figure 1: *Nutrition data of CCF in the leaflet (Source: (a) Global Holdings, Inc. 2015; (b) Coffee Cherry Co.,2021). Note: (a) Fe = 49.6 mg 100 g^{-1}, (b) Fe = 13 % or 23.4 mg 100 g^{-1} (FDA, 2020).*

CP (*Coffea arabica* L.) samples were randomly picked from the pulper during May to June 2018 production. CP with 70 % to 85 % water contents were drained under the shade and oven-dried (Maksindo cabinet dryer) at 80 °C for 15 h, and only 5 % water content remained. CP was then ground into CCF using Eureka Mignon Coffee Grinder at the speed of 1 350 rpm (1 rpm = 1/60 Hz) and stored in plastic bags.

The CCF commercial product (as a comparator) from La Boite, a store at Manhattan, 724 11th Avenue New York, NY 10019, was bought in May 2018. The CCF had been made in Brazil.

Fe Analysis

The Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) Varian-730-ES by a Varian Inc under the Agilent Technologies (Palo Alto, USA) was employed to perform the Fe mineral content analysis. A total of 5 g CCF of samples were used by the dry-ashing procedures with hydrochloric acid dilution to extract the minerals, then analyzed in duplicates from each sample and replicated at least twice times (Xiandeng *et al*., 2016).

Vitamin C Analysis

The Iodimetric method (AOAC, 1995) was used in

Vitamin C (Vit. C) analysis. A total of 5 g CCF of samples were diluted in a 100 mL flask and marked. The dilutions were then filtered, and 25 mL of each was then mixed with a few drops of starch and quickly titrated with 0.01N sodium thiosulfate to blue color. Vit. C content was calculated based on Equation (1):

Vit. C (mg/100g) = (V I2 × 0.88 × Fp) × 100 W s (1)

Where;
V I2 = Iodium Volume (mL), NFp = Dilution Factor, W s = Sample weight (g).

Amino acid, total carotene, and glucose and fructose
The amino acid composition of the major ingredients was determined by an automated amino acid analyzer (Hi-Tachi, Tokyo, Japan) following acid hydrolysis with 6 N HCl (reflux for 23 h at 110 °C), according to Qiu *et al*. (2016) and Zmrhal *et al*. (1975). Amount 0.1 g of samples were solved and homogenized with acetone, followed by a UV-Vis spectrophotometer reader at λ = 450 nm to determine Carotene content, which was estimated according to the absorbance of samples at the standardized linear curve (Machmudah and Goto, 2013; Rodriguez-Amaya and Kimura, 2004). Glucose and Fructose contents were determined by the colorimetry method (DuBois *et al*., 1956).

Statistical analysis
Utilizing descriptive statistics, the result is presented in box-plot in accordance with the Student's *t*-test α = 0.05. Statistical significance for differences between samples was determined by the GLM-ANOVA (Ramesh *et al*., 2019).

Results and Discussion

Fe content
Results on Fe contents of both Mengani's CCF and La Boite's are presented in Figure 2.

Figure 2 shows that Fe in median (Q2) La Boite's CCF is 183.730 mg kg^{-1}, which is higher than in median (Q2) Mengani's CCF of 92.687 mg kg^{-1} but statistically (P > 0.0.5) insignificant. Although relatively low, Fe in Mengani's CCF (9.269 mg 100 g^{-1}) includes a range of CP or CH [(4.3 to 15) mg 100 g^{-1}], referring to Iriondo-DeHond *et al*. (2020).

The low Fe content in Mengani's CCF corroborates data compiled by Setyobudi *et al*. (2018). Kintamani land is categorized as Inceptisol (Asfimanto *et al*., 2013; Nurul *et al*., 2022), young land after the Mount Batur volcanic eruption. Some references mentioned by Hasibuan *et al*. (2014) and Nandini and Narendra (2012) stated that Inceptisol characteristics as pH being acidic to slightly acidic and soil electrical conductivity (EC) being shallow, whereas organic matter, total nitrogen, cation exchange capacity (CEC), saturation bases, potassium potency, and iron hydrous oxide low. Nandini and Narendra (2012) also found that the Fe content of Bangli, Kintamani soil was in the range of 15.0 mg kg^{-1} to 18.4 mg kg^{-1}, which was categorized as very low.

