Prospect of Fe non-heme on coffee flour made from solid coffee waste: Mini review

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Abstract. Coffee flour (CF) from coffee pulp or husk, solid waste of coffee processing have launched in Canada since 2015. This product is claimed as certified of gluten-free, vegan, kosher, paleo, and non-GMO. Coffe flour is stated to contain three times Fe content than fresh spinach (*Spinacia oleracea* L.). Several receipts of cookies, donuts, and cakes using CF has been introduced as wheat flour substitution. However, the scientific publication of CF impact for health does not appear until August 2018 yet. A review has been carried out using data on Google with a maximum publication age of 15 yr. This Fe non-heme prospect is allegedly unable to be absorbed optimally by the organism. Coffee pulp and husk contain an inhibitor, such as caffeine, polyphenol, calcium, dietary fiber, manganese, magnesium, and zinc; which detain Fe absorption. On the other hand, the promoter/enhancer of Fe absorption such as vitamin C, vitamin A, and amino acid was decreased in CF processing. Several types of research have to be conducted to tackle this problem in Faculty of Medicine and Faculty of Agriculture and Animal Husbandry University Muhammadyah of Malang, Indonesia.
Keywords: Biorefinery, Fe inhibitor, Fe promoter, hemoglobin, zero waste.

1.Introduction

Pulp waste is produced by the wet method, to remove the outer skin/external skin/exocarp/epicarp and mesocarp coffee cherries. Husk waste is generated from the dry method for removing exocarp, mesocarp, and endocarp [1, 2]. Both of Coffee Processing (CP) solid waste has been dumped into the river and around the CP environment [3, 4]. This action has an adverse effect since the pulp and husk contain the toxic compounds such as caffeine, alkaloids, tannins dan polyphenolics [5, 6]. Augur et al. [7] said that the pulp provides the severe pollution. It also supported by Corro et al. [8] which stated that the pulp impacts the serious environmental problem in coffee-producing countries. Several references [9–12] also show the negative effect of CP waste.

A small amount of pulp and husk have been utilized as a mixture of animal feed as reported by Adwitiya and Venkatachalapathy [13], and Kassu et al. [14]. Moreover, it is also utilized as mulch, composting and vermin-composting [15, 16]. Some studies [9, 13] reported the utilization for mushrooms media. Some references also exhibited the coffee pulp and husk utilization in various research-scale such as alcohol production, bio-sorbents for the removal of heavy metals from aqueous solutions, converted into fuel pellets, extracted for bioactive substances recovery, mould-yeast and enzyme production, extraction of phenolic compounds, gallic acid, aroma compounds and silage [17, 13].

Reference [18] states that biogas from agricultural biomass has a positive impact on economic value. Some references report the application of husk and pulp from coffee-waste in biogas digesters in Indonesia [19], Ethiopia [3], Nicaragua [20] and Mexico [21]. Bruno and Oliveira [22] suggested to using two-stage digester. Some references indicate the two-stage digester must be modified [23], specifically with ballast [24], which is accompanied by augmentation [25], co-digestion [26] and biofilm [27].

Almost all of the previous pulp and husk utilization technology still provide a waste residue. It means the cost of further waste treatment is needed. Utilization as mulch, land amelioration, organic fertilizer, animal feed, and silage can overcome the pulp and husk problem. However, these technologies require relatively great labors and only produce the product at the relatively low price [28]. This study was conducted for looking at the truth about the usefulness of coffee flour (CF) made from solid coffee waste, mainly the impact on Fe's nutrition. This manuscript review was compiled using data on Google with a maximum publication age of 15 yr.

2. Coffee flour

Nowadays, there are two terminologies of coffee flour (CF), namely: i) The first version, it is made from coffee pulp and husk, CP solid waste. The difference between pulp and husk has explained in the previous studies [1, 2]. A wet method in further was also mentioned as washed or fermented method [2, 9]. The wet method improvement is semi-wet or semi-washed or semi-dry [17, 29–31] when the dry method was also mentioned as a natural processing or unwashed processing system [2, 9].

The pulp is produced from the pulper in CP wet method and has a water content between 80 % to 85 % [Bressani et al. in (32)]. The pulp is dried under the sun on the drying floor or the trays in the plastic-house. The drying process can be executed in the oven until the water content under 10 %. The husk as the CF raw material is more accessible to produce since the drying method standard range of 10 % to 11 % [29, 1]. The dry pulp or husk is converted into the flour using mill in further [33, 34].

