10. Who owns the taste of coffee – examining implications of biobased means of production in food

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Abstract

Synthetic foods advocates offer the promise of efficient, reliable, and sustainable food production. Engineered organisms become factories to produce food. Proponents claim that through this technique important barriers can be eliminated which would facilitate the production of traditional foods outside their climatic range. This technique would allow reducing food miles, secure future supply, and maintain quality and taste expectations. In this paper, we examine coffee production via biobased means. A start-up called Atomo Coffee aims to produce synthetic coffee with the aim of saving 'the taste of coffee' from the effects of climate change. This decontextualisation of coffee production ignores the current and historical contributions of coffee farmers in two ways: the traditional varieties in taste of coffee and their cultural significance, and the potential shade-grown coffee plantations have in capturing carbon. In addition, synthetic coffee may lead to the loss of agricultural biodiversity and the removal of resources away from production systems that provide a safe space for tropical flora and fauna. How should the 'taste of coffee' be owned? We investigate the property regimes under which we could consider owning the taste of coffee as a 'synthetic' agrobiodiversity to help identify rights and responsibilities. Building on this analysis, we consider dimensions of responsible innovation and social justice to help guide synthetic foods as an agricultural innovation.

Keywords: cellular agriculture, bioeconomy, ownership, responsible innovation, biodiversity

Introduction

Synthetic foods advocates offer the promise of efficient, reliable, and sustainable food production. By engineering microorganisms (via conventional non-GM processes, gene insertions or artificial synthesis), these become factories for the production of food products, presenting a new trend called cellular agriculture. Proponents claim that through this technique important barriers can be eliminated which would facilitate the production of traditional foods outside their climatic range: In other words, anywhere a bioreactor could be placed with the engineered microorganisms, and with considerably less environmental impact. This technique would allow reducing food miles, secure future supply, contribute to circular processes, and maintain nutritional quality and taste expectations. In addition, this technique can tap into waste streams or use renewable resources and can therefore be an essential part of a new bioeconomy for food production.

In this paper, we examine a case of cellular agriculture to produce coffee, a biobased process. Biobased means processes typically employ microorganisms to transform inputs like sugar, or CO_2, to beneficial compounds. At this moment, a start-up called Atomo Coffee produces synthetic coffee, that they call atomic coffee. This means that the coffee itself does not come from a bean, but from the transformation of other products into elements that, together, make coffee. The mission of Atomo Coffee is to save the taste of coffee from the effects of climate change (Atomo Coffee, n.d.). While their aims are laudable, they also embody a central concern that the rising trend of cellular agriculture presents: a complete social and ecological decontextualization of coffee production. Indeed, what cellular agriculture produces are

not coffee beans, but the taste of coffee with equivalent, or adapted nutritional properties. While the production of synthetic coffee itself might be decontextualised, it is hard to argue that a synthetic coffee that appropriates properties of coffee agrobiodiversity for the purpose of taste and nutritional qualities is devoid of connection and independent of commitments to this agrobiodiversity.

The new method of production afforded by cellular agriculture ignores current and historical contributions of coffee farmers in at least two ways: the traditional varieties in taste of coffee and their cultural significance, and the potential shade-grown coffee plantations have in capturing atmospheric carbon. In addition, synthetic coffee may lead to the loss of agricultural biodiversity and the removal of resources away from production systems that are currently providing a safe space for tropical flora and fauna. This is particularly unfortunate when synthetic coffee is presented as sustainable, as it is likely that it will take a cut from the market share of organic fair-trade producers while seeking for concerned customers. Because cellular agriculture is not producing coffee beans, but captures the taste of coffee, this invites asking: who owns the taste of coffee? Establishing such a claim has normative implications with regard to the conservation of farmed coffee beans and the contributions of farmers to agrobiodiversity and carbon capture.

