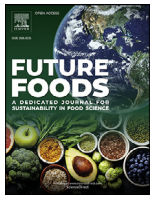
Future Foods 5 (2022) 100109

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo



Aspects that affect tasting studies of emerging food – a review

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ARTICLE INFO

Keywords:
Alternative food
Sustainable development
Food acceptance
Algae
Entomology
Filamentous fungi

ABSTRACT

Providing food security to the growing global population, and the resource depletion associated with current food systems, let to calls for more sustainable food sources. Food that can be produced in a sustainable way (taking all three aspects of sustainable development into consideration) is currently emerging in Western societies. Through tastings, insight can be gathered not only into sensory characteristics but also other aspects that aid innovation and development of food. The current study identified aspects that can affect tastings of emerging food by reviewing relevant literature. General aspects; meat alternatives; ingredients or processing technologies; information, prior knowledge and (un)familiarity; taste and liking; emotional factors; and willingness to engage with emerging food can affect tastings of emerging food. Awareness of the effect that these aspects can have on methodological considerations and results can be constructive in future research that use tastings as a platform to develop new and emerging food. The findings are significant for food science in terms of cornerstones towards potential industrial applications. These include innovating new types of food, assessing most effective technologies in the context of such food, developing new products, and understanding engagement with emerging food products.

Introduction

The growth of global population and welfare has led to increasing food consumption, resulting in increased greenhouse gas emissions, and negative consequences on natural ecosystems and biodiversity (IPCC, 2020). Agriculture supports global food security, and it is currently estimated to account for 70% of global fresh water use (IPCC, 2020). The human population is estimated to reach nearly ten billion by 2050 (UN, 2017), which will exacerbate this situation. Food products and ingredients that are affordable, nutritious and that have the potential to contribute to sustainable development are thus needed to provide food security (Smith and Gregory, 2013).

Managing the earth's resources has never been as critical as it is today (UN, 2015), and current ways of producing food are not considered sustainable when they are resource intensive (Khan and Hanjra, 2009). Products and ingredients that are part of staple diets in other countries are being introduced to the West because they are nutritious and their production is expected to contribute to making food systems more sustainable.

Food products and ingredients made from algae,[1] fungal-fermentation[2] and insects are among such products, and can contribute to more sustainable food systems (Dawczynski et al., 2007; Hashempour-Baltork et al., 2020; Testa et al., 2017), but these are not yet commonly consumed in Western[3] cultures. The use of the term 'emerging food' in this review therefore refers to food made from algae, insects or through fungal fermentation.

While there are other types of food that can be considered as being emerging by this definition, these three sources are getting more attention because they are expected to be sustainable alternatives to feed the global population in environmentally more benign ways than, for example, meat (Finnigan et al., 2019; Tiwari and Troy, 2015; van Huis and Oonincx, 2017). Even though these are not the only emerging sources of food, their production is more scalable than that of, for example, lab-grown meat.

Food developers and manufacturers often use tasting studies as a tool to assess food properties and sensory characteristics, and use these evaluations in the development of products (Lawless and Heymann, 2013).

[1] Marine macro-algae and seaweeds are henceforth referred to as 'algae'
[2] In this article, 'fungal-fermented' food refers to products and ingredients made through fungal fermentation.
[3] i.e., European and North American

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https://doi.org/10.1016/j.fufo.2021.100109
Received 4 November 2021; Received in revised form 1 December 2021; Accepted 9 December 2021

Tasting studies are also done to assess how information, contextual factors, certain ingredients or processing technologies affect taste, as well as how taste affects liking, intention to purchase, intention to adopt, and willingness to pay. In general, tastings can encourage individuals to try new products or ingredients for the first time (Lensvelt and Steenbekkers, 2014), and provide a better understanding of, for example, the appropriateness of food, insight into socio-cultural and practical concerns, estimates of regular consumption, and psychological factors that influence the willingness to eat products or ingredients (Stone et al., 2020; Tan et al., 2017).

While tasting studies generally contribute to constructive development of food products, tastings are especially relevant for emerging food given its relative novelty. For example, sensory attributes need to be carefully assessed to develop food that will be preferred to conventional, often meat-based, alternatives (Hoek et al., 2011). Developing food in this way will encourage adoption and consumption which can then contribute to more sustainable food systems.

Aim and relevance of the review

Aspects that are important to consider when conducting tasting studies to develop emerging food products have yet to be addressed in the literature. This review aims to fill this gap and identify aspects that can affect tastings of emerging food in the context of products and ingredients from algae, fungal-fermentation or insects. Even though this study focuses on emerging food based on these three resources, the findings may also be true for other emerging food products that consumers may not be familiar with. The results of the review may thus be relevant for the wider issue of consumer adoption of new food products and ingredients.

Methods

Literature was reviewed to identify aspects that can affect tasting studies in the context of emerging food, and that should be considered when planning, conducting and analyzing tastings on this type of food. A search for relevant literature was undertaken using databases such as Scopus and Web of Science. Search terms including “tasting”, “sensory evaluation”, “mycoprotein”, “algae”, and “insects” were used. Reference lists of articles that came up using these search terms were manually searched. Literature published prior to the end of October 2020 was included. Other inclusion criteria included: studies that arranged a tasting in which participants were asked to evaluate sensory characteristics, how they felt about emerging food, or how they perceived their engagement with the food or product they tasted. These tastings had to be conducted on either fungal-fermented, algae or insect food. Only studies that described the tasting in detail in terms of methodology, panel and participants, attributes, rating scales and data analysis were included. Moreover, articles were excluded when participants were only asked to evaluate the smell or aroma but did not actually taste emerging food products or ingredients.

