Foods 2021

Proceeding Paper

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

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† Presented at the 2nd International Electronic Conference on Foods, 15–30 October 2021; Available online: https://foods2021.sciforum.net/.

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 not to dispose the by-products of coffee production and 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 presentation. Some of these products may have—at least an indirect—history of consumption in Europe (silverskin), while others have already been used as traditional food in non-EU-member countries (coffee leaves, flowers, cascara, coffee cherry spirit). From these, coffee leave tea has already been approved by the European Commission, while the approval for cascara is currently pending. Spent coffee grounds were determined following a consultation with EU member states as being not novel. For the other products, toxicity and/or safety data need to be gathered to advance further 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

Citation: Lachenmeier, D.W.; Rajcic de Rezende, T.; Schwarz, S. An Update on Sustainable Valorization of Coffee By-Products as Novel Foods within the European Union. *Biol. Life Sci. Forum* **2021**, *1*, x. **2021**, *1*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s):

Published: date

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]. Historic 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 be applicable for human nutrition as well. 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 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 approval has already been granted for coffee leaf tea and the one for cascara is currently in process [3–6]. A novel food application had also been filed for a certain form of spent coffee grounds [7]. However, according to an article 4 consultation request, is 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" [8].

In an update of our previous review about the topic [1], this article aims to provide a brief overview on coffee by-products, their socioeconomic effects as well as regulatory issues regarding the novel food regulation in the EU, focusing on new evidence having become available since 2020. An up-to-date overview about 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 [9].	[4]	[3]
Coffee cherry materials (husks, cascara, dried or fresh coffee cherries, coffee pulp or mucilage)	Novel, currently not approved. Notifications for cascara and cherry pulp as traditional food from third country have been submitted [10,11] as well as a full application for further uses [12].	[5,6]	Expected
Green unroasted beans	Not novel [13]. 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 suggested.	-	-
Coffee grounds	Not novel (spent coffee grounds, defatted spent coffee grounds and defatted unused coffee grounds) [8].	-	-
Stems, twigs, 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

When the coffee production is currently considered, every effort appears to be focused on the bean. It is taken for granted that all side products are just thrown away; if at all, they are used as a sort of a natural fertilizer [14]. For making, to specify one example, one kilogram of coffee beans considering 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 a 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, if not even pervert considering its properties. If the cherries are brought out on coffee fields, for instance, as a fertilizer, there is on the one hand the hazard to spread diseases and pests across the farm. And secondarily, caffeine is carried out because the coffee cherry but also the coffee leaf are containing comparably high concentrations of caffeine. By the redistribution of caffeine in the fields, the production will be diminished due to autotoxicity effects [15]. Therefore, it is advisable not to use the cherries directly or as a compost, but if possible in the form of ashes. However, they can be used much, much better 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. They are often not even covering the cost of production. Due to climate change, producing coffee is even much more a challenge today than it has been before. But now, with all those new challenges, using coffee by-products can help. Farmers

may have extra income options using all these products, which are already there while producing the bean. Clearly, industry must change the ways of thinking, and the ways of just throwing away things or taking them for granted. To highlight the coffee leaves as an example: they are already there. Therefore, they should also be used. This will even allow to cut down the costs for having a better pruning management on the farms. Because farmers will have additional income, while pruning the plant. According to initial estimates, farmers may multiply the income they had before. So, the use of coffee by-products will 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 on using the coffee leaves as a kind of tea, i.e., the dried leaves are applied to make an aqueous infusion [1]. Canephora leaves remind of tobacco leaves, and the coffee leaves were also historically used for smoking, a practice not to be endorsed anymore.

In July 2020, coffee leaf tea was approved in the EU [3,4,16] but it is still a very niche product and not many suppliers have been becoming aware about the coffee leaf tea. From a sensory standpoint, coffee leaf tea is reminding more on green tea than black tea, with light floral notes, a little bit honey-ish.

The EU within the novel food approval has provided some standards (see Table 2) [3,4,16]. Nevertheless, the approval has some restrictions. First, *C. liberica* was not included in the notification of the applicant, despite having the largest leave 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 traditional food and/or full novel food application to the EU would be required. Second, 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 *Coffea arabica* L. and/or *Coffea canephora* 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 *Coffea arabica* and/or *Coffea canephora*'.
Description/Definition	The traditional food consists of an infusion of leaves from *Coffea arabica* L. and/or *Coffea canephora* Pierre ex A. Froehner (family: Rubiaceae).
	The traditional food is prepared by mixing a maximum of 20 g of dried leaves from *Coffea arabica* L. and/or *Coffea canephora* 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).
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
	Escherichia coli: Absence in 1 g *Salmonella*: Absence in 25 g
Heavy metals	Lead (Pb): <3.0 mg/L
	Arsenic (As): <2.0 mg/L
	Cadmium (Cd): <1.0 mg/L

Abbreviations: CFU—Colony Forming Units.