Re-creating taste, or flavour, is not a new endeavour. Chemically, famous flavours to be synthesized are vanilla with vanillin, and the flavour of the now defunct Cavendish banana, that remains the staple for banana synthetic flavours. What is then the difference with flavours and food produced through bio-based processes instead of chemicals? One is that they make strong claims about being sustainable, and two, the emergence of new processes on multiple fronts in the food sector makes that such processes do more than re-creating flavour, or taste, but recreate the actual food item. Together, these two differences present a long-term challenge to farming and the conservation of agrobiodiversity.

In the following, we first consider the historic labour efforts of farmers globally to establish the taste of coffee as we know it today. Then, we consider what the taste of coffee consists of in cellular agriculture. Next, we investigate the property regimes under which we could consider owning the taste of coffee (Timmermann and Robaey, 2016), and finally, we sketch how dimensions of responsible research and innovation (RRI) and social justice (Robaey and Timmermann, 2018) might help guiding synthetic foods as an ethical agricultural innovation.

Cultivating coffee, what led to its taste

Coffee is one of the oldest commodified agricultural goods. The early limitations to seek appropriate new cultivation sites outside its native Ethiopian Highlands and the Mountains of Yemen made controlling the trade with the beans very lucrative. After coffee first began to be consumed in Yemen in the 15th century, it was diffused through ample trade networks throughout the Arabic peninsula and later on to Turkey. Ensuring an adequate taste experience was from early on a central feature in the diffusion of coffee. Merchants introduced coffee to a new public in the Muslim world and Western Europe by establishing prestigious coffee houses that served as places of gathering and social exchange (Topik, 2009).

Nowadays coffee is grown in highly different production systems. Some regions, particularly in the Spanish-speaking Latin America, India and Africa, maintain highly biodiverse systems that grow coffee under the trees canopy, providing a refuge for wildlife and delivering important ecosystem services, from which farmers also draw immediate benefits. Shade-grown coffee farms vary in the number of trees per hectare, but even scant-shade coffee systems (including 1-3 tree species) sequester an additional 53-55 tons of carbon per hectare aboveground compared to sun grown coffee systems without counting the extra carbon stored in much richer soils (Jha *et al.*, 2014). Unfortunately, traditional production sites

such as Brazil and new coffee areas in East Asia are concentrating on non-shaded production systems (idem.).

A major challenge for shaded coffee growers is to find support and financial compensation for their ecologically superior production methods. A strategy that has been followed is to secure additional revenues through labelling. Yet here too consumers may find it tricky to navigate around the large variety of labels, supporting goals such as fair trade, carbon footprint reductions, bird sanctuaries, agroforestry, gender justice and child labour prevention. Consumers are left on their own to figure out which label guarantees the fairest and most sustainable coffee (Ingenbleek and Reinders, 2013). An over-emphasis on ecological sustainability may leave labour issues unaddressed by giving the impression that coffee comes out effortlessly and without hazards from an idyllic forest (Jimenez-Soto, 2020). Fair trade also needs to be guaranteed in organic agriculture.

There is some indication that shaded coffee farms produce also a more tasteful coffee (Jha *et al.*, 2014). Here shaded coffee farmers' cooperatives could take advantage of an additional instrument provided by intellectual property: geographic indications. Here farmers have the advantage of securing additional income by offering added value, through special regional preparation methods, or agroecotourism services that provide a full coffee experience.

Due to the extensive commodification of coffee, much of the effort to add specialty value has concentrated on the roasting process, as it allows coffee traders additional control over the quality and thereby reduces the bargaining power of coffee growing regions. The fierce competition among major coffee brands is however opening up new marketing opportunities. Coffee taste varies with factors such as altitude, humidity, degrees of shade, plant age and maturation (Seninde and Chambers, 2020). An interesting example is offered by the Colombian coffee growers Juan Valdez. To highlight the diversity of geographic regions within the country and the differences in taste, the coffee growers launched their *Café deorigen* series branding coffee produced in the Colombian regions of Huila, Cauca, Antioquia, Santander, Nariño, among others (Juan Valdez, 2020). This series has allowed coffee growers to market a particular regionally specific taste, for example by offering an extra strong high-altitude variety from the highest Coastal mountain range of Sierra Nevada de Santa Marta, at the Caribbean Coast of Colombia.