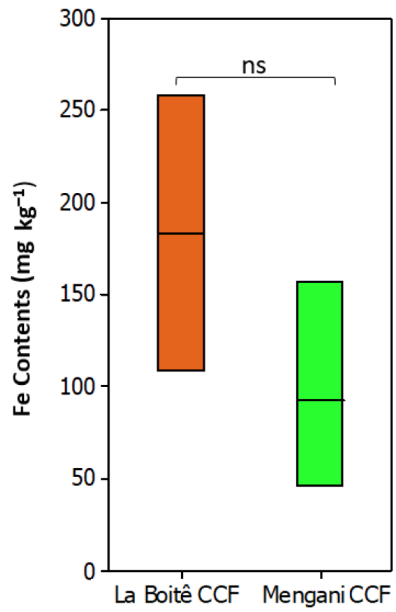

Figure 2: *Box-plot of Fe from Mengani's CCF samples compared to La Boite's (mg kg^{-1}).*

Box plot in Figure 2 shows Fe content in Mengani's CCF with Q1 = 47.166 mg kg^{-1}, Q2 = 92.687 mg kg^{-1}, and Q3 = 156.86 mg kg^{-1}. Interquartile Range (IQR) depicts how Fe data is dispersed and asymmetrical since Q2 tends to go downwards (Q1) or slant rightwards. However, the distribution is considered normal since the tilt is not too drastic (0.299 %), and there is no apparent Outlier. As for Fe content in La Boite's CCF – Q1 = 109.14 mg kg^{-1}, Q2 = 183.73 mg kg^{-1}, and Q3 = 258.87 mg kg^{-1} – IQR comes out with dispersed but symmetrical data.

Comparing Figure 1 and Figure 2, the Fe content in the latter is lower. It is then presumed that the claims made by CCF producers (Global Holdings, Inc., 2015) of 13 % = 23.4 mg 100 g^{-1} (FDA, 2020) and 49.6 mg 100 g^{-1} (Coffee Cherry Co., 2021) were "overestimated" (especially Figure 1a). Other studies also found variously "lower Fe contents" in CP or

CH. Kayhanian *et al.* (2016) found ones between the ranges of (10 to 50) mg 100 g^{-1}. Wich (2015) reported it as 10 mg 100 g^{-1}. Iriondo-DeHond *et al.* (2020) came up with (4.3 to 15) mg 100 g^{-1} in their review article referring to five studies. Marín-Tello *et al.* (2020) concluded that to be 7.70 mg 100 g^{-1}. Elias (1979) went with 15 mg 100 g^{-1}. Anna *et al.* (2019) discovered 15 mg 100 g^{-1}. Zupancic and Grilc (2012) declared 25 mg 100 g^{-1}. Avinash *et al.* (2017) came across about 28.7 mg 100 g^{-1} in the fresh CP. Setyobudi *et al.* (2018) found that CP from Kintamani-Bali, Indonesia, processed as hay with 15 mo shelf life, contained Fe of 13.9 mg 100 g^{-1}.

Fe in Mengani's CCF is indeed lower than La Boite's; yet, the content of 9.269 mg 100 g^{-1}, ranged (4.717 to 15.686) mg 100 g^{-1} is still higher than in spinach (*S. oleracea*.). DKBM Indonesia (2017) stated that Fe content in *S. oleracea* was 3.9 mg 100 g^{-1}, while the USDA (2018) mentioned that about 2.7 mg 100 g^{-1}. It is higher than several other vegetable sources, such as *Sauropus androgynus* L. (Merr), *Manihot esculenta* Crantz leaf, *Carica papaya* L. leaf, *Brassica juncea* L., *Solanum lycopersicum* L., and *Daucus carota* subsp. Sativus (Hoffm.) Schubl. & G. Martens. (Setyobudi *et al.*, 2019). It is even higher than the current study of haemoglobin booster, *i.e. M. oleifera* (7 mg 100 g^{-1}) and *Phoenix dactylifera* L. [(4.06 to 7.06) mg 100 g^{-1}] (DKBM Indonesia, 2017; Rania *et al.*, 2014).

Fe nutrition is divided into heme (Ferro, Fe^{2+} bond, generally animal-based food) and non-heme (Ferri Fe^{3+} bond, generally plant-based food). Human body absorption of non-heme Fe is relatively low, around 5 % only, while heme Fe can be absorbed between 10 % to 30 %. Therefore, nutrition elements in Fe should be taken in more easily if enhancer (booster or promoter) agents are available (Ari, 2014, Jumadi, 2020, Nurbadriyah, 2019; Setyobudi *et al.*, 2019).