Relevant literature was identified by first scanning titles of articles and reading abstracts when applicable. The methodological sections of articles that had relevant abstracts were then read to assess whether enough information about methodological aspects of the tastings were presented. To identify aspects that may affect tasting studies, the first data analysis involved collecting data from the reviewed articles to identify the following parameters: title; year; emerging food type; number of participants, gender and age; whether participants were trained, semi-trained or untrained; what kind of data was collected regarding sensory attributes, emotional attributes, intention and acceptance; questionnaire methods, measurements, scales and analysis strategy; information regarding serving methodology; as well as identified methodological limitations.

Results and discussion

The results of this review revealed that aspects that can affect tasting studies of emerging food include general considerations such as panel type and size, socio-demographics, contextual factors, venue, and ethical review. However, other identified affecting aspects include meat alternatives; ingredients or processing technologies; information, and prior knowledge and (un)familiarity; taste and liking; emotional factors; and willingness to engage with emerging food.

These aspects were extracted from 37 articles that were relevant and therefore included in this review. As part of some of the included studies, fungal-fermented biomass, algae and insects were prepared to make samples directly. However, these three emerging foods were also used as ingredients. Fungal-fermented biomass was used as an ingredient to make sausages, filet-like pieces, mincemeat, burgers, chips, bread, spreads, koji-based soy, fish- and bean sauces as well as soy pastes. Algae were used as ingredients in snacks, cookies, biscuits, pasta, fish burgers and chicken rottis. Insects were also used as ingredients in baked goods including biscuits and cookies, cereal bars, sweet dairy drinks and meatballs, and burgers. The focus of the reviewed studies, i.e., on algae, insect or fungal-fermented food products or ingredients as well as aims; objectives and analysis strategies; panel information; attributes and sensory characteristics; scales; analyses; and software are detailed in Appendix A. The information presented in Appendix A reveals that there is not a single, well-defined way to conduct tastings of emerging food. Instead, the way that the reviewed studies measured and analyzed the data varied depending on methodologies, aims and, to some extent, preference of the research teams.

General considerations

There are several aspects that apply to all tasting studies and sensory evaluations regardless of the type of food being evaluated. Several of these aspects can potentially affect tasting studies of emerging food. These regard the panel, socio demographics, venues, contextual factors, and ethical reviews.

Panel type and size

To assess sensory profiles of emerging food products or ingredients, general considerations regarding the panel type and size are important. Whether a trained, semi-trained or untrained panel is asked to rate samples is thus relevant because data derived from different panels can assist the development of such products in different ways such as identifying specific sensory characteristics or assessing acceptability across representatives of consumer markets (Stone et al., 2020). Few of the reviewed studies used a trained panel or had both trained and untrained panels evaluate samples. In some cases, regular eaters of certain product types were invited to participate. For example, only people who regularly consume algae-based food were invited to participate in tastings about seaweed-based food (Prabhasankar et al., 2009; Skrzypczyk et al., 2019). Another tasting in, which insect fat was used as partial butter replacement in bakery products, only invited consumers of the applicable bakery products (Delicato et al., 2020). While participants were specifically trained in several of the other studies, untrained panels were the most common type of panel chosen to evaluate samples. Not all reviewed studies specified whether panels were trained or not (Appendix A).

A trained panel of up to 15 participants can establish the intensity of sensory characteristics. Semi-trained panels consist of up to 30 participants who are familiar with the quality of the product-type being evaluated, and are able to discriminate sensory differences and communicate their reactions. Lastly, untrained panels of at least 100 randomly chosen participants are commonly used to assess how products are evaluated by representatives of consumer populations (i.e., in terms of socio demographic aspects). While large numbers of participants are more representative of consumers (McIlveen et al., 1999), it might not always be easy to find this many people willing to taste food that they may be

unfamiliar with. This is likely be the case for emerging food. When the aim is to gain data that can provide a general impression of how consumers perceive food that is unfamiliar to them, then smaller numbers of participants can be sufficient (Husson and Pagès, 2003; Peinado et al., 2014).

Socio-demographics

Socio-cultural aspects are important to consider in any tasting study but this is especially important when introducing food into cultural contexts where they are not commonly eaten (Tan et al., 2015). This aspect is therefore important when evaluating consumer adoption of emerging food products and ingredients. When this is the aim of a tasting, it is important that the participants not only represent diversity in socio-demographic aspects such as age, gender and income (Stone et al., 2020) but also ethnicities (Caparros Megido et al., 2016), cultural beliefs (Tan et al., 2015) and consumption situations (Tan et al., 2016). This is because these aspects can influence the way participants perceive the samples under evaluation. In spite of this, only one of the reviewed studies provided information regarding, for example, ethnicities of participants that participated in a tasting of insect-based burgers (Caparros Megido et al., 2016) (Appendix A).

To assess how a product is perceived in a way that reflects the wider society as well as those less eager to adopt it, it may be important to consider the ages of the participants evaluating the samples. This is because Schouteten et al. (2016) noted in a tasting of insect-based burgers that young adults might be more willing to trade taste characteristics for other, not necessarily sensory, benefits of the product. Younger people also tend to be more ready to try and adopt emerging food (Verbeke, 2015). This is in line with the results of this review which found that, even though emerging food was evaluated by participants of diverse ages, participants were most commonly between 18 and 30 years of age (Appendix A). However, the lower age of participants can to some extent be related to the venue of the tasting. Many of the reviewed tastings, for example, took place on university campuses, which facilitates participation from young adults.