Synthesizing the taste of coffee

What does synthetic coffee mean? A literature search for synthetic coffee in scientific literature databases reveals a great interest in coffee, which can be broadly categorized in four groups: health effects of coffee, molecular composition of coffee, the role of coffee waste in the bioeconomy, and farming practices of coffee. Interestingly, we could not find a paper describing the phenomenon of bio-based synthetic coffee.

In a review of sustainable production of food flavours (Bel-Rhlid *et al.*, 2018), authors point to different techniques that can help reproducing coffee aroma, with enzymes, or fermentation. Interestingly, the very process of fermentation on coffee beans also seems to be a topic of research and an ambition for standardisation in order to maintain a more predictable flavour that can be related to a particular brand (Elhalis *et al.*, 2021; Lee *et al.*, 2015). What makes coffee flavour has therefore been a long endeavour, a paper from 2014 lists 72 compounds that play a role in Arabica coffee flavour with the ability to link sensory perception to composition (Sunarharum *et al.*, 2014). One flavour compound, alkyl pyrazines for instance, seems to be important to recreating flavour in many food items, including coffee (Mortzfeld *et al.*, 2020). In this review, they highlight bio-based synthesis options, in other words, synthetic options from microorganisms. Also, the articles cited all refer to the complexity of identifying coffee taste, precisely due to the complex process from farming, to fermenting, to roasting described in the previous

section. So, while we did not find one paper that indicates how to make synthetic coffee, there is certainly knowledge and technology available to know how to produce it.

If we return to the start-up, Atomo Coffee, that sparked our interest in the matter of investigating the ethical implication of claiming benefits on the taste of coffee, the start-up explains on their website that they reverse engineer the taste of coffee, sourcing the needed components from waste streams (Atomo Coffee, n.d.). They call it up-cycling from plants and describe their proprietary technology to recreate a coffee bean that is then roasted and brewed. As described in the previous paragraph, they tap into the chemical properties of coffee to recreate aroma, body, colour, taste and caffeine. In 2020, Atomo raised 9 million USD in addition to a kick-starter and earlier venture seed funding (Brown, 2020). In a nutshell, Atomo Coffee is one of the first, and maybe many more to come to make coffee, without coffee.

Property regimes and the taste of coffee

Establishing what property regime best fits 'owning the taste of coffee' is not a descriptive endeavour. Indeed, property regimes are inherently socially constructed systems of ownership to help manage resources (Thompson, 2007). The question here should be specified to which property regime best captures the connection between synthetic coffee, and farmed coffee beans? We consider each with a focus on conservation of agrobiodiversity of coffee beans, for the advantages it provides as highlighted previously. In Timmermann and Robaey (2016) we present five alternatives of property regimes: no property, commons, private goods, state sovereignty, and common heritage. In this section, we explore each for the taste of coffee produced via bio-based means (what we call synthetic in this paper) and their implications for agrobiodiversity conservation in a *long-term* perspective.

No property

In the case that there are no property rights that can be established on the taste of coffee and its varieties, this means that the labour and ecological contributions of coffee farmers that are currently rewarded through selling coffee beans, might find themselves replaced by other ways of producing coffee. Should this replacement occupy a large portion of the coffee market in the future, there would be no incentive left to develop and conserve varieties of coffee *in situ*.

Commons

In the case that the taste of coffee is considered as a commons, this means that there would be some norms developed to regulate the behaviour of stakeholders involved in coffee production. Coffee taste as a commons could organize around different varieties of coffee beans, and include other ways of producing coffee in the governance of a particular taste. A commons conception for the taste of coffee would favour a reciprocal relationship between stakeholder benefiting from the taste of coffee, and would likely create strong incentives for at least the conservation of popular coffee varieties. A potential risk would be that such a property regime might not encourage the development of new varieties, unless explicitly part of the governance norms for the taste of coffee as a commons.

