Sustainability, health and consumer insights for plant-based food innovation

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ABSTRACT

Plant-based foods are part of a needed change in the food system. This opinion article addresses sustainability, health and consumer issues to inform plant-based food innovation and research. Consumers are key players in the food system. In 2020, consumers require that cues of sustainability be clearly addressed in food innovation. Consumers are more and more conscious of the detrimental effects of animal farming on the environment as well as the ethical issues resulting from poor animal welfare. Consumers want their products to be sustainable, healthy and conscious of animal welfare. Plant-based foods deliver on all fronts. Nevertheless, consumers have to deal with facilitators and barriers towards dietary change such as cooking skills, taste preference and family support.

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KEYWORDS

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Sustainability, health and consumer insights for plant-based food innovation

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The past few years have seen the calls for radical transformation of the food system. The current food system, as a major driver of climate change, needs a profound metamorphosis, where concerted and synergic actions are required instead of single solutions (Springmann et al. 2018). In 2018, the International Panel on Climate Change called for the transitions of systems based on an alarming need for urgent climate change mitigation investments, policies, the acceleration of technological innovation and behaviour changes to avoid reaching the irreversible climate tipping point (IPCC 2018). In early 2019, the EAT-Lancet Commission issued recommendations towards a responsible food consumption within planetary boundaries (Willett et al. 2019). Almost in parallel, another Lancet Commission described the concurrence of obesity, undernutrition and climate change as a syndemic, as the latter exerts sweeping effects on human health and the environment (Swinburn et al. 2019). At the same time, following growing consumer demand, the first generation of plant-based foods directed towards the Western market has been developed to mimic the characteristics of dairy and meat. It is noteworthy that pioneers like Alpro (soy-based dairy alternatives) or Oatly (oat-based dairy alternatives) have set the benchmark for future development and innovation. The next generation of plant-based foods in the Western market may have to address a number of different sustainability, health and consumer challenges (Perez-Cueto 2019; Aschemann-Witzel et al. 2020).

CONSUMERS AND SUSTAINABLE DIETS
A sustainable diet is characterized by having a low carbon footprint, protecting and respecting biodiversity and ecosystems. A sustainable diet is also nutritionally adequate, safe, healthy, culturally acceptable and economically affordable (FAO 2012; Chai et al. 2019; Macdiarmid and Whybrow 2019). It is increasingly acknowledged that the composition of livestock diets and the sheer quantity of livestock are the strongest determinants of greenhouse gas emissions (GHGE) (Poore and Nemecek 2018; Theurl et al. 2020). Diets richer in foods of plant origin (vegan, vegetarian) are those with the lowest carbon footprint, water and land use (Chai et al. 2019; Rabès et al. 2020). Moreover, foods of animal origin are the most inefficient step in nutrient conversion (Pimentel and Pimentel 2003; Shepon et al. 2016). Therefore, changing food consumption towards a more plant-based diet has large GHGE mitigation potential (30–50 per cent of personal emissions) (Poore and Nemecek 2018; Carter 2019). Moreover, growing scientific consensus exists that diets rich in foods of plant origin are both healthy and sustainable (Dernini and Berry 2015; Godfray et al. 2018; Clark et al. 2019; Hu, Otis and McCarthy 2019; Willett et al. 2019; Zheng et al. 2019). Consumers are key players in the food system. In 2020, they require that cues of sustainability be clearly addressed in food innovation. Consumers are more conscious of the detrimental effects of animal farming on the environment as well as the ethical issues resulting from poor animal welfare (Toma et al. 2012; Goldstein et al. 2016; Grasso et al. 2019).

CONSUMERS AND A HEALTHY DIET
A healthy diet is characterized by daily consuming a large proportion of plant origin foods, limiting or restricting intake of animal origin foods, and even more severely limiting intake (or avoiding) of highly processed foods (whether of plant or animal origin) (IARC 2014). From a health perspective,
the consensus of more than 30 years of epidemiological research confirms that a healthy diet is predominantly plant-based, as it prevents chronic non-transmissible diseases. Indeed, the continuously growing body of evidence underscores the healthful role of plant-based (PB) foods and diets on improved cardiovascular health (Satija and Hu 2018), reduced risk of developing Type 2 diabetes (Eguaras et al. 2017; Qian et al. 2019), lower body mass index (BMI) (Lin et al. 2015; Gómez-Donoso et al. 2019; Satija et al. 2019), improved blood pressure (Borgia et al. 2015; DiNicolantonio and O’Keefe 2016; Wang et al. 2019), and the list can continue. At the same time, consumption of foods of animal origin is associated with undesirable health outcomes despite being considered nutrient dense foods (Godfray et al. 2018; Zheng et al. 2019; Fraser et al. 2020; Willett and Ludwig 2020).

CONSUMER RESPONSES TO HEALTHY EATING CAMPAIGNS
Although most countries have been systematically investing in the promotion of healthy food consumption through social marketing (Brambila-Macias et al. 2011; Capacci et al. 2012; Pérez-Cueto et al. 2012), the population at large is still consuming insufficient foods of plant origin such as fruits, vegetables, pulses and nuts (Appleton et al. 2016; Dinnella et al. 2016; Appleton et al. 2019), while overconsuming animal based foods, as well as ultra-processed foods (rich in refined sugars, added salt, and saturated fats or trans-fats) (DiNicolantonio and O’Keefe 2016; Gómez-Donoso et al. 2019).