One of the reviewed studies (Caparros Megido et al., 2016) obtained results from a tasting on insect-based food that are in line with other research that found that women tend to be more neophobic and less adventurous than men (Verbeke, 2015). That women are less adventurous is contradictory to the results of this review which show that in many cases more women than men evaluated food was unlikely to be familiar to them (Appendix A). Women tend to eat more vegetable products than men, and may therefore rate them higher than men (Sobal, 2005). Moreover, food choice is strongly influenced by considerations regarding taste, price and availability (House, 2016). Individuals who are likely to choose food that is expected to contribute to sustainability are young, female, and educated (Gilg et al., 2005). This would seem to be important to consider both when designing the methodology of a tasting of emerging food, as well as in the analysis.

The results of previous tastings on emerging food mostly reflect specific regional contexts and are not necessarily representative outside that context. Large cross-country research might be able to provide data that is more representable of how emerging food is perceived among representatives of large consumer populations.

Venue

In sensory profiling it may be important to strategically plan how samples are served, providing participants with water or something else to neutralize their palates, using booths, and adhering to protocols by the International Organization for Standardization. An overview of how samples were served in the reviewed literature, and the environment in which tastings took place is presented in Appendix A.

For tasting studies of emerging food, it is important to consider the set-up of the venue. This is because Lensvelt and Steenbekkers (2014), who conducted tastings on roasted crickets and biscuits made with insect flour, found that the decision of potential participants to participate may be influenced by being able to see what type of food is to be tasted. In research where it is of interest to assess how willing people are to taste emerging food, such a set-up may limit the relevance of the results. Additionally, when tastings are held in venues where participants can see what others are doing, pressure arising from peers or others can encourage or discourage participants to taste and evaluate the food being studied (Lensvelt and Steenbekkers, 2014). The use of booths, for example, might mediate this and would thus be good to consider when planning tasting studies of emerging food.

Another concern regarding the venue of a tasting of emerging food was discussed by Schouteten et al. (2016) who pointed out that tastings that are conducted in laboratory environments should be interpreted with caution because the context of tastings influences both emotional and sensory ratings (Piqueras-Fiszman and Jaeger, 2014). When planning tastings of emerging food, it might therefore be constructive to consider how participants evaluate food in different settings and contexts.

Contextual factors

Contextual factors such as the time required to participate in a tasting study, multiple sensory cues and product-related factors can affect tastings in terms of perception and liking (Q.J. Wang et al., 2019). While this is true for all tastings, a considerable limitation for emerging foods is that participants tend to have little time to participate in tastings (Lensvelt and Steenbekkers, 2014). This issue needs to be acknowledged, and tastings may thus need to be conducted in an efficient way, so that participants do not feel stressed and discontinue their participation. This would seem especially important in the context of emerging food, which is not familiar to the participants. This is because participants may wish for a moment to contemplate what it is they are about to eat and whether they wish to taste it.

Ethical review

Any study involving human subjects may be subject to an ethical review. This is also relevant for tastings, and depends on the emerging food as well as legislation where the tasting takes place. This is because some emerging food or ingredients may be considered novel, for example, by the European Union's Commission for Food Safety (EC, 2021). Altogether seven reviewed studies specified that they had ethical approval, and a few studies mentioned having asked participants to consent to participate in the study (Appendix A).

Meat alternatives

Developing plant- or fungi-based products that mimic sensory characteristics of meat can contribute to more sustainable food systems and cater to people who would like to eat meat less often (Siegrist and Hartmann, 2019). Multiple reviewed tastings studies focused on meat alternatives including mincemeat, filets, sausages, burger patties and meatballs, which were made with or from insects or fungal biomass (Appendix A).

Sensory characteristics have a strong influence on which products individuals choose to consume (Tan et al., 2016). This is especially true for products aimed to become alternatives to meat because their sensory characteristics drive acceptance (Hoek et al., 2011). Tastings can thus be useful in the development of emerging food in the context of meat analogues. Meat is often used in Western cuisine because of its appearance, texture and taste (Caparros Megido et al., 2016). However, sensory characteristics of meat are difficult to imitate using alternative ingredients (Elzerman et al., 2011; Hoek et al., 2013). When aiming to study how participants evaluate sensory characteristics of emerging food that aims to imitate meat, it may be constructive to consider that non-vegetarians tend to evaluate sensory characteristics lower in meat analogues than those of meat because they expect the sensory characteristics to be identical (Caparros Megido et al., 2016). While this indicates the significance of developing meat analogues with meat-like sensory

characteristics (Hoek et al., 2013, 2011), it also shows that the way that participants who are used to eating meat evaluate emerging food needs to be considered when designing tasting studies.

Ingredients and processing

Tasting studies can be used to gather information about the importance of modifying or substituting ingredients or about different ways of processing food products (Świąder and Marczewska, 2021). Given the relative novelty of emerging food, the need to assess the most favored processing technologies and ingredients in products seems critical. While all reviewed studies assessed various sensory characteristics (Appendix A), only some assessed which ingredients, flavor and texture characteristics participants were able to taste, how familiar they were with the taste and ingredients, and to rate which one they preferred (Appendix A).

Lensvelt and Steenbekkers (2014) noted a limitation of their tasting of insects and biscuits made with insect flour which lay in the perceived naturalness of products. When designing tastings on emerging food in Western cultures, it may be constructive to consider that a strong desire for natural food is culturally embedded. This is because natural products are perceived to taste and look better than products that have additives or artificial ingredients (Siegrist, 2007). It might be good to find ways of preparing emerging food for tastings in a way that suits culturally dominant demands.