Private goods

In the case that the taste of coffee should be considered a private good, this would not be primarily linked to the way coffee is produced, via farming, or via bio-based means, or chemical synthesis, as the ultimate profile of a taste could be the object of property claims. At the moment, there are already patent claims on enhanced flavour profiles to be found. If a flavour profile would result of a specific process only, then a utility or process patent could also play a role. Either of these cases offer little incentives to preserve

and develop agrobiodiversity in coffee in the long term, essentially pitting modes of production against each other in a market where the most efficient and affordable product will dominate. In addition, this might move farmed coffee to the realm of luxury goods, and therefore represent a much smaller portion of the market for this beverage.

State sovereignty

State sovereignty over the taste of coffee presents an interesting opportunity that is fraught with pitfalls (for full discussion see Timmermann and Robaey, 2016). A notion of property linked to the state could strengthen the geographical link to the taste of coffee. Coffee is consumed worldwide but only produced in the Global South at the moment. With the advent of new technologies to recreate the taste of coffee, this property regime could strengthen the requirement for conservation of agrobiodiversity. However, major pitfalls include the lack of political continuity in sovereign states, as well as the unwillingness of industrialized countries to fairly share in conservation costs where agricultural genetic resources are already stored in seed banks. State sovereignty therefore offers little incentives for preserving and developing coffee agrobiodiversity.

Common heritage

The notion of common heritage of humankind was adapted to manage crop genetic resources in the 1980s. The concept never gained ground due to existing global inequalities that would render implementing the principle nearly impossible. What this principle does underline is the need of a recognition of global efforts in creating genetic diversity. Considering the taste of coffee as a common heritage of humankind, without going into the details of how to implement the different demands of the principle, calls for recognizing that the taste of coffee, and its varieties, comes from the agrobiodiversity of coffee, as well as the multiple fermentation and roasting practices. What this concept offers to the taste of coffee is the opportunity to keep it contextualised, independently of its method of production.

Moving forward responsibly with synthetic coffee

In this paper, we take a critical look at developments in the bioeconomy for food production, specifically looking at coffee production through cellular agriculture, or through bio-based processes. We ask, who owns the taste of coffee and why does this discussion matter when considering historical efforts of farmers in the Global South, that contribute not only to taste, but to creating carbon sinks, and agrobiodiversity. Building on previous research on how property regimes incentivize agrobiodiversity in terms of conservation and development of new varieties, we explore that these property regimes can mean for the taste of coffee.

Currently, the taste of coffee is under no property regime. Our analysis suggests that in the long-term, this could lead to market dominance of bio-based processes, where agrobiodiversity of coffee beans could come to be threatened.

As explained in the introduction, such techniques decontextualize coffee production. In order to recontextualize coffee production, we suggest framing it within the context of a property regime. Our analysis suggests that none of the existing property regimes are without pitfalls. However, having a commons governance that specifies conservation and agrobiodiversity goals could step up to the challenge. Likewise, a concept of common heritage of humankind can come to strengthen the link between coffee beans and the taste of coffee.

Our aim is not to stigmatize these new developments, but to reflect on how to move forward responsibly. There is a considerable amount of learning to be done in the bioeconomy (Asveld and Stemerding, 2017) and for doing responsible innovation (Van de Poel *et al.*, 2020). For specific concerns relating to agricultural innovations, in Robaey and Timmermann (2018) we present five key social challenges that need to be addressed: availability, accessibility, participation in science and governance, arbitration and long-term sustainability.

Taking into account these challenges, the need to learn, and the opportunities of property regimes such as commons and common heritage of humankind, ethicists would invite the cellular agriculture community to keep a close link to the geographical origins of coffee, in order to recontextualize it, continue technological development in a responsible manner, and recognize that synthetic coffee is inextricably linked to coffee beans. Without the historic work of coffee farmers, synthetic coffee would simply not have come to exist.

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