The first version of CF was introduced by Andrew Fedak and Daniel Alderic Belliveau in TED Conference, Vancouver, Canada, March 16 to 20, 2015 [35]; registered in Trademarkia, 9/8/2015, serial number: 86245457 and registration number: 4806487 [36]. Justia Patentes [37] reported in 2013 and 2014, the United States Patent and Trademark Office (USPTO) has published eight patents of CF on behalf of Daniel Alderic Belliveau. The CF patent is also found in the Canadian Intellectual Property Office. The CF has obtained an International Award in 2017 as innovative ideas and technologies in agribusiness for overall category: Waste management, agro-industry and circular economy [38]. The United Nations Industrial Development Organization (UNIDO) award was

obtained since the CF production is designed based on three aspects of social-environmental, environmental-economic, and economic-social [39].

(ii) The second version, it is CF of US Patent No. 9210948, 15 December 2015 on behalf to Dan Perlman, Brandeis University, Waltham, Massachusetts. This product aims to keep the anti-oxidant content still high by roasting the coffee bean at a lower temperature (300 °F) than the standard temperature (400 °F to 450 °F), so creates 'parbaked' bean [40, 41]. This CF version contains anti-oxidant, mainly chlorogenic acid which is relatively higher than the standard coffee roasted. This anti-oxidant utilizes to inhibit glucose absorption in digestive system control blood pressure, cardiac disease, and cancer [40].

This manuscript restricts the study of the first version of CF only. In further discussions, the CF terminology means the flour is made from pulp and husk. This condition is appropriate with the aims of study to overcome the problem of pulp and husk by bio-refinery action, particularly converting pulp and husk waste into functional food ingredients with high-value and high-useful.

Several receipts of cookies, donuts, and cakes from CF as gluten-free flour has been introduced. However, the study of the CF impact on health has not yet appeared until August 2018. Markham [17] showed that there is CF product as the part of the utilization of solid coffee waste only. Harvey [42] showed some CF content errors in the inclusion of ingredients in CF leaflets (figure 1).