Vitamin C

Vitamin C (Vit. C), with its capability to reduce Ferri (Fe^{3+}) into Ferro (Fe^{2+}) in the small intestine, helps to increase non-heme Fe absorption. It is also keen to prevent haemosiderin from forming, which is beneficial since it is difficult to mobilize in iron release when needed (Pratiwi, 2015). Several research teams have proven the role of Vit. C as an enhancer agent, *e.g.*, Conner *et al.* (2012) and Agusmayanti *et al.* (2020).

Vit. C contents in Mengani's CCF and La Boite's are detailed in Figure 3.

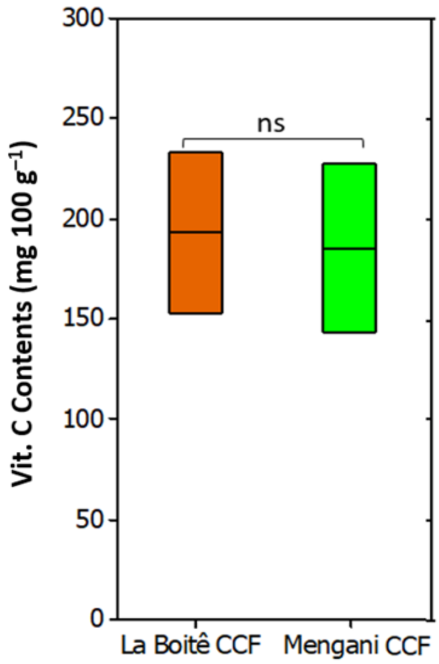

Figure 3: *Box-plot of Vitamin C from Mengani's CCF samples compared to La Boite's (mg 100 g^{-1}).*

Figure 1, Coffee Flour BJ (2021) and Wich (2015) have put 0 (zero) content of Vit. C in CCF. In spite of that, this research has recorded median Vit. C in Mengani's CCF to be 185.45 mg 100 g^{-1} and median Vit. C in La Boite's CCF to be 194.6 mg 100 g^{-1} in Figure 3, which is statistically insignificant ($P > 0.05$) when compared. Box-plot of Mengani's CCF shows Q1 =143.03 mg 100 g^{-1}, Q2 = 185.45 mg 100 g^{-1}, dan Q3 = 227.27 mg 100 g^{-1} with evenly-spread data. Similarly, IQR of La Boite's CCF comes out with evenly-spread data with Q1 = 153.33 mg 100 g^{-1}, Q2 = 194.6 mg 100 g^{-1}, and Q3 = 234.55 mg 100 g^{-1}. Figure 3 is in sync with Sukartiningsih (2011) 's conclusion that the cascara (pericarp, exocarp, and mesocarp) of fresh before-ripe Arabica coffee contains Vit. C = (275.7 to 651.2) mg 100 g^{-1}.

Despite insignificance in statistics, Mengani's CCF tends to have lower Vit. C. Different CP or CH drying method is inferred to be the cause. While Mengani's was non-naturally dried at a constant temperature of 80 °C for 15 h, La Boite's was naturally dried under the sun on the drying floor (CGTN America, 2014). Mahendra *et al.* (2014) and Usamah *et al.* (2019) informed that tropical drying floors are typically 22.67 °C to 37.90 °C with inconsistent temperatures – therefore, goods must be turned over every 1 h to

2 h – and drying time of approximately 7 h d^{-1}.
Vit. C in Mengani's CCF = 185.45 mg 100 g^{-1} [ranged (143.03 to 227.27) mg 100 g^{-1}], which is higher than Iriondo-DeHond *et al.* (2020) 's data of 69.80 mg 100 g^{-1}. Furthermore, it is superior compared to other haemoglobin booster plants, such as *S. oleracea* (80 mg 100 g^{-1}), *M. oleifera* (fresh = 220 mg 100 g^{-1}, dried = 17.3 mg 100 g^{-1}), and *P dactylifera* [(0.7 to 0.9) mg 100 g^{-1}] (DKBM Indonesia, 2017; Egbuna, 2015; Sultana *et al.*, 2015).

