





An Update on Sustainable Valorization of Coffee By-Products as Novel Foods within the European Union [†]

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Abstract: The coffee plant *Coffea* spp. offers much more than the well-known drink made from the roasted coffee bean. During its cultivation and production, a wide variety of by-products are accrued, most of which are currently unused, thermally recycled, or used as animal feed. The modern, ecologically oriented society attaches great importance to waste reduction, so it makes sense to not dispose of the by-products of coffee production but to bring them into the value chain. The aim of this presentation is to provide an updated overview of novel coffee products in the food sector and their current legal classification in the European Union (EU). Coffee flowers, leaves, cascara, coffee cherry spirit, silver skin, and coffee wood are among the materials considered in this article. Some of these products may have, at least, an indirect history of consumption in Europe (silver skin), while others have already been used as traditional foods in non-EU-member countries (coffee leaves, flowers, cascara, and coffee cherry spirit). Of these, coffee leaf tea and cascara have already been approved by the European Commission. Following a consultation with EU member states, spent coffee grounds were determined as being not novel. For the other products, toxicity and/or safety data need to be gathered to further advance novel food applications.

Keywords: cascara; coffee by-products; coffee flower; coffee leaves; coffee pulp; coffee silver skin; coffee cherry; coffee cherry spirits; husk; novel food; spent coffee grounds



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1. Introduction

All parts of a coffee plant, including the cherry, the leaves, and the wood could be used for various applications, but are currently wasted [1]. Literature shows that the practice of using the by-products as foods was widely known in the 18th and 19th centuries (see review in [1]), but has been lost over the last 100 years when the focus on the bean as a commodity rather than as a food was shaped by international trade. Specifically, the fleshy fruit, which is suitable for consumption, as evidenced by some coffee-eating animal species [2], appears to also be applicable for human nutrition. Most coffee by-products are traditionally consumed in several coffee-producing countries and may appear to consumers in the European Union (EU) as normal foods. Nevertheless, an approval procedure as a novel food is necessary for most by-products, because there is no or only limited evidence available on their consumption in the EU before 1997 [1]. The first approvals have already been granted for coffee-leaf tea and for cascara [3–8]. A novel food application had also been filed for a certain form of spent coffee grounds [9]. However, according to an Article 4 consultation request, it was concluded that “spent coffee grounds, defatted spent coffee grounds, and defatted unused coffee grounds (from *Coffea* sp., mainly *Coffea arabica* L. and *Coffea canephora* (Robusta)) are not novel foods” [10].

In an update of our previous review about the topic [1], this article aims to provide a brief overview of coffee by-products and their socioeconomic effects as well as regulatory

issues regarding the novel food regulations in the EU, focusing on new evidence that became available in 2020. An up-to-date overview of the novel food status of coffee by-products in the EU is provided in Table 1.

Table 1. Coffee by-products and assessment of their novel food status considering Regulation (EU) No 2015/2283 (updated with permission from Klingel et al. [1]).

Coffee By-Product	Novel Food Status ^a	EFSA Opinion	EC Implementing Regulation
Flowers (blossoms)	Novel, currently not approved. Some anecdotal evidence for traditional food uses in third country. Needs approval procedure.	-	-
Leaves	Authorization granted for infusion from coffee leaves based on notification as traditional food from third country [11].	[4]	[3]
Coffee cherry materials (husks, cascara, dried or fresh coffee cherries, and coffee pulp or mucilage)	Authorization granted for cascara and cherry pulp based on notifications as traditional food from third country [12,13].	[5,6]	[8]
	A full application for some further beverage uses has been submitted [14].	[7]	expected
Green unroasted beans	Not novel [15]. The classification also applies to the non-selective water extraction made of them. Selective extracts could be novel.	-	-
Silver skin	Unclear but indirect consumption before 1997. Consultation procedure currently ongoing.	-	-
Coffee grounds	Not novel (spent coffee grounds, defatted spent coffee grounds, and defatted unused coffee grounds) [10].	-	-
Stems, twigs, and wood	Non-food material, contamination up to certain levels typically tolerated in the trade of green coffee.	-	-
Parchment	Novel, currently not approved. No application pending. Needs approval procedure.	-	-

^a Authors' judgement considering the EU Novel Food Catalogue, Article 4 consultations and pending applications/notifications. Abbreviations: EU, European Union; EFSA, European Food Safety Authority; EC, European Commission.