CONSUMERS AND THE ADOPTION OF PB FOODS AND DIETS
Therefore, transitioning towards PB foods and diets is desirable from both health and environment perspectives. However, the transition process is undergone by consumers navigating between a series of barriers and facilitators (Reipurth et al. 2019). Many known barriers include taste preferences towards animal foods (Briers et al. 2020), uncertainty about nutritional sufficiency, unsupportive family/partner and social environment, lack of cooking skills and unavailability of PB foods (Pohjolainen, Vinnari and Jokinen 2015; Reipurth et al. 2019; Cheah et al. 2020). Women in general are more prone to adopt predominantly PB diets (Nakagawa and Hart 2019; Satija et al. 2019). This gender effect seems to stem from the common belief that meat consumption is a masculine feature (Rothgerber 2013; Munt, Partridge and Allman-Farinelli 2017; Reipurth et al. 2019; Cheah et al. 2020).

THE PARADOX OF TASTE
Taste in particular can be both a barrier and a facilitator (Pohjolainen, Vinnari and Jokinen 2015; Reipurth et al. 2019). For PB consumers, exposure to a variety of pulses, fruits, vegetables, mushrooms and tubers has increased the dietary diversity (desirable from a health perspective) and it has opened new sensory experiences. Many consumers of foods of animal sources are attached to the taste of meat and dairy (particularly cheese); this attachment is key to understanding their reluctance towards eating foods of plant origin. Umami, the taste imparted by the amino acid glutamate and 5′-ribonucleotides such as inosinate and guanylate (Ninomiya 2015), may explain consumer attachment. These compounds are often found in foods of animal origin and contribute to the perception of their deliciousness (Mouritsen and Styrbaek 2014), but the animal foods are also associated with less sustainable dietary choices
Moreover, another common belief that unhealthy is tasty is a strong predictor of poor food choices in the short term and often undesirable weight gain in the long term (Briers et al. 2020). Such belief systems may be challenged in practice by taste-oriented labelling (Turnwald and Crum 2019) or by using other umami sources in new product development. Umami compounds are also present in vegetables typical of traditional gastronomy, such as tomato, basil and garlic (in Italy), mushrooms, onions and garlic (in Central Europe), and fermented beans like tempeh in Indonesia (Fibri and Frøst 2019, 2020). In practice, the taste-enhancing properties of umami may improve the acceptability and palatability of PB foods (Ninomiya 2015). Promoting the adoption of PB diets should focus on facilitators including health, sustainability, the ethical aspects of animals, but above all, the consumer hedonic experience (Reipurth et al. 2019). Taste and the resulting liking of eating plant-based foods (Appleton et al. 2019) has been an understudied facilitator, likely predicting a long-term adherence to a PB diet (Faber et al. 2020) and advocated as public policy intervention (Briers et al. 2020).

**FOOD INNOVATION CHALLENGES**

Key for PB food innovation is the concept of ultra-processed foods that was coined by Brazilian nutritionist Carlos Monteiro (Monteiro 2009; Monteiro et al. 2019). The term describes those foods that are made by mixing ingredients, containing mainly added sugar, salt and fat, little or no whole foods (thus poor in dietary fibre) which are typically ready for consumption (Monteiro et al. 2018). Most recent evidence hints towards a detrimental effect of ultra-processed foods on health (Fiolet et al. 2018; Srour et al. 2019). Although such considerations may apparently include some of the existing dairy and meat alternatives, it is worth noting that many of the first generation PB foods that might be classified as ultra-processed contain already protein, fibre and other nutrients (calcium and vitamin B12) and are not high in amounts of added fat, sugar and salt. Nevertheless, PB foods are not all equal, and concerns have been risen. Therefore, it would be worth taking the amount of processing into account until proper proof of their health effects is produced (Gómez-Donoso et al. 2019; Hemler and Hu 2019) as well as using fewer and more natural or whole ingredients (Aschemann-Witzel et al. 2020).

Likewise, for cell-cultured meat and dairy (Broad 2019), a balance should be sought between being animal-friendly foods and the unknown health effects on the consumer. One can speculate that if consumption of tissue grown in a living organism is detrimental to human health, it is likely that the same effects would be seen in humans after ingesting the same tissue grown in petri dishes.

**CONCLUDING REMARKS**

Plant-based foods deliver on sustainability, animal ethics and human health. However, innovation in plant-based foods needs to take into account the minimal processing of foods, or a clean label (Asioli et al. 2017), appeal to naturalness (use of as little as possible of additives and preservatives) (Aschemann-Witzel et al. 2012a, 2012b), and facilitate the factors that would make transitioning towards a more plant-based dietary pattern easier (such as ethics, animal welfare, taste, health and empowerment).
Innovation in foods directed towards achieving improved plant-based diet may include developing plant-based protein enriched products (and using raw materials such as tempeh, quinoa, amaranth, peas, lentils, almonds and nuts) while focusing as much as possible on the ‘whole food’ link to consumer health and wellbeing (Campbell, Fidahusain and Campbell 2019) and increasing the consumer’s dietary quality. Food innovation may develop tasty and pleasurable plant-based meals and recipes as well as provide meals in either ready to eat or conveniently pre-portioned raw materials for preparation at home. Innovation in behavioural interventions should address taste experience coupled with empowering consumer’s cooking skills and making sustainable and healthy plant-based choices easier.

Lastly, the field of PB foods and meals is ready for innovation and offers plenty of opportunities. Innovators may benefit from strategic multidisciplinary knowledge from sustainability, health and consumer preferences in order to direct their innovation and creativity. Studying how to use taste as a nudge strategy to promote transition towards a more PB consumption would be helpful because such a change protects biodiversity. Adoption of PB diets facilitate citizen’s ethical choices. Producers have the opportunity to create and market new foods, new meals and new food categories.

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**SUGGESTED CITATION**


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