Comparing the rates of Vit. C in fresh *M. oleifera* to in dried one (Egbuna, 2015) as well as in fresh coffee cascara (Sukartiningsih, 2011) as shown in Fig. 3, it is safe to deduce that a low-temperature drying process is essential to preserve the substance in CP. Alakali *et al.* (2015), Kang *et al.* (2007), and Rizki *et al.* (2018) also supported the using low temperature.

Vitamin A

Vitamin A (Vit. A) is also able to increase non-heme Fe absorption, as research done by Damayanti *et al.* (2016) and Fernanda *et al.* (2013). Figure 4 points out Vit. A (carotenoid) content in Mengani's CCF and La Boite's.

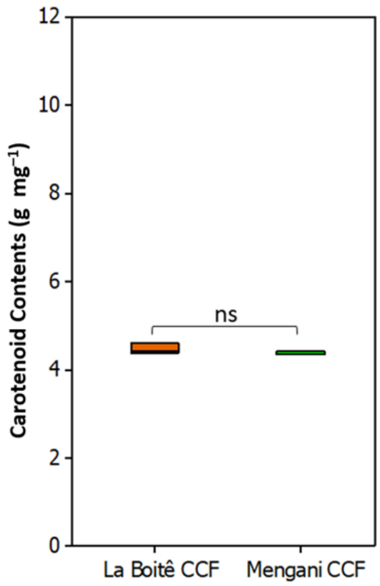

Figure 4: *Box-plot of carotenoid from Mengani's CCF samples compared to La Boite's (g mg^{-1}).*

Figure 4 illustrates that carotenoid in median (Q2) Mengani's CCF is of 4.370 g mg^{-1}, which is lower than in median (Q2) La Boite's of 4.435 g mg^{-1} but statistically ($P > 0.05$) insignificant. The box-plot shows carotenoid in Mengani's CCF of Q1 = 4.370 g mg^{-1}, Q2 = 4.370 g mg^{-1}, dan Q3 = 4.435g mg^{-1} with centralized data. La Boite's IQR shows Q1 = 4.367 g mg^{-1}, Q2 = 4.435g mg^{-1}, dan Q3 = 4.587 g mg^{-1} with evenly-spread data.

Resembling the Vit. C result, Mengani's CCF tends to have lower carotenoids due to the CP or CH drying process, although it statistically insignificant. Alakali *et al.* (2015), Ayegba *et al.* (2017), Kurniawati (2016) and Meiliana *et al.* (2014) have demonstrated in their studies how high temperature degrades carotenoid.

The carotenoid median in Mengani's CCF, as recorded in Figure 4, is 4.370 g mg^{-1}, ranging (4.367 to 4.587) g mg^{-1} – it is higher than the same nutrition contained in *S. oleracea*, *M. oleifera*, and *P dactylifera* (Alakali *et al.*, 2015; Kemenkes, 2018; Priyo *et al.*, 2020; Sultana *et al.*, 2015).

Amino acid

Ari (2014) and El-Hawary *et al.* (1975) have confirmed the role of protein as an enhancer agent in the Fe absorption process. Comparison of total amino acid contents in Mengani's CCF and La Boite's are presented in Figure 5.

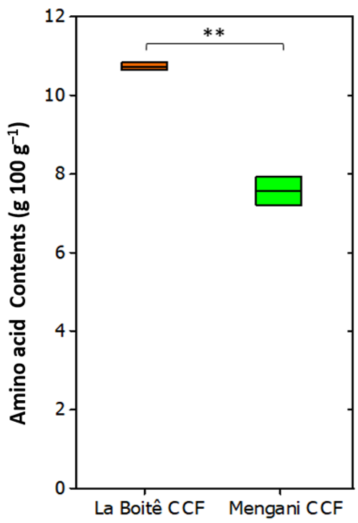

Figure 5: *Box-plot of total amino acid from Mengani's CCF samples compared to La Boite's (g 100 g^{-1}).*