2. Coffee By-Products and Their Socioeconomic Impact for Coffee Farmers

At present, when coffee production is considered, every effort appears to be focused on the bean. It is taken for granted that all by-products are just thrown away, or, at best, they are used as a sort of a natural fertilizer [16]. For example, taking one kilogram of coffee beans as an average rendement (i.e., how many cherries are required to make one kilogram of coffee beans), about 2.5 kg cherries are needed for *Coffea canephora* var. conilon. For *C. liberica*, a rare species, the rendement is up to 16. Taking Brazilian *C. arabica* var. catuaí, which is the most distributed Arabica in the world, and probably one of the biggest single varieties in production, the rendement would be around 4 to 6. This means that 5 kg of natural material is wasted and using it as a biomass is completely absurd, considering its properties. If the cherries are brought out onto the coffee fields as a fertilizer, for instance, there is the potential to spread diseases and pests across the farm. In addition, caffeine is also carried out because both the coffee cherry and the coffee leaf contain comparably high concentrations of caffeine. With redistribution of caffeine in the fields, production will be diminished due to autotoxicity effects [17]. Therefore, it is advisable not to use the cherries directly or as a compost, but if possible, to use them in the form of ashes. However, they

are much better used as a food than just being brought out as a fertilizer as is currently the prevalent practice. There might even be multiple uses, first as foods and later as fertilizers or to create energy. There are also uses as building or packaging materials.

The big economic problem for coffee farmers is that globally coffee prices are way too low, no matter how farmers are paid. The prices often do not even cover the cost of production. Due to climate change, producing coffee is even much more of a challenge today than in the past. However, using coffee by-products can help with these new challenges. Farmers may have extra income options by using all these products, which are already there while producing the bean. Clearly, industry must change its ways of thinking, and its ways of just throwing away things or taking them for granted. In the case of coffee leaves, for example, they are already there and therefore, should also be used. This will even allow costs to be cut through having better pruning management on farms because farmers will have additional income, while pruning the plant. According to initial estimates, by using coffee by-products, farmers may multiply the income they had before, and in so doing, make a big change.

3. Coffee Leaves

The leaves are an obvious by-product because coffee plants must be regularly cut on the plantation so high amounts of leaves are regularly obtained. Historically and also today in some coffee-producing countries, there is a tradition of using the coffee leaves as a kind of tea, i.e., the dried leaves are applied to make an aqueous infusion [1]. *C. canephora* leaves are similar to tobacco leaves, and the coffee leaves were also historically used for smoking, a practice no longer endorsed.

In July 2020, coffee-leaf tea was approved in the EU [3,4,18] but it is still a very niche product and not many suppliers are aware of it. From a sensory standpoint, coffee-leaf tea is more like green tea than black tea, with light floral notes and a little bit honey-ish.

The EU, within the novel food approval procedure has provided some standards (see Table 2) [3,4,18]. Nevertheless, the approval has some restrictions. First, *C. liberica* was not included in the notification of the applicant, despite having the largest leaf size making it commercially interesting. Hence, for coffee-leaf tea from *C. liberica* and for any other species besides *C. arabica* and *C. canephora*, another notification as a traditional food and/or a full novel food application to the EU would be required. Secondly, the approval is specifically and exclusively for an infusion [3,4]. So currently, derivative products such as lemonade containing coffee-leaf tea or coffee-leaf tea extracts are not covered by the approval. For such uses, a new approval procedure must be initiated.

Table 2. Specifications of Commission Implementing Regulation (EU) 2020/917 of 1 July 2020 authorizing the placing on the market of infusion from coffee leaves as a traditional food from a third country [3].

Authorized Novel Food	Infusion from Coffee Leaves of <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner (Traditional Food from a Third Country)
Specified food category	Herbal infusions
Additional specific labelling requirements	The designation of the novel food on the labelling of the foodstuffs containing it shall be 'Infusion from coffee leaves of <i>Coffea arabica</i> and/or <i>Coffea canephora</i> '.
Description/definition	The traditional food consists of an infusion of leaves from <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner (family: <i>Rubiaceae</i>).
	The traditional food is prepared by mixing a maximum of 20 g of dried leaves from <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner with 1 L of hot water. Leaves are removed and the infusion is then subjected to pasteurization (at least 71 °C for 15 s).

Table 2. Cont.

Authorized Novel Food	Infusion from Coffee Leaves of <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner (Traditional Food from a Third Country)
Composition	Visual: brown green liquid
	Odor and taste: characteristic
	Chlorogenic acid (5-CQA): <100 mg/L
	Caffeine: <80 mg/L
	Epigallocatechin gallate (EGCG): <700 mg/L
Microbiological criteria	Total plate count: <500 CFU/g
	Total yeast and mold count: <100 CFU/g
	Total coliforms: <100 CFU/g
	<i>Escherichia coli</i> : absence in 1 g
Heavy metals	<i>Salmonella</i> : absence in 25 g
	Lead (Pb): <3.0 mg/L
	Arsenic (As): <2.0 mg/L
	Cadmium (Cd): <1.0 mg/L

Abbreviations: CFU, colony-forming unit.