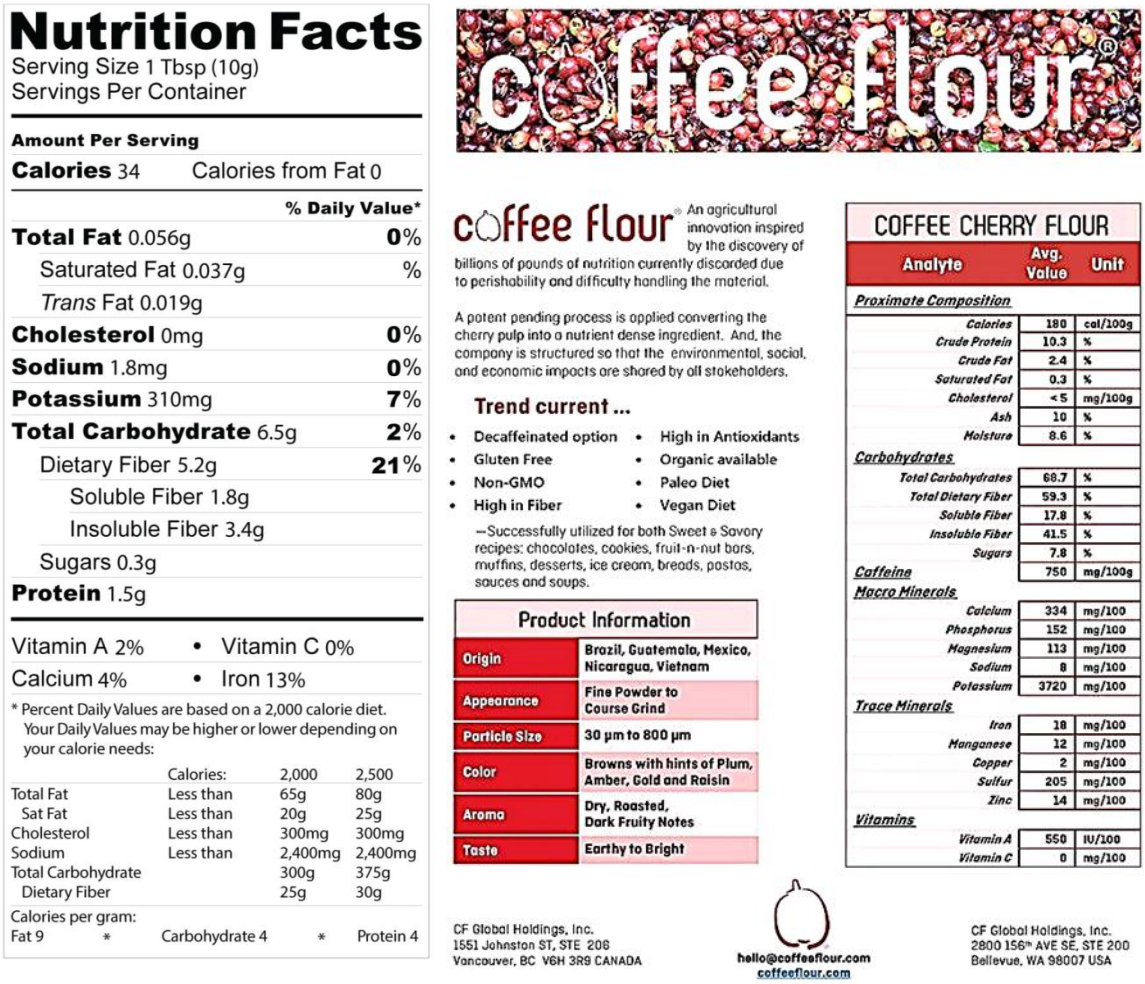
3. Coffee Fluor contents

The CF is declared and certified of (i) gluten-free, (ii) vegan (iii) kosher, (iv) paleo, (v) no GMO project [43]. References [44–47] stated that CF contains three times of iron content than fresh spinach (*Spinacia oleracea* L.); five times of fibre content than wheat flour; 84 % of fat content lower and 42 % fibre content higher than coconut flour; 38 % of anti-oxidant content higher than pomegranate (*Punica granatum* L.); three times of protein content than kale (*Brassica oleracea* L. var. sabellica); and two times of potassium content than banana (*Musa paradisiaca* L.). The CF ingredients content is shown in figure 1.

4. Iron (Fe)

Figure 1(a) shows Fe content in CF of 13 %, while the Figure 1(b) mentions CF content of 18 mg per 100 g. Several studies have reported the numbers of Fe content in the pulp as CF raw material. Avinash et al. [50] reported the Fe content in fresh pulp of 28.7 mg per 100 g. Brestani [in Elias (51)] stated Fe content of 15 mg per 100 g. Kayhanian et al. [52] said that the Fe content of 10 mg per 100 g to 50 mg per 100 g. Zupancic and Grilc [53] declared that the Fe content of 25 mg per 100 g. Setyobudi et al. [54] expressed that coffee pulp from Kintamani-Bali, Indonesia which processed as hay with 15 mo shelf life, contains Fe of 13.9 mg per 100 g.

The above results support the references [44–47] about the Fe content of CF and pulp are higher than fresh spinach (*Spinacia oleracea* L.). DKBM Indonesia [55] stated that Fe content in spinach of 3.9 mg per 100 g. United States Department of Agriculture, Agricultural Research Service [56] mentioned the Fe content of *S. oleracea* is 2.7 mg per 100 g. Fe data in figure 1 and the references [50–54] are also higher than several other vegetables, such as *Sauropus androgynus* L. (Merr), *Moringa oleifera* L., a leaf of *Manihot esculenta* Crantz, a leaf of *Carica papaya* L., *Brassica juncea* L., *Solanum lycopersicum* L., and *Daucus carota* subsp. *Sativus* (Hoffm.) Schubl & G. Martens. The highest Fe content is found in *M. oleifera* of 7 mg per 100 g [55] which also supported by another study [57] about Fe content in the leaf of *M. oleifera* is (6.79 ± 1.82) mg per 100g.



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

COFFEE CHERRY FLOUR

Analyte	Avg. Value	Unit
Proximate Composition		
Calories	180	cal/100g
Crude Protein	10.3	%
Crude Fat	2.4	%
Saturated Fat	0.3	%
Cholesterol	<5	mg/100g
Ash	10	%
Moisture	8.6	%
Carbohydrates		
Total Carbohydrates	68.7	%
Total Dietary Fiber	59.3	%
Soluble Fiber	17.8	%
Insoluble Fiber	41.5	%
Sugars	7.8	%
Caffeine	750	mg/100g
Macro Minerals		
Calcium	334	mg/100
Phosphorus	152	mg/100
Magnesium	113	mg/100
Sodium	8	mg/100
Potassium	3720	mg/100
Trace Minerals		
Iron	18	mg/100
Manganese	12	mg/100
Copper	2	mg/100
Sulfur	205	mg/100
Zinc	14	mg/100
Vitamins		
Vitamin A	550	IU/100
Vitamin C	0	mg/100

(a) (b)

Figure 1. Nutrition data of CF in the leaflet (Source: [43, 45, 48, 49]).