Figure 5 shows the median (Q2) of total amino acid in Mengani's CCF to be 7.571 g 100 g^{-1}, which is statistically ($P > 0.01$) of significant difference compared to the median (Q2) of total amino acid in La Boite's CCF = 10.735 g 100 g^{-1}. The box plot lists total amino acid content in Mengani's CCF to be Q1 = 7.222 g 100 g^{-1}, Q2 = 7.571 g 100 g^{-1}, and Q3 =7.92 g 100 g^{-1}, with symmetrical, evenly-spread data. Meanwhile, the IQR of La Boite's CCF is Q1 = 10.625 g 100 g^{-1}, Q2 =10.735 g 100 g^{-1}, and Q3 = 10.822 g 100 g^{-1} with centralized dispersion. Overheating affects amino acids, as it considerably degrades the one in Mengani's CCF. Oestreich (2013) stated that the amino acid content in roasted arabica and robusta beans is lower than green beans. Ika *et al*. (2015) also reported decreases in amino acids, fatty acids, cholesterol, and mineral composition in eel (*Monopterus albus* Zuiew, 1793) due to deep frying. Ayegba *et al*. (2017) came up with further information on the dwindling percentage of protein in *M. oleifera* related to high temperature.

Fructose and Glucose

Ari (2013) and Christides and Sharp (2013), declared that sugar is also an enhancer agent for non-heme Fe. Researchers Nur and Maulany (2021) and Resti *et al*. (2021) proved that even with relatively little Fe in *P. dactylifera* – amounted (4.06 to 7.06) mg 100 g^{-1} (Rania *et al*., 2014) – the fruit was able to boost haemoglobin because of sugar as an enhancer. Nadeem *et al*. (2019) catalogued that *P. dactylifera* contained glucose 26.75 % to 44.44 %, fructose 21.03 % to 33.21 %, and sucrose 4.17 % to 6.32 %. Fructose and glucose contents of both Mengani's CCF and La Boite's are disclosed in Figure 6.

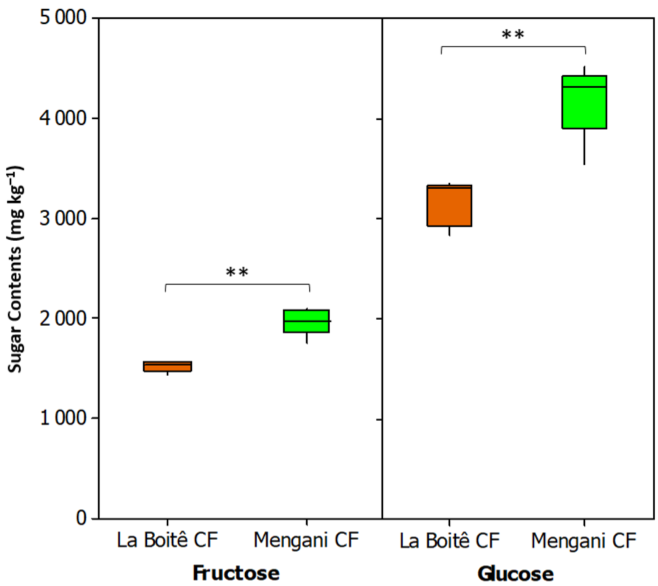

Figure 6: *Box-plot of fructose and glucose from Mengani's CCF samples compared to La Boite's (mg kg^{-1}).*

Figure 6 shows the median (Q2) of fructose in Mengani's CCF to be 1 997.80 mg kg^{-1}, which is statistically (P > 0.01) of significant difference compared to the median (Q2) of fructose in La Boite's CCF = 1 533.33 mg kg^{-1}. The box plot lists total fructose content in Mengani's CCF to be Q1 = 1 877.80 mg kg^{-1}, Q2 = 1 997.80 mg kg^{-1}, and Q3 = 2 088.90 mg kg^{-1}. The minimum (Q1-1.5*IQR) = 1 755.6 mg kg^{-1} and the maximum (Q3-1.5*IQR) = 2 111.10 mg kg^{-1}. Meanwhile, the IQR of fructose in La Boite's CCF is Q1 = 1 466.7 mg kg^{-1}, Q2 = 1 533.33 mg kg^{-1}, and Q3 = 1 566.70 mg kg^{-1}. The minimum (Q1-1.5*IQR) = 1 433.30 mg kg^{-1}. IQR of Mengani's CCF is quite evenly dispersed, while La Boite's CCF tends to ascend.