4. Coffee Flowers (Blossoms)

Similarly to the leaf, the flowers could also be used to prepare an infusion or as a non-food application in the perfumery industry because of their aroma, which is similar to that of jasmine, roses, or honey [1]. The flavor of the coffee flower depends on how and when it is harvested and how it is dried. As with the coffee cherry, a natural process could be used or a process including a certain amount of fermentation. For example, if the flower is dried within plastic bags, a completely different flavor develops than if it is quickly dried with air, which gives a pure, floral, and less honey-ish flavor. Our own experiments with *C. liberica* in Sarawak (Borneo, Malaysia) showed that even rose-bud flavors as well as jasmine can be produced from this blossom. In the context of coffee flowers, it is of note that the blossom originally gave Arabian coffee its first name. Before Linnaeus classified it as *Coffea arabica*, it was called *Jasminum arabicum* [19] because due to the flower aroma, it was often confused with jasmine. There are only a few available studies on the composition of the coffee flower. These show that it contains potentially bioactive compounds such as caffeine, trigonelline, chlorogenic acid, protocatechuic acid, gallic acid, melanoidins, and several sugars [20,21] and it exhibits antioxidant activity [22].

Interestingly, there are ways to obtain both the beans and the blossoms. The blossoms must be harvested at the moment when pollination had fully occurred. To be on the safe side, this is 24 h after pollination. This is actually also the moment when the blossom starts to descend. Therefore, the blossoms can be harvested without any risk to bean production [21]. If the blossoms are harvested in too fresh a state, a loss of the crop will occur and no cherries would form.

There may be several applications for the blossoms—they may have been used traditionally, in fine foods, pastries and sweets, especially in the Yemenite area. Nevertheless, the flower does not yet have a novel food approval in the EU [1].

5. Coffee Cherry (Cascara)

Coffee-cherry-derived products are better known under the Spanish name cascara, and are typically commercialized in the dried form [1]. A systematic study of volatile compounds has shown that cascara contains several common key odorants of dried fruits and black tea among the 151 identified substances [23]. The dried husk can be used for extraction of various phenolic compounds [24].

Products from wet and dry processes give some slightly different products. Generally speaking, the dry process is currently recommended for farms with less advanced technology because it is much less prone to contamination such as molding. A cascara derived from a dry process contains some parchment. This is usually a more traditional way of gaining a sensorially acceptable and fruity-tasting cascara. The parchment is a by-product, that by itself can also be used in different applications [1,25].

However, problems may arise with a fully washed cascara where contamination due to water in combination with sugar from the fruits can occur. The pulper is often the main infection place for microorganisms because it is hard to keep pulpers free of microorganisms. Disinfection in rural coffee farms is impossible, and, therefore, the production of a cascara within a wet process is definitely a delicate procedure. Additionally, off-flavors may be produced by the non-controlled microorganisms and during the fermentation process. The risk of contamination is therefore extremely high, as is the risk of formation of toxins such as ochratoxin A and aflatoxins. Good manufacturing practices are needed. Cascara production is more challenging than, for instance, the production of coffee leaves or blossoms. Alternatively, cascara can also be used in a fresh form or as a fruit puree [26] so it does not necessarily have to go through a drying process (see also Section 6, below).

The applications for dried cascara in the food industry are manifold. It is possible to make an aqueous infusion for beverage use, but it can also be used as a base ingredient for other foods such as flour replacement [27] (e.g., for gluten-free cookies) or to flavor foods and alcoholic beverages [28].

Based on two well-prepared notifications as a traditional food from a third country and one full application [12–14], the European Food Safety Authority (EFSA) has already made its evaluations and did not raise safety objections to the placing of cherry pulp or dried cherry pulp on the market within the EU [5–7]. The implementing regulation from the European Commission as traditional foods has been recently published [8] (see Table 3), while the one for the full novel food application for a use of cascara as an ingredient in non-alcoholic infusions and water-based beverages is expected soon.

Table 3. Specifications of Commission Implementing Regulation (EU) 2022/47 of 13 January 2022 authorising the placing on the market of *Coffea arabica* L. and/or *Coffea canephora* Pierre ex A. Froehner dried cherry pulp and its infusion as a traditional food from a third country [8].