5. Fe absorption

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 [58, 59]; while the heme Fe can be absorbed between 10 % to 30 % [60, 61]. Some nutrients are categorized as enhancer agent and the vice versa as an inhibitor of non-heme Fe absorption.

5.1. The enhancers agent

5.1.1. Vitamin C. Vitamin C (Vit. C) is categorized as one of the nutrients which increase non-heme Fe absorption. Almatsier [58] and Mulyawati [59] stated that the Vit. C increases the non-heme Fe absorption up to four times. Marudut [60] said that the Vit. C is a facilitator agent, while Linder [61] reported about reducing equivalent. The references [62, 59] declared that the Vit. C is an essential reductor which diminishes Fe^{3+} (Ferri) into Fe^{2+} (Ferro). The references [63, 64] said that Fe^{2+} is more accessible to be absorbed by the duodenum and small intestine of a human than Fe^{3+}.

Wahyuni [65] showed that Vit. C has evidence to increase the hemoglobin content of *Rattus norvegicus* (Berkenhout, 1769), which related to Fe absorption. Wirawan et al. [66] said that

supplementation of Fe tablet with Vit. C for pregnant woman impacts significantly to hemoglobin content changing. Supplementation of 100 mg Vit. C increases Fe nutrition absorption of 37.5 % to 46.0 % for a pregnant woman.

Figure 1 mentions that Vit. C in CF is zero, whereas pulp as a raw material of CF contains Vit. C [67–69]. Ariadi [67] reported Vit. C of Arabica coffee (*Coffea arabica* L.) pulp before ripe is (2 376 ± 29.33) mg per 100 g, Arditta [68] stated that the Vit. C content of Arabica coffee var *Sigarar utang* extract pulp is 5 021 mg per 100 g, while Sukatiningsih [in 68] said that the Vit C content is 642.4 mg per 100 g, and (275.7 to 651.2) mg per 100 g [69].

The zero finding of Vit. C content in CF needs to study further. If the zero content is proven, the three times Fe content of CF than *S. oleracea* [44–47] is useless. The reference [55] said that the Vit. C of *S. oleracea* is 80 mg per 100 g, while *M. olefeira* is 220 mg per 100 g. The Vit. C lost assumption happens as the pulp and husk drying which is shown in figure 2.

Figure 2. Pulp and husk drying on the drying floor [38, 70].

Figure 2 shows the pulp and husk drying is carried out on the drying floor. Pratama [71] said that the drying floor temperature under the direct sunshine in the tropical area reaches higher than 160 °F (71 °C). However, Lesmana et al. [72] said that the drying floor temperature in the drought season reaches (32 to 36) °C only for the drying of unhulled rice as the requirement of thickness of 5 cm to 7 cm, reversal every 1 h to 2 h or 4 to 6 times per day, the drying time: 08.00 to 11.00 in the morning, 14.00 to 17.00 in the afternoon, and tempering time of 11.00 to 14.00.

Vit. C is unstable and degrades easily, mainly by temperature, *i.e.*, in the drying process. The decreasing or destructing of Vit. C by temperature is called as oxidation. Harper et al. [in 73] stated that Vit. C is oxidized when contacting with air (oxygen) and accelerated by heat. Andarwulan and Sutrisno [in 73] explained the Vit. C is oxidized easily since the compound contains a very reactive functional group of hydroxyl (OH). This reaction is called as spontaneous oxidation, wherein this reaction does not involve enzyme but is affected by temperature and air.

Arditta [68] said that the Vit. C destruction starts at 35 °C. Parfiyanti et al. [73] declared the significant difference in the Vit. C of *Capsicum frutescens* L. at 27 °C compared to the drying at 50 °C, 60 °C, and 70 °C. The similar conclusion is obtained by Fauzi et al. [74] in the drying of *Cucurbita moschata* (Duchesne ex Poir.) at 40 °C, 50 °C, and 60 °C. Based on the references [68, 73, 74], the low-temperature drying of 35 °C to 45 °C is needed as a requirement [75]. However, Moursy et al. [76] reported the optimum Vit. C is obtained at 90 °C in the lemon fruit drying.