The same figure shows median (Q2) of glucose in Mengani's CCF to be 4 311.10 mg kg^{-1}, which is statistically (P > 0.01) significant when compared to median (Q2) of glucose in La Boite's CCF = 3 300.00 mg kg^{-1}. The box plot records glucose content in Mengani's CCF to be Q1 = 3 911.10 mg kg^{-1}, Q2 = 4 311.10 mg kg^{-1}, and Q3 = 4 422.20 mg kg^{-1}, with minimum (Q1-1.5*IQR) =3 533.30 mg kg^{-1} and maximum (Q3-1.5*IQR) = 4 533.30 mg kg^{-1}. As for La Boite's, Q1 = 2 933.30 mg kg^{-1}, Q2 = 3 300.00 mg kg^{-1} and Q3 = 3 333.33 mg kg^{-1} with minimum (Q1-1.5*IQR) = 2 822.20 mg kg^{-1}, and maximum (Q3-1.5*IQR) = 3 366.70. IQR of both Mengani's CCF and La Boite's tend to ascend.

Elías (1979) and Murthy and Naidu (2012) stated that reducing sugars in CP was 12.4 %. Sugars are formed in the mesocarp when the exocarp is red. The low rate of reducing sugars in La Boite's CCF is believed to result from postharvest treatment. A product of Brazil, La Boite's, should employ dry processing (Padmapriya *et al*., 2019) where coffee cherry goes directly to drying floors, preventing further metabolism to run in the pulp. On the other hand, Mengani's is wet processing, where coffee cherry is soaked before peeling under running water. Since the pulp is constantly damp before processing, reducing sugars are formed in the wait.

The problem of wet-processing coffee is categorized as polluting the environment, especially river water and soil (Elida, 2012). Therefore, the authors suggest anaerobic treatment of process water (Setyobudi *et al*., 2021) in a biogas digester before discharge into rivers. This action is doubly beneficial because, in addition to minimizing pollution, renewable energy from biogas can be used as a coffee bean dryer or CCF.

Conclusions and Recommendations

CP of Arabica Mengani, Bali, Indonesia, is eligible for further processing into CCF, which is beneficial as a source of Fe non-heme. Although Fe content in Mengani's pulp is relatively low [9.269 mg 100 g^{-1}, ranging (4.717 to 15.686) mg 100 g^{-1}], it is higher than what is contained in *S. oleracea* (2.7 mg 100 g^{-1} to 3.9 mg 100 g^{-1}), *M. oleifera* (7 mg 100 g^{-1}), or *P. dactylifera* [(4.06 to 7.06) mg 100 g^{-1}]. Mengani's CP also contains vitamin C, beta carotene, amino acid, and reducing sugars that act as Fe enhancers. Reducing sugars in it is significantly higher than in La Boite's CCF. Nevertheless, the oven-drying process of 80 ° C for 15 h needs reviewing, as the enhancers – especially amino acid – tend to get degraded.

Further research should be recommended towards other coffee production centers in Indonesia, particularly in the Java area. Moreover, *in vivo* studies are suggested to ensure bioavailability on this Fe non-heme content.

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Novelty Statement

A product of the circular economy and environmentally friendly, Coffee Cherry Flour (CCF) has been around American and European markets since 2014. Reducing coffee production costs, minimizing pulp pollutants, and creating functional food are the reasons behind its invention. As the fourth biggest coffee producer globally, it is only proper for Indonesia to research and develops CCF as a beneficial commodity. This study has gained data that vitamin C in CCF acts as a Fe non-heme enhancer and that Mengani coffee pulp is able to serve as a Fe non-heme source. Vitamin C levels are not listed in the leaflets of several CCF manufacturers.

Author Contribution

RHS: Conceptualized and designed the study, elaborated the intellectual content, performed literature search, data acquisition, data analysis, manuscript format, manuscript preparation and manuscript revision.
EY: Elaborated the intellectual content, performed literature search, manuscript review, check and re-check similarity (Turnitin), and Premium Grammarly.
YAN, MSS and SKW: Statistic analysis, data conversion, carried out experimental studies, performed the literature search, and manuscript preparation.
WW, LZ and DD: Elaborated the intellectual content, research supervision, performed the literature search, and manuscript review.
EAS and MM: Elaborated the intellectual content, performed the literature search, and manuscript review.
MFMA and MIM: Performed the literature search, manuscript review, and guarantor.
DY, DR, PGA and SM: Performed the literature search and manuscript review.
RKM and HS: Figure, performed the literature search, and manuscript review.
All authors read and approved the final manuscript

Conflict of interest
The authors have declared no conflict of interest.

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