Authorized Novel Food	<i>'Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner Dried Cherry Pulp and Its Infusion (Traditional Food from a Third Country)
Specified food category	Coffee cherry pulp from <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner for the preparation of infusions; Coffee, coffee and chicory extracts, instant coffee, tea, herbal- and fruit-infusions, coffee substitutes, coffee mixes and instant mixes for hot beverages (and their flavoured counterparts); Flavoured and unflavoured non-alcoholic ready-to-drink beverages
Additional specific labelling requirements	<p>The designation of the novel food on the labelling of the foodstuffs containing it shall be “coffee cherry pulp” and/or “cascara (coffee cherry pulp)”, and/or “coffee cherry pulp infusion” and/or “coffee cherry pulp dried infusion”.</p> <p>If the product containing the novel food contains more than 150 mg/L of caffeine (as such or after reconstitution), it shall be labelled with the following indication: “High caffeine content. Not recommended for children or pregnant or breast-feeding women” in the same field of vision as the name of the food, followed by the caffeine content expressed in mg per 100 mL.</p> <p>Typical infusion preparations are prepared with up to 6 g of coffee cherry pulp per 100 mL of hot water (>75 °C). For the coffee cherry pulp placed on the market as such for the preparation of infusions, instructions shall be given to the consumer on the preparation.’</p>

Table 3. Cont.

Authorized Novel Food	<i>'Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner Dried Cherry Pulp and Its Infusion (Traditional Food from a Third Country)
Description/definition	<p>The traditional food consists of the dried unroasted coffee cherry pulp of <i>Coffea arabica</i> L. and/or <i>Coffea canephora</i> Pierre ex A. Froehner (genus: <i>Coffea</i> family: <i>Rubiaceae</i>) and its infusion. The infusion can be used as such or concentrated or dried.</p> <p>Ripe coffee cherries are collected, and then the coffee beans are mechanically removed, prior or after a drying process, leaving the dried coffee cherry pulp, which can be milled to a powder.</p> <p>The separated coffee cherry pulp is also known as “cascara”, from the Spanish “cáscara”, meaning “husk”.</p> <p>Typically, the infusion is prepared by mixing up to 6 g of cascara pulp or husk in 100 mL of hot water (>75 °C) for a few minutes and then pouring through a strainer, or using corresponding amounts in dried or instant infusions.</p>
Composition	Water: <18 %
	Water activity (aw): ≤0.65
	Ash: <10.4 % DM
	Protein: <15 % DM
	Fat: <5 % DM
	Carbohydrates: <85 % DM
Microbiological criteria	Aerobic Plate Count: <104 CFU/g
	Total yeasts and moulds: <100 CFU/g
	Enterobacteriaceae: <50 CFU/g
	Salmonella: Absence in 25 g
	Bacillus cereus: <100 CFU/g
Mycotoxins	Ochratoxin A: <5.0 µg/kg
	Aflatoxin B1: <2.0 µg/kg
	Aflatoxin B1. B2. G1. G2 (as sum): <4.0 µg/kg
Heavy metals	Cadmium (Cd): <0.05 mg/kg
	Lead (Pb): <1.0 mg/kg
	Copper: ≤50 mg/kg
	Mercury: ≤0.02 mg/kg
	Arsenic: ≤0.2 mg/kg
Impurities	Benzo(a)pyrene: <10.0 µg/kg
	Sum of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene and chrysene: <50.0 µg/kg
Pesticides	Pesticide levels in the traditional food shall comply with levels set by Regulation (EC) No 396/2005 for “0639000” for “Herbal infusions from any other parts of the plant”.

Abbreviations: CFU, colony-forming unit; DM, Dry Matter.

6. Coffee Cherry Spirits (Alcoholic Distillates)

The fresh coffee cherry can be used to manufacture a fruit spirit because it has a certain sugar content, which can be alcoholically fermented using yeast [29]. The smell and taste of such a spirit is similar to that of stone fruits such as plum distillate. There are some examples where cooled, frozen, or concentrated coffee cherry pulp have been transported to the United States or Europe for fermentation and distillation (e.g., [30]). From a sustainability standpoint, this makes little sense, both for energy reasons and for quality reasons due to

possible spoilage during transport, which often is difficult in coffee-producing countries due to lack of road infrastructure. The fruits should be as fresh as possible for fermentation, so a shift to local production is suggested. Of course, not every small farmer can distill cherries. However, as long as there is an opportunity for fermentation and distillation a short distance away, the production of a quality product may be possible. The conditions of the fermentation should be closely controlled to avoid off-flavors, as well as to reduce methanol formation from fruit pectins [29]. In a pilot study on coffee spirits in Brazil, the potential for using by-products from wet processing to produce distilled beverages showed a preference of coffee spirits over sugarcane spirits during sensory analysis [31]. Another option may be to produce non-distilled fermented alcoholic beverages (similar to wine) from coffee pulp and mucilage [32].