Tan et al. (2017) served insect-based savory meatballs and sweet dairy drinks at a tasting, and highlighted that issues can arise when the sensory characteristics of emerging ingredients do not match products because participants might evaluate such ingredients according to the quality standard of the product category (van Trijp and van Kleef, 2008). However, moderate levels of newness might also have a positive effect (Mandler, 1981) even though individuals tend to expect emerging food to have similar sensory characteristics to the product type they replace (Hoek et al., 2011). To study this, it might be constructive not to hide sensory characteristics of emerging food (Tan et al., 2017). Instead, samples could be processed the traditional way and be presented as a new product, instead of replacing an existing product (Tan et al., 2017). Cultures that cook these foods traditionally may have recipes that best complement the characteristics of emerging food (Deroy et al., 2015).

Participant familiarity with, and sensory evaluations of, emerging food are only partially related to how appropriate participants perceive emerging food to be (Tan et al., 2017). When designing tastings, it can therefore be constructive to consider the way that food is prepared before asking participants to evaluate it. This is because the willingness to taste emerging food does not necessarily increase when it is served in combination with other ingredients which participants are familiar with and like (Stallberg-White and Pliner, 1999). To avoid contaminative effects in future tastings, findings by Tan et al. (2016) could be taken into account. These indicate that perceptions of whether an emerging food is appropriate for eating may be influenced by whether participants are asked to evaluate a combination of the product or ingredient and the product preparation, instead of a familiar product that contains emerging ingredients.

Another methodological consideration that should be considered regards the interpretation of relative comparisons from multiple samples containing different ingredients (Schouteten et al., 2016). Whether participants were able to taste which samples contained emerging food was investigated in one of the reviewed studies, in which participants were asked to identify the burger samples they thought contained insects (Caparros Megido et al., 2016). While offering participants multiple samples can better reflect real choice and consumption, future tastings can also develop knowledge if they compare identical products with the exception that one of the products contains the emerging ingredient.

Information, prior knowledge and (un)familiarity

Aspects such as distrust in new food can hinder emerging food from being consumed (Siegrist et al., 2007), which is why it is important to consider providing information about samples to the participants. Such information was provided in some of the reviewed articles (Appendix A). Schouteten et al. (2016) found that 10% of participants did not want to taste samples when they were informed that these were insect-based. However, these participants tasted insect-based samples under blind conditions. However, ethical issues of not providing information prior to tastings need to be considered with regards to, for example, the declaration of Helsinki (WMA, 1964).

When participants are asked to evaluate samples under informed conditions it is important to consider the way the information is phrased. For example, one of the reviewed studies explained that having used professional Latin-based terminology to describe specific insect species rather than writing “eating of [insects or insect-based food]” or “[insects] as food” could have impacted how participants perceived the significance of the food (Caparros Megido et al., 2016).

Other studies also concluded that further research is needed to establish easily understandable and attractive terminology, and to avoid linguistic misunderstandings regarding emerging food (Evans et al., 2015; Wood and Looy, 2014). This is relevant because the choice of phrasing can cause negative feelings towards the food that is evaluated, which may strengthen psychological barriers that prevent individuals from eating the samples (Caparros Megido et al., 2016). On the other hand, phrasing the food as ethnic using foreign words might decrease neophobia (Wood and Looy, 2014).

One of the reviewed studies found that participants perceived emerging food (in this case insects) as significantly more nutritious than other options under informed conditions (Schouteten et al., 2016). However, it is methodologically important to consider that information about all products should be given to participants when they are asked to compare samples. This is important when the aim is to assess how participants compare an emerging food product with the conventional alternative.

As part of a tasting of insect-based burgers, Schouteten et al. (2016) observed low expectations and low overall liking under both blind and informed conditions but significantly higher liking under informed conditions. A possible explanation of assimilation effects in tasting studies of emerging food can be the information that is provided (Schouteten et al., 2016). Information of the benefits of emerging food that is comprehensible to the participants can assist in building a foundation of acceptance of such products (Lensvelt and Steenbekkers, 2014). This is in line with other studies that conclude that awareness of benefits need to be raised to increase the likelihood of acceptance (Siegrist, 2008). As mentioned above, it is important to consider issues related to time when designing tastings. This is because Lensvelt and Steenbekkers (2014) identified that most participants do not have enough time to carefully read the information provided, and this was a limitation of their research.

Unfamiliarity with food can influence sensory evaluation and cause low ratings (Tuorila et al., 1998). Some of the reviewed asked participants questions related to familiarity, and asked whether participants had tasted such food previously (Caparros Megido et al., 2016; Delicato et al., 2020; Lücke et al., 2019), and, if so, whether this was a positive experience (Caparros Megido et al., 2016). Participants were also asked whether they had heard about the food before the tasting (Caparros Megido et al., 2016) or whether they felt informed about it (Caparros Megido et al., 2014). However, data about prior knowledge or familiarity may be inconclusive when participants receive information about the food as part of the tasting.

When participants are asked to rate how familiar they are with the product they are tasting, it may also be constructive to ask them to do the same rating for a similar conventional product. While this can provide an estimation of how regular they consume this type of product, it is important to consider that individuals may be famil-

iar with certain products but may still not consume them regularly (Tan et al., 2017).

The way participants evaluate the appearance of food can also be positively affected by prior experience with the food studied (Caparros Megido et al., 2016). It may thus be constructive to ask participants whether they tasted the food prior to the tasting, and how they experienced this if they did. However, it is also important to consider that remembering positive experiences with food is linked to increased liking and preference of that food (Robinson et al., 2013).

Taste and liking

Ratings of overall liking can be affected by how people consider sensory inputs of what they are tasting (Moskowitz and Krieger, 1995). This was also found to be relevant for tastings of emerging food. One of the reviewed studies concluded that it is not always possible to establish how sensory characteristics impact the way participants experience and evaluate their liking of the food they tasted (Tan et al., 2017). Future research may be designed in a way that can provide a better understanding of how sensory characteristics of emerging food influence the way participants like or dislike the food. Moreover, tastings can also be designed in a way that enables insight into how the evaluation of sensory characteristics may indicate which product types may be most suitable for emerging food.

Emotional factors

Emotional factors are important to consider in tastings of emerging food because emotion can affect eating behavior and vice versa (Desmet and Schifferstein, 2008). “Fear” is commonly associated with emerging food (Verbeke, 2015). In previous tastings, participants feared emerging food (insect-based burgers in this case) more when they were asked to rate how they expected to experience it as opposed to blind or informed conditions (Schouteten et al., 2016). These findings are in line with other research that suggests that emotions are predominantly driven by sensory experiences rather than information provided to participants (Gutjar et al., 2015; Ng et al., 2013). However, participants might be willing to taste samples that contain emerging food despite feeling negative about the ingredient, but their willingness to eat it again strongly depends on their evaluation of its appropriateness to eat (Tan et al., 2016).

Emotional aspects are thus important to consider when aiming to introduce emerging food. This is because satisfying sensory characteristics can convey positive emotions attributed to a product and so outweigh the expected negative emotions individuals may face prior to having tasted them (Schouteten et al., 2016).

Terminology can be a challenge when gathering data about emotions in the context of a tasting because the discriminative ability of emotional attributes differ depending on how samples are presented or the conditions under which they are evaluated (Schouteten et al., 2016). Since emerging food will be presented and evaluated in different ways in future user-product interactions, it is important to assume that sensory characteristics are important in each condition which can lead to diverse emotional perceptions (Ng et al., 2013).

In terms of measures and analysis of future tastings of emerging food, it is recommended to avoid compromised hedonic evaluations of sensory characteristics by asking participants to evaluate sensory characteristics first and only then identify emotional attributes (King et al., 2013). Schouteten et al. (2016), however, showed that further research needs to be conducted to understand the extent to which hedonically evaluating sensory characteristics can impact emotional reflections. This might be important to consider when designing the order of tasks that participants are asked to complete during tastings.

Willingness to engage with emerging food

Changing consumption patterns from conventional food products to food products and ingredients that can contribute to social, economic and environmental sustainability is an important part of achieving sustainable development (Abrahamse, 2020). This is highlighted in, for example, the Paris Climate Accord or the United Nations Sustainable Development Goals zero hunger, good health and well-being, responsible consumption and production, and climate action. An individual’s decision to taste emerging food despite little or no prior experience likely depends more on how neophobic or interested they are rather than what they expect from sensory characteristics (Martins and Pliner, 2005; Tan et al., 2015; Tan et al., 2016). This is why it may be constructive to assess how willing participants are to try emerging food, and why they would like to taste these types of food. To provide data of the perceptions of those that are unwilling to try emerging foods, it may also be constructive to give those who do not wish to taste the option to fill out questionnaires or express their thoughts in short interviews.

It may also be constructive to ask participants what factors, in addition to their experience during the tasting of the food, affect their intention to engage with emerging food. This is because individuals base their choice of food products not only on their liking of taste but also on other motives (Steptoe et al., 1995). While negative experiences associated with tasting new food can become barriers to intended consumption, extrinsic aspects like environmental impact, costs or health can interfere with intended consumption (Grunert and van Trijp, 2014; Tan et al., 2015). Perceived risks, trust, attitude, convenience and culture can also impact engagement with emerging food (Hoek, 2010; Siegrist, 2008). In terms of convenience, one reviewed study assessed whether participants would eat what they had just tasted if it was on the market (Ribeiro et al., 2019). Because the availability of new food products can be different in cities as opposed to the countryside, it is important to consider the relevance of such data in the context of rural areas.

A qualitative approach might be useful in assessing willingness to engage with emerging food. Tan et al. (2017) used qualitative elements and found that participants were significantly more willing to purchase emerging food for trial consumption than for regular consumption. Their use of qualitative elements also showed that participants were highly willing to taste emerging food (insect-based in this case) because they felt curious about it and because they expressed interest in sustainable development (Tan et al., 2017).

When designing tastings, it may also be constructive to consider that multiple exposure to food are required for individuals to develop preferences (Birch, 1999). While it is certainly insightful to ask participants to engage in reflections about how they perceive emerging food and whether they intend to consume it, it would also be constructive to repeatedly expose participants to emerging food to assess how their perception and intentions develop (Tan et al., 2017). Moreover, coupling tastings with purchasing and consumption will provide additional information to self-assessed data.

Perceived meaning is a critical behavioral trigger in the context of sustainability (Erlandsson and Persson, 2020). Since the development of emerging food is a sustainable way to feed the global population, asking participants to reflect over perceived meaning in choosing such food would seem highly constructive. Whether participants perceive meaning in engagement with emerging food has not yet been studied. This new dimension could be integrated in future studies. This can be done, for example, by encouraging participants who take part in tastings of emerging food to reflect over how they perceive the consequences of their engagement with this food. Moreover, participants could be asked questions that assess how they perceive glocal consequences of their food-related choices on other people and the environment near them (i.e., locally) as well as elsewhere in the world (i.e., globally).

Because dietary practices, such as eating or cooking, are embedded in individual and cultural dietary habits (Rozin, 2006), it can be difficult for individuals to adapt to new routines and substitute familiar

food with emerging ones. Using tastings as a way of gathering data that address factors related to food behavior on the individual, product or environment level, seems to be appropriate when addressing barriers to the engagement with emerging food (Meiselman, 2003).

The impact of having tasted emerging foods on perceived engagement also needs to be considered. For example, studies found that participants who tasted insect-based emerging food were ready to include this in their diet (Caparros Megido et al., 2014) even in specific forms (Caparros Megido et al., 2016). Another study that did not conduct a tasting (Verbeke, 2015) found that participants saw no potential for emerging food. Future studies may be able to provide data that enables a better understanding of the impact of having tasted emerging food on how participants perceive their engagement with it.

Notable information missing in the reviewed articles

The current review aimed to identify aspects that can affect tasting studies of emerging food. On several occasions, however, the reviewed literature did not provide information that could have let to the identification of further affecting aspects. While all the reviewed articles were of quantitative nature, four articles also utilized qualitative elements (Appendix A). Of these, only two provided information about how the qualitative data were analyzed. One study mentioned the use of a content analysis technique for detailed analysis of qualitative data to identify findings, while another provided a more detailed qualitative data content analysis strategy. Due to this missing information, it is not possible to review methodological considerations for qualitative elements in tastings on emerging food. However, general aspects for qualitative research that apply to all tastings regardless of the type of food are valid.

Only very few reviewed studies mentioned missing data. For example, questionnaires were dismissed when answers were inappropriate or when questionnaires were not filled out in a way that provided data for analysis. Aspects such as missing data, discontinued participation, unanswered questions in questionnaires, drop-outs during the tasting or difficulties to find participants in the first place can be of importance and should be considered during data analysis. Such aspects can pose limitations to results and their implications. Weaknesses, such as participants discontinuing a tasting or not filling out questionnaires, occur for several reasons. It could be, for example, that the tasting was designed in a way that did not accommodate participants, or that questions were difficult to understand. It is constructive to assess reasons for such occurrences so that the design of future tastings can be improved.

Only one of the reviewed articles appended the questionnaire used. Providing insight in the questionnaires used and how questions were phrased or presented can contribute to methodological transparency. Access to the questionnaires would also have contributed to a more in-depth analysis of the reviewed articles as part of this study.

Conclusions

The results of this review show that there is no standard procedure to design, conduct and analyze tasting studies of emerging food. Instead, previous studies have tailored their tasting studies to their aims and objectives. Because the methodological design of tastings on emerging food will depend on aspects such as venue, country, culture, context, samples, panel, socio-demographic diversity, etc., it is not possible to establish a single standard that applies to all tasting studies.

General aspects regarding the panel type and size, socio-demographics, venue, contextual factors, and ethical reviews affect tasting studies on emerging food. The influence that meat consumption and meat alternatives can have on ratings of sensory characteristics should also be considered when designing tasting studies. Perceptions of the appropriateness to eat emerging food can be affected when a combination of an ingredient and its preparation are evaluated instead of a familiar product that contains emerging ingredients. Culturally embedded desires in the context of food also need to be considered.

Ethical implications associated with information, terminology as well as the effect of providing information must be considered given the barrier that distrust can pose to consumption of emerging food. Further research is needed to establish easily understandable and attractive terminology that avoids linguistic misunderstandings.

Prior knowledge of, and familiarity with, emerging food can influence evaluations. However, asking participants to rate how familiar they are with the food they are tasting to predict how regularly they consume this food may not be conclusive. In terms of taste and liking, the impact of sensory characteristics on participants experiences and evaluations needs to be addressed in future research. This may also provide insight into how evaluations of sensory characteristics may indicate the most suitable product types for emerging food.

The presentation and evaluation of food samples can affect emotional conceptualizations. Compromised hedonic evaluations of sensory characteristics can be methodologically addressed but further research is needed to assess the extent to which hedonically evaluating sensory characteristics can impact emotional reflections.

Tastings that gather data that address factors relating to food behavior can be constructive. This can be done, for example, by addressing barriers to engagement with emerging food, and giving participants who do not wish to taste emerging food the option to express their thoughts. Qualitative or mixed methods approaches can reveal new aspects that affect acceptance of emerging food and can be used to assess perceived meaning in choosing food that is expected to be sustainable. This is important since meaning is a highly influential behavioral trigger in the context of what people expect to be sustainable choices. Participants who taste food that is specifically developed to answer calls for sustainable food security should be encouraged to reflect over how they perceive the consequences of their engagement with this food.

Funding

This work was supported by the Swedish Agency for Economic and Regional Growth through a European Regional Development Fund with grant number 20,201,656.

Data availability

Not applicable.

Conflicts of Interest

There are no conflicts of interest to declare.

Acknowledgments

Not applicable.

Appendix A

Table A
Descriptive information about the reviewed articles and tastings.

Reference	Type of product	Aim	Objectives and analysis strategies	Type of panel & panel characteristics*	Information about the tasting	Attributes and sensory characteristics**	Scales***	Analysis****	Software
(Abd El Baky et al., 2015)	Algae (ingredient in biscuits)	Establish the bioactive and nutritive compounds present in *Spirulina platensis* biomass and demonstrate health benefits to consumers	Analysis of data (one way); testing significance differences in two replications for sensory evaluation	Non-trained (20 participants; no information about age or gender provided)	Water to neutralize palate, screens/booths, served in random order, coded samples, information provision, ethical approval	Color, aroma, texture, odor/smell, flavor, appreciation	Hedonic	Analysis of variance (ANOVA), Duncan's multiple range test	IBM® SPSS®, version 11.0 (USA)
(Batista et al., 2017)	Algae (ingredient in cookies)	Study microalgae addition to enhance functional properties of this baked food matrix, especially at high biomass incorporation levels. It was intended to use significantly higher concentrations than the ones found in commercial algal products (typically below 1% w/w), in order to provide higher levels of bioactive compounds, while not compromising sensorial acceptability and digestibility	One-way analysis and post-hoc comparisons	Non-trained (41 participants; 78% female, 22% male, 18–60 years)	–	Color, texture, odor/smell, taste, appreciation	Hedonic	ANOVA with Scheffé test	StatSoft Statistica, version 8.0 (USA)
(Bolanho et al., 2014)	Algae (ingredient in cookies)	Investigate the addition of S. platensis biomass to cookies formulat- ed with flours of cassava, soybean and peach palm by-products, in order to evaluate their antioxidant potential, nutritional enrichment and their techno- logical, microbiological and sensorial properties	Variance analysis and analysis of principal components	Non-trained (30 participants; no information about age or gender provided)	Ethical approval	Appearance, aroma, texture, flavor, prefer- ence/liking/impression	Hedonic	ANOVA with Tukey's HSD test	StatSoft Statistica, version 7.0 (USA)
(Bruhn et al., 2019)	algae	analyze the effect of lactic acid bacteria fermentation on the taste, smell, visual appearance, and content of protein and specific minerals and metals of sugar kelp (saccharina latissima)	Confirming normal distribution and equality of variance of data regarding sensory properties, and two-sided analysis of variance	Semi-trained (13 participants; no information about age or gender provided)	Size of sample pieces, served one at a time, served in random order, coded samples	Appearance, texture, odor/smell, taste	Centimeter lines	*t*-tests, ISO 13,299:2016	JMP, version 12.1.0. (USA)
(Caparros Megido et al., 2014)	Insects	The sociocultural and basic food formulation aspects related to edible insects were investigated on Belgian consumers to determine the potential of insects to replace and/or complement our traditional protein sources	Compare the global liking of the participants for each insect preparation using one-way analysis considering the presentation order of insect preparation a random factor; analysis of hedonic tests using 5 (age classes) × 2 (gender) × 8 (insect preparations) × 8 (presentation order); analysis between age classes and gender	- (189 participants; children to retiree)	Water and neural food to neutralize palate, screens/booths, size of sample pieces, served in random order, coded samples, information provision	Acceptance	Centimeter lines	Analysis of variance (ANOVA), Chi square test	Minitab®, version 16.0 (USA)
(Chen et al., 2015)	Fungal-fermented biomass (koji as an ingredient in soy sauces)	Investigate the detailed differences in physicochemical and sensory properties between soy sauces prepared using *A. oryzae koji* (SSAO) and mixed-strain *koji* (SSAOM, *A. oryzae* mouldstarter:*M. purpureus* mouldstarter = 1:2, w/w)	Analysis of variance and significant differences among means	Trained and non-trained (7 participants; 57% female, 43% male, 20–43 years)	–	Odor/smell, taste, bitterness	Numeric	Analysis of variance (ANOVA)	IBM® SPSS®, version 16.0 (USA)

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(Delicato et al., 2020)	Insects (ingredient in bakery products)	Investigate the potential of bakery products containing black soldier fly larvae fat as an ingredient	Assess overall liking and WTP data, considering sample as a fixed source of variation and consumers as a random source of variation; Assess RATA data, considering sample as a fixed source and consumer as a random effect; post-hoc comparison of means; examine if there were significant differences regarding consumers' preferences of the blends; examine if the intensities of the bad aftertaste differed significantly with the good aftertaste for the same product; Emotional/sensory attributes separately to graphical visualize the emotional/sensory space of each bakery product; balance the elicitation rate and average rating scores of emotions/attributes; qualitative open-ended questions in the questionnaire regarding willingness to pay (WTP) (no reference price was included)	Non-trained (344 participants; 57% female, 63% male, mean age 25 years)	Water to neutralize palate, size of sample pieces, coded samples, identified samples, consent, ethical approval	Appearance, aroma, texture, flavor, aftertaste	Rate-all-that-applies (RATA), hedonic	ANOVA with Tukey's HSD test, Chi square test, paired *t*-tests, Principal Component Analysis (PCA) using Dravniek's scores, no details about qualitative data analysis strategy	IBM® SPSS®, version 25 (USA)
(Elzerman et al., 2011)	Fungal-fermented biomass (ingredient in meat analogues: filet-like pieces and mincemeat)	Obtain insight into the influence of meal context on the acceptance of meat substitutes	Applied when the assumption of sphericity was not met; post hoc tests to differentiate between samples; analysis of variance procedures	Non-trained (93 participants; 77% female, 33% male, 18–66 years, average age 35)	–	Acceptance, preference/liking/impression	Centimeter lines	Greenhouse–Geisser correction, Sidak correction	IBM® SPSS®, version 14.0 (USA)
(Fradique et al., 2010)	Algae (ingredient in pasta)	Prepare fresh spaghetti enriched with different amounts of *Chlorella vulgaris* and *Spirulina maxima* biomass and to compare the properties of the dough and the cooking quality parameters (optimum cooking time, swelling index, water absorption, cooking losses) as well as pasta color, texture and sensorial characteristics, with standard *durum* wheat semolina spaghetti	–	Non-trained (43 participants; no information about age or gender provided)	Size of sample pieces, served in random order	Color, texture, odor/smell, flavor	Discontinuous structured	ANOVA with Scheffé test	StatSoft Statistica, version 6.0 (USA)
(Fradique et al., 2013)	Algae (ingredient in pasta)	Prepare fresh spaghetti enriched with different amounts of Dv and Ig as natural source of ω3 PUFA, and to compare their fatty acid profile before and after the cooking process, in order to conclude about their stability to the thermal process; evaluate the effect of this incorporation on the sensorial attributes of the pasta and on the proximate composition and cooking quality parameters	Analysis and post-hoc comparisons	Non-trained (41 participants; 80% female, 20% male, 19–48 years)	Size of sample pieces, served in random order	Color, texture, odor/smell, flavor	Centimeter lines	ANOVA with Scheffé test	StatSoft Statistica, version 6.0 (USA)
(Hellwig et al., 2020)	Fungal-fermented food (burger patty)	Assess whether age or gender are associated with (i) preferences across different food sources, and (ii) the perceptions of fungi-based products from bread residuals; investigate preferences from a sustainability and economic point of view	Analysis for association in combination with cross-tabulation to assess whether or not gender or age were associated with preference profiles; Investigate association of age or gender across the first and second part of the questionnaire; assess the findings of the taste experience of the sample and the participants' preferences as a group	Non-trained (72 participants; 50% female, 50% male, mean age 30–40 years)	Water to neutralize palate, size of sample pieces, information provision, consent	Appearance, texture, odor/smell, taste, bitterness	Hedonic, multiple choice	Chi square test, Overall preference profiles	Minitab® (USA)

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(Hentati et al., 2019)	Algae (ingredient in fish burgers)	Produce new eatable fish burgers prepared from minced flesh of common barbel and fortified with algae (*Cystoseira compressa* and *Jania adhaerens*), which are rich in bioactive compounds (pigments and polysaccharides); and assess the beneficial effects of algae on the sensorial, textural, physicochemical, microbiological, functional, and antioxidant properties of these fish products	Compare the results with statistically significant differences in triplicates	Non-trained (32 participants; 69% female, 31% male, 20–45 years)	Water to neutralize palate, size of sample pieces, served in random order, coded samples	Color, aroma, texture, odor/smell, taste	Hedonic	ANNOVA with Duncan's multiple comparison tests	IBM® SPSS, version 19 (USA)
(Kim et al., 2016)	Fungal-fermented biomass (koji as an ingredient in fish sauce)	Investigate the effects of the use of rice koji inoculated with *A. luchuensis* on the fermentation and quality of fish sauce produced from sailfin sandfish	One-way to assess statistical relevance, and identify significant difference between means	Non-trained (10 participants; 50% female, 50% male, 20–30 years)	Water to neutralize palate	Color, taste, acceptability	Hedonic	ANNOVA with Duncan's multiple comparison tests	IBM® SPSS® (USA)
(Kim et al., 2018)	Fungal-fermented biomass (ingredient in doenjang)	Identify the sensory characteristics that drive consumer preferences of commercially mass-produced *doenjang* in Korea, via a descriptive sensory analysis and consumer acceptance testing	Determine differences among samples with regard to each sensory attribute, and means separation; on the mean values of each attribute from descriptive sensory analysis to summarize the sensory profiles of the samples; determine how samples with different sensory characteristics were placed on the sensory preference map	Trained, semi-trained and non-trained (155 participants; 100% female, 25–59 years)	Neutral food and 5-minute breaks to neutralize palate, size of sample pieces, coded samples	Appearance, mouthfeel, odor/smell, flavor, taste, aftertaste	Hedonic, centimeter lines	ANOVA with Student Newman-Keuls multiple range test, Principal Component Analysis (PCA), Cluster analysis and external preference mapping	XLStat, version 2016 (France)
(Laras et al., 2018)	Fungal-fermented biomass (ingredient in chips)	Determine the chemical properties and sensory tests of simulated chips with the addition of rice bran tempe flour	One-way to determine the statistical significance of the results, and to determine the differences between the mean values	Non-trained (75 participants; no information about age or gender provided)	–	Color, aroma, texture, taste, aftertaste, acceptability	Hedonic	ANNOVA with Duncan's multiple comparison tests	IBM® SPSS®, version 16.0 (USA)
(Lensvelt and Steen-bekkers, 2014)	Insects (as is and as an ingredient in biscuits)	Explore respondents' attitudes toward eating insects—both consumed whole, as well as unrecognizably incorporated into another product—in the hopes of answering the research question, *Which factors are most effective to positively influence the consumer acceptance of entomophagy among Dutch and Australian consumers?*	Assess goodness of fit	Non-trained (133 participants; 63% female, 37% male, children to retiree, mean age 41–50 years)	Identified samples, information provision	Taste	Likert	Analysis of variance (ANOVA), Chi square test, Wilcoxon signed rank test, Kruskal-Wallis test, Mann-Whitney U test, Spearman's Rank Order Correlation, Cramér's V test	IBM® SPSS, version 19 (USA)
(Lucas et al., 2018)	Algae (as an ingredient in snacks)	Develop snacks enriched with *Spirulina* sp. LEB 18 and thus improve their nutritional characteristics	Determine differences among means	- (100 participants; no information about age or gender provided)	Water to neutralize palate, served in random order, coded samples, information provision, ethical approval	Color, texture, flavor, taste, acceptability	Hedonic	ANOVA with Tukey's HSD test	–

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(Lücke et al., 2019)	Fungal-fermented biomass (as an ingredient in breads and spreads)	Contribute to the efforts of replacing animal or soy proteins in human nutrition by exploring the prospects and limitations into enriching food products with rapeseed protein through addition of fermented rapeseed presscake	Detect deviations from random distributions	Semi-trained and non-trained (220 (64% female, 36% male, 45% <30 years)	Water and neutral food to neutralize palate, coded samples, information provision	Appearance, texture, odor/smell, aftertaste, bitterness, acceptability	Hedonic, centimeter lines