5.1.2. Vitamin A. Figure 1 mentions the vitamin A (Vit. A) content of CF. Vit. A is reported by some studies that it increased nutrition absorption. Moyo et al. [77] stated that Vit. A is nutrition for bone narrow which related to the Fe element. Zimmermann et al. [78] suggested that Vit. A supports in iron absorption and or utilization of iron reserve for new heme Fe production. Suharno et al. [in 79]

showed that Vit A addition increases iron supplementation effect on hemoglobin concentration. The references [66, 79] recommended that the supplementation of Fe tablet is conducted in companion with others nutrition, such as Vit. A and Vit. C; since multiple micronutrients are more effective to support Fe absorption.

Sukatiningsih [69] said that the beta-carotene (Vit. A precursor) content of Arabica coffee pulp is (646.7 to 1 085.1) mg per 100 g and 737.4 mg per 100 g [in 68]. Arditta [68] reported Vit. A of Arabica coffee var *Sigarar utang* pulp is (362 ± 418) mg per 100 g. Beta-carotene is sensitive to light, heat, and oxygen; although heat sensitivity of beta-carotene less than Vit. C. Haris and Karmas [in 68] said that carotene compound is decreased or destructed significantly on heating of over 80 °C, in steaming, boiling or frying with destruction level between 40 % to 50 %. As the sensitivity of Vit. A and Vit. C, production of CF has to conduct carefully. It is suspected that the artificial drying process is more efficient and effective to overcome the destruction of Vit. A and Vit. C.

5.1.3. Amino acid. Non-heme Fe absorption is impacted by the presence of a substance which holds iron nutrition remain dissolved. This substance is called as booster or promoter or enhancer. The amino acid is one of booster substance which improves iron absorption by the formation of dissolved chelate [80–82]. Figure 1 does not mention the amino acid content. The references [3, Penalosa in 83] reported that pulp contains 17 type of amino acid. Elias [in 84] said that amino acid content of pulp is better than corn. Tadesse and Mebratu [3] reported pulp contains eight essential amino acid, while Penalosa [83] reported 9 of 10 essential amino acid types. The presence of 9 essential amino acids in the pulp is similar to *M. olefeira* [Tshikaji in 85]. Essential amino acid or indispensable amino acid is needed for body growth. Unlike fat or carbohydrates that can be stored, the human body cannot store amino acids. So that enough intake of amino acids from food is always needed every day.

Related to amino acid and protein sensitivity on temperature, Elviani [86] reported the protein decreases with increasing the temperature and heating time periods. Purawisastra et al. [in 87] said about the amino acid content changing of *Glycine max* (L.) Merr in tofu and tempeh production process. In further, the amino acid reduction occurs when tofu and tempeh are fried. The reference [2] confirmed that the amino acid content in the roasted bean arabica and robusta is lower than the green bean. The negative impact data of decreasing amino acid content by increasing temperature is essential to manage CF production. It is also necessary to apply the CF as an alternative in various recipes of cookies, donuts, cakes and bread.

5.1.4. Other nutrients. Figure 1 mentions the minerals content of Cu, Mn, and Zn in CF. The reference [88] stated that Cu and Mn are active catalysts for converting iron nutrient into hemoglobin. The references [89, 90] said that Cu and Zn is a co-factor of anti-oxidant enzymes. The reference [50] showed that pulp contains Cu, Mn, dan Zn of 6.35 mg per 100 g, 48.07 mg per 100 g and 22.5 mg per 100 g respectively. The data in reference [50] is higher than figure 1b.

5.2. Inhibitors agents

Several references stated that majority of inhibitor agents in Fe absorption is secondary metabolites, such as chlorogenic acid, caffeine, phenol, tannins, and calcium nutrient [Soekirman in 91–93]. The secondary metabolism is created by plants to defend their life against biotic and abiotic attacks around their growing environment. It produces secondary metabolites, such as phenol compounds, phenylpropanoids, saponins, terpenoids, alkaloids, tannins, steroids, and flavonoids. Several studies said that secondary metabolite has pharmacology bioactivity [94, 95], such as an antioxidant.

5.2.1. Chlorogenic acid. Some references [13, 96, 97] show that the pulp contains chlorogenic acid (CGA), one of the prospective phenolic compounds as an antioxidant. The CGA content is the highest among other phenolic compounds in the coffee pulp. Ramirez-Martinez [in 49] shows the data of eight types of phenolic compounds from eight coffee pulp cultivars. There is CGA of 561 mg per 100 g

from the total phenolic compounds of 1 289 mg per 100 g. Table 1 shows the CGA content comparison of coffee bean and pulp/husk.

Table 1. CGA content of Arabica and Robusta in green bean and roasted compare to CGA in coffee pulp/husk

Coffee Bean (mg per 100 g)		Pulp/Husk (mg per 100 g)
Arabica	Robusta	
4 100 to 7 900 in GB[d]	6 100 to 11 300 in GB[d]	2 600[a,b]
1 900 to 2500 in Rs[d]	3 300 to 3 850 in Rs[d]	2 00 to 3 200[c]
8 100 in GB in GB[e]	9 900 in GB[e]	
2 500 in Rs[e]	3 800 in Rs[e]	
6 500[f]	10 000[f]	
6 700 to 9 200[g]	7 100 to 12 000[g]	

Note: GB = green bean, Rs= roasted
Source : [a][28], [b][98], [c][99], [d][100], [e][2], [f][101], [g][102]

Table 1 shows (i) the decreasing of CGA content by converting green bean into roasted bean; (ii) robusta contains CGA higher than arabica; (iii) CGA content of pulp is 40 % to 50 % than a green bean. Some references reported the positive impact of CGA for health; such as preventing monochloramine genotoxicity in the gastric mucosa [103], maintaining the health of the liver and gallbladder and reduce the risk of type II Diabetes Mellitus [104], inhibition of cancer growth [105], decreasing risk of coronary heart disease and weight loss [106, 107], reducing gouty arthritis risk [108]. The statement of the reference [108] was supported by some references [109–111]. The references [112, 113] show that CGA is an inhibitor of Fe absorption. The further investigation is needed, particularly in CF, since Farah et al. [114] said that CGA from green coffee extract is highly bioavailable in humans.

5.2.2. Polyphenol. The references [115, 116] said that the interest of pulp waste as a food additive increase, particularly since the high content antioxidant of polyphenols [11]. This statement is supported by some references [117, 8, 14]. Juliastuti et al. [118] reported polyphenols content in pulp of 3 480 mg per 100 g, Sukatiningsih [69] said the content of (157.6 to 727.3) mg per 100 g. Mullen et al. [119] compared the flavonols in coffee husk from Mexico, India, and China. The highest one is India husk robusta of (55.3 ± 7.2) mg per 100 g. The references [67–69] reported polyphenol contents are (1 217.58 ± 29.28) mg per 100 g, 678.6 mg per 100 g and 1 578 mg per 100 g. Setyobudi et al. [54] reported pulp-hay after storage in 15 m.o. to contain polyphenols of 550 mg per 100 g.

Polyphenols play important roles in human health as protecting against a number of diseases related to oxidative stress and free radical-induced damage [120]. Polyphenols have ten times antioxidant activity higher than Vit C and 100 times higher than Vit E and carotenoids. In beverages, one of the most top antioxidant resources is coffee [121, 122]. The coffee bean which is roasted in 10 min with the color of medium-black, increase the total oxidant activity since the termination of in vitro free radical chain [123].

Seriki et al. [124] stated that polyphenols are an inhibitor of Fe absorption. Yuniastuti [113] explained that phenol which has three hydroxyl groups, binds the three-valent iron forming chelates, so decreasing iron bioavailability. However, Hart and Glahn [125] stated that not all polyphenols inhibit iron uptake and that some are promoters.

5.2.3. Tannin. The references [7, 8, 11, 14, 117, 123, Evans and Trase in 123, 126] said that pulp contains tannins. Echeverria and Nuti [1] reported that pulp contains tannins of (1 000 to 9 000) mg per 100 g, and Juliastuti et al. [118] reported tannins of 4 810 mg per 100 g. Tannins have a molecular weight of 1 000 m.w. to 5 000 m.w. It is divided into two groups, namely hydrolyzable

tannins (HT) and condensed tannins (CT). Evans and Trase [in 123] said the proliferation of HT is limited in dicots plant only, including coffee. Polyphenols are also the predominant found in the pomegranate juice, as supported by references [44–47]. However, Clifford and Ramirez-Martinez [in 126] did not find HT in the coffee pulp. Kumari and Jain [127] and Colmenares [in 126] said that coffee contains CT.

HT has been shown to induce apoptosis (programmed cellular death) of cancerous cells or to inhibit the proliferation of cancerous cells (Min-Hsiung and Lea in 7]. CT is useful as antioxidants and can reduce the cholesterol levels in mice (Bursill, and Gutteridge in 7). Kumari and Jain [127] said that tannins have a positive impact on managing Diabetes Mellitus.

The positive impact of tannins contradicts with references [113, 124] which said that tannins are an inhibitor of Fe nutrient absorption. However, the negative impact of coffee tannins on Fe absorption was suspected in a small amount relatively. The reference [128] stated that tannins of coffee are categorized in pseudo tannins or false tannins. They are phenolic compounds of lower molecular weight and do not show the Goldbeater's test. The reference [123] also said that CGA of coffee is categorized in pseudo tannins. The further study is needed to investigate this condition.

5.2.4. Anthocyanin and calcium. The references [28, 129–131] said that coffee pulp and husk contain anthocyanins. Anthocyanins are one of flavonoids group [28, 131], which affect in coffee cherries color. The anthocyanins from coffee pulp yielded 25 mg of monomeric anthocyanins per 100 g of fresh pulp on a dry weight basis [129, 131]. The references [67–69] stated that anthocyanins contents of pulp are (1 349.8 ± 89.6) mg per 100 g, 94.6 mg per 100 g, 1 353 mg per 100 g and (30.6 to 1 578) mg per 100 g. This anthocyanin is a prospective resource of natural dyes in the food industry [131].

Matsui [in 129] said that anthocyanins have prospective benefit in health as antioxidant, anticarcinogenic, anti-inflammatory agents and anti-hypoglycemic effect. Some reports indicate that the natural anthocyanins extract inhibited amylase action, meaning that anthocyanins would have a potential function to suppress the increase in postprandial glucose level from starch.

However, anthocyanins are categorized as an inhibitor of Fe absorption [113, 124] since it is involved in the flavonoids and phenolic compound [28, 131]. The further study is needed whether anthocyanins is still prospective as inhibitor since the CF drying is conducted in drying floor. Furthermore, anthocyanins are also proceeded in the oven in producing bread and cookies using CF as a substitution.

Figure 1a shows that CF contains calcium (Ca) of 4 %, while Figure 1b shows calcium of 344 mg per 100 g. World Health Organization (WHO) since 2013 have recommended the Ca supplementation of (1 500 to 2 000) g d^{-1}, besides the Fe tablet supplementation for pregnant women. Ca nutrient supplementation aims to control hypertension, including preeclampsia which is the number two cause of maternal deaths worldwide [132]. However, references [113, 124] said that Ca is an inhibitor of Fe absorption. Yuniastuti [113] explained that Ca competes with Fe in transferring at the intracellular line.

5.2.5. Caffeine. Caffeine is a secondary metabolite of alkaloids group [133, 134]. Wolde [134] said that caffeine is an antioxidant to prevent diseases, reduce the risk of several chronic diseases, including diabetes, liver disease, and cancer, as well as improve immune function. However, it also has a risk of developing coronary artery disease, osteoporosis, gastritis, iron deficiency anemia, and stillbirths. Nawrot et al. [135] supported the data [134] about the positive and negative impact of caffeine on human health.

Mainly related to Fe and hemoglobin, Fitday [136] said that caffeine stimulates the production of stomach acid, which supports the B-12 absorption. Some studies reported that the consumption in moderate levels decrease fatigue by increasing energy availability and thereby lead to physical and psychological enhancement [137]. *In vitro* studies has shown that in high amounts, caffeine is also an inhibitor of mold [138] and bacteria [139]. Figure 1b shows that CF contains caffeine of 750 mg

per 100 g. This data is relatively lower than the caffeine content of pulp/husk in some references as shown in table 2.

Table 2. Caffeine content comparison of arabica and robusta bean than pulp/husk

Bean (mg per 100g)		Pulp/Husk
Arabica	Robusta	(mg per 100 g)
900 to 1 300[a]	1 500 to 2 500[a]	1 300[d,e]
8 00 to 1 400[b]	1 700 to 4 000[b]	2 300[f]
1 300[c] in GB	2 300[c] in GB	1 000[g,h]
1 300[c] in Rs	2 400[c] in Rs	458[i]
		860[j]

Note: GB = green bean, Rs= roasted
Source: [a][100], [b][102], [c,i][2], [d][8], [e][13], [f][29], [g][140], [h][141], [j][118]

Table 2 shows (i) caffeine content of robusta bean is higher than arabica bean; (ii) caffeine content of pulp/husk is around 65 % of green bean content; (iii) there is an increase of roasted caffeine content than a green bean. Leloup data [in 2] of caffeine increasing occurs in robusta only. Table 3 shows that the caffeine content of roasted beans relatively higher than a green bean. Table 3 data is supported by some references [142, 143].

Table 3. Caffeine content comparison of green bean than roasted bean

Greean bean (mg per 100 g)	Roasted (mg per 100 g)
800 to 1 400[a]	1 200 to 2 400[a]
1 200[b]	1 400[b]

Source: [a][144], [b][145]

However, some references [113, 124, 134] said that caffeine is an inhibitor of Fe absorption. Caffeine properties of roasting in table 3 are useful to overcome the issues of Fe absorption inhibitor. The further study is needed to investigate whether the pulp/husk drying on the drying floor increase the caffeine content of CF, then whether the caffeine content in bread and cookies using CF has a negative impact, particularly for hemoglobin. Figure 1(a) shows that CF contains potassium of 310 mg or 7 %, while figure 1(b) shows potassium content of 3 720 mg per 100 g and magnesium content of 113 mg per 100 g. Otten coffee [146] said that potassium and magnesium inhibit the negative impact of caffeine.

5.2.6. Dietary fiber, manganese, magnesium, copper, and zinc. Figure 1(b) stated that CF contains Dietary Fiber (DF) of 59.3 %, which consist of soluble fiber of 17.8 % and insoluble fiber of 41.5 %. DF macro-molecule has capacity and specification to associate with the metal ion, for example Fe. The negative impact of this condition is absorption reduction and Fe nonheme bioavailability which affecting further hemoglobin production of blood [147, 148].

Dreher [in 147] stated that the main components of DF, which has an affinity to construct strong bond, are hemicellulose and lignin. Setyobudi et al. [54] concluded some manuscripts data and said that hemicelluloses content of coffee pulp is in the range of (2.30 to 21.80) % and lignin in the range of (17.50 to 31.58) %.

Figure 1(b) mentions that CF contains Manganese (Mn) of 12 mg per 100 g. This data is small relatively since Avinash et al. [50] mentioned that the coffee pulp contains Mn of 4 807 mg 100 g. Freeland-Graves [149] said that Mn has negatively affected in Fe absorption since Fe and Mn share a common intestinal transport system. Some references [113, 150, 151] supported the statement of Mn as inhibitors, but there is a contradict statement since the reference [88] said that Mn is enhancers.

CF also contains magnesium (Mg), copper (Cu), and zinc (Zn) of 113 mg per 100 g, 2 mg per 100 g, and 114 mg per 100 g respectively. Gurevich [152] said that Mg reduces Fe nonheme

absorption. Some references [113, 153, 154] supported and said that Mg, Cu, and Zn are inhibitors. There is also some contradict statements since the references [88–90] said that Cu, Mn, and Zn are enhancers, while the references [155, 156] said that Mg is not inhibitors.

6. Raw material

As mention in part two, the raw material of CF are pulp and husk of CP solid waste. Several references reported that nutrition and element composition in the pulp and husk could be improved by biological treatment. Penalosa [in 83] reported about utilization of *Aspergillus niger*, while Dzung et al. [15] using Trichoderma sp. and Streptomyces sp.; and Ulloa et al. [157] employing Bacillus sp.

References [158, 159] suggested biological treatment in silage processing technology, as conducted by Wahyudi et al., which employing Lactic Acid Bacteria [160]. Anaerobic treatment of biogas digester was hypothesized more efficient than silage processing treatment since resulting three products namely renewable energy of biogas, the slurry as organic liquid fertilizer, and the sludge as a raw material of CF. While, some references [161, 162] showed that pulp or husk needs ballast [24], since the low bulk density relatively [54]. The further investigation was needed to improve the nutritive value of coffee pulp and husk.

7. Conclusions and further actions

This review concludes that the Fe content of coffee flour—CF (and coffee pulp/husk) is higher, at least three times than *Spinacia oleracea*. However, the supply of nutrients to the human body not only depends on the amount of the nutrient in the food but also on its bioavailability. Fe absorption of CF is suspected to be constrained by (i) enhancers agent, such as vitamin A, vitamin C, and amino acids in CF; which decreases than the content of coffee pulp/husk since the drying impact. (ii) CF contains some inhibitors, such as chlorogenic acid, polyphenols, calcium, caffeine, dietary fiber, manganese, magnesium, copper, and zink. These problems are suspected to increase inside the oven, when CF is used as an alternative for producing bread, cookies, cakes, etc.

However, the nutrient is not stand alone in food, but side by side and acts as "the team players". The nutrients interact in complex, often in unpredictable ways. The further study is being carried out *in vivo* testing of CF on *Rattus norvegicus* (Berkenhout, 1769) Wistar strain at the laboratory of biomedical the Faculty of Medicine and Faculty of Agriculture and Animal Husbandry University of Muhammadyah Malang, Indonesia.

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