4. Coffee Flowers (Blossoms)

Similar 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 its flavor, reminding 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 a coffee cherry, a natural process could be done or also a process where a certain fermentation is included. 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. Own experiments with *C. liberica* in Sarawak (Borneo, Malaysia) showed that even rose bud flavors besides jasmine can be provoked out of 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* [17] because due to the flower smell, it was often confused with jasmine. There are only a few studies on the composition of the coffee flower available, showing that it contains potentially bioactive compounds such as caffeine, trigonelline, chlorogenic acid, protocatechuic acid, gallic acid, melanoidins and several sugars [18,19] and it exhibits antioxidant activity [20].

Interestingly, there are ways to both gain the beans and the blossoms. The blossoms must be harvested in a moment when pollination had already fully occurred and after pollination it takes about 24 h to be on the safe side. This is actually also the moment when the blossom starts to descend. Therefore, the blossoms can be harvested without any risk to bean production [19]. If harvested in too fresh a state, a loss of the crop will occur and there would not be any cherries forming anymore.

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

5. Coffee Cherry (Cascara)

Coffee cherry-derived products are better known under the Spanish name cascara, which are typically commercialized in 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 [21]. The dried husk can be used for extraction of various phenolic compounds [22].

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 by itself that can also be used in different applications [1,23].

However, more problems may arise with a fully washed cascara where contamination due to water in combination with sugar from the fruits can occur. The pulper often is a main infection place for microorganisms because it is hard to keep pulpers clean from microorganisms. Disinfection in the rural areas of 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 and 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 [24] so it does not necessarily have to go through a drying process (also see section on spirits 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 be used as a base ingredient for other foods such as flour replacement [25] (e.g., for gluten-free cookies) or to flavor foods and alcoholic beverages [26].

Currently, the novel food application of cascara in the EU is ongoing. Based on two well-prepared notifications as a traditional food from a third country [10,11], the European Food Safety Authority (EFSA) has all already made their evaluations and they did not raise safety objections to the placing of cherry pulp or dried cherry pulp on the market within the EU [5,6], so the authorization is only missing the implementing regulation from the European Commission as last step and this is expected soon.

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 [27]. The smell and taste of such a spirit are reminding of stone fruits such as plum distillate. There are some examples where cooled, frozen or concentrated coffee cherry pulp was transported to the United States or Europe for fermentation and distillation (e.g., [28]). From a sustainability standpoint, this makes not much sense for energy reasons but also quality reasons due to possible spoilage during transport, which often is difficult in coffee-producing countries from lack of road infrastructure alone. The fruits should be as fresh as possible for fermentation, so that it is suggested to shift to a local production. Of course, not every small farmer can distill cherries. However, as long as there is some short distance opportunity for fermentation and distillation, 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 [27]. In a pilot study on coffee spirits in Brazil, the potential for using by-products from wet processing to produce distilled beverages was shown by a preference of coffee spirits over sugarcane spirits during sensory analysis [29]. Another option may be to produce non-distilled fermented alcoholic beverages (similar to wine) from coffee pulp and mucilage [30].

7. Silverskin

Unlike the previously discussed coffee by-products, silverskin 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. Silverskin has a wide range of applications. Traditionally, also in Central Europe, silverskin has been used as animal feed. Non-food applications include the use of silverskin as raw material for paper production [31]. However, for human consumption, it could be used, for example, in any type of bakery product, extruded food products or even meat products [32,33]. 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 own empirical results that a silverskin 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, silverskin exhibits a nice smoky character, and flavor. Unlike guaiacol-type smoke flavors, which remind of smoked ham or smoked fish, the silverskin flavor reminds of a firewood flavor, which may even be suited for vegetarian or vegan consumers, which are often disliking 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 past years on silver skin showing its high protein content, but also a 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, but also energy bars because it contains caffeine [33–35].

Regarding the novel food status of silverskin, a consultation to determine its status was previously recommended [1]. The silverskin has been consumed to a certain degree with the coffee bean because it cannot be completely removed during roasting, e.g., in the cut of the bean there is always a remainder of the silverskin. 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 silverskin has been, 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 [36] or furniture (e.g., in the German town 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*, but also from *C. liberica*, which yields the biggest trees. Harvesting the wood means typically to kill the plant, if it is chopped down too low. Nevertheless, coffee plants may already have a lower production (down to below 10%) starting from 70 years onwards. Therefore, it is often not economically viable to keep those plants alive in that moment, even though coffee plants do have a significant positive change in flavor from the age 50 years and upward (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 economical extract, and added value to the farms. There are huge potentials 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 to be 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 are only encompassing *C. arabica* and *C. canephora.* In the future it would be prudent to include all *Coffea* species that have a provable 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 be applied for, e.g., to use the by-products as an ingredient in various foods apart from aqueous infusions.

It is certainly in the interest of 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. And those companies that will get most strongly involved will probably also obtain interesting new products and also in the public awareness increasing sustainability.

Author Contributions: Conceptualization, D.W.L. and S.S.; investigation, D.W.L.; data curation, D.W.L.; writing—original draft preparation, D.W.L. and S.S.; writing—review and editing, T.R.d.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: S.S. is owner of Coffee Consulate, Mannheim, Germany. Coffee Consulate is an independent training and research center. Coffee Consulate is currently researching the potential of coffee by-products. However, S.S. reports no conflict of interest related to the work under consideration. The other authors declare no conflict of interest.

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