7. Silver Skin

Unlike the previously discussed coffee by-products, silver skin is not produced in the coffee-producing countries but at the end of the chain in the roasteries as a roasting by-product in huge amounts. Silver skin has a wide range of applications. Traditionally, in Central Europe, silver skin has been used as animal feed. Non-food applications include the use of silver skin as raw material for paper production [33]. However, for human consumption, it could be used, for example, in any type of bakery product, extruded food product, or even meat product [34,35]. For instance, it could be used in breads that would usually be covered with herbs, or on the surface of potato breads. There are some of our own empirical results that show that a silver skin cover on bread may have the effect of leaving more moisture inside the bread, making it juicier. Furthermore, it can be used as a flavoring compound. For instance, in spices or salts, silver skin exhibits a nice smoky character, and flavor. Unlike guaiacol-type smoke flavors, which remind one of smoked ham or smoked fish, the silver skin flavor reminds one of a firewood flavor, which may even be suitable for vegetarian or vegan consumers, who often dislike guaiacol-type smoke flavors. There are not many natural sources in the food industry for such alternative kinds of smoke flavor.

Several studies have been conducted over the years on silver skin showing its high protein and high fiber content so that it could be used as an ingredient to increase protein and fiber in bakery products, fitness products, or sports products, as well as in energy bars because it contains caffeine [35–37].

Regarding of the novel food status of silver skin, a consultation to determine its status was previously recommended [1] and is currently ongoing. Silver skin is consumed to a certain degree with the coffee bean because it cannot be completely removed during roasting—in the cut of the bean there is always a remainder of the silver skin. There are also some applications of coffee beans where no infusion is prepared, but the beans are directly eaten, for example, in chocolate-coated coffee beans, or if finely powdered coffee is used on tiramisu (a coffee-flavored Italian dessert). The Article 4 consultation request for spent coffee grounds also states: “Several recipes exist for using ground coffee beans e.g., in preparation of chocolate products in the EU. Whole coffee beans (e.g., chocolate-coated coffee beans) have been on the market in the EU before 15 May 1997” [8]. Additionally, some coffee preparations without filtration (such as Greek or Turkish preparation styles) lead to partial consumption of the sediment. Hence, it could be assumed that silver skin was, at least indirectly and inadvertently, consumed to a significant degree in the EU before 1997, suggesting that it is possibly not a novel food.

8. Coffee Wood

Coffee wood is a coffee by-product that has no direct food use, but can potentially be used to make certain food-contact materials such as coffee filters or paper cups. Coffee wood can be used to manufacture panels [38] or furniture (e.g., in the German town of Paderborn, a whole coffee shop was made of coffee wood including accessories such as pens and tampers). Typically, *C. canephora* wood is used because *C. canephora* has a much

bigger stem than *C. arabica*. However, wood can also be produced from *C. arabica*, and from *C. liberica*, which yields the biggest trees. Harvesting the wood typically means killing the plant if it is chopped down too low. Nevertheless, coffee plants may already have a lower production (down to below 10%) after 70 years. Therefore, it is often not economically viable to keep those plants alive after that time, even though coffee plants do have a significant positive change in flavor from the age of 50 years (the so-called amber coffees). Little branches and twigs might also be used, for instance, to produce interesting types of paper, which may also be usable as a coffee-based coffee filter. The relative shortness of the fibers will make this application a future challenge.

9. Conclusions

All of the coffee by-products do deliver a high level of economy and added value to the farms. There is huge potential for all of these products, especially on markets not currently accessible due to regulations. The existing successful novel food applications for coffee by-products may be seen as a kind of wave-breaker for further applications in the sense of being used as a template to apply for other products. For example, applications for cascara and coffee-leaf tea are needed for *C. liberica* because the current approvals only encompass *C. arabica* and *C. canephora*. In the future it would be prudent to include all *Coffea* species that have a proven history of human consumption to avoid making the approvals too specific. Evidence has been increasingly provided that all parts of the coffee plant, which humans have used for centuries, are safe. Furthermore, derivative uses could also be applied, e.g., the use of by-products as ingredients in various foods and aqueous infusions.

It is certainly in the interest to the entire coffee industry to strive for and promote the use of coffee by-products. Many steps in forming and changing public awareness can be taken in trying to push through the frontiers of these novel materials. Those companies that get most strongly involved will probably also obtain interesting new products as well as increasing public awareness of sustainability.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/Foods2021-10969/s1>, Powerpoint presentation: An Update on Sustainable Valorization of Coffee By-Products as Novel Foods within the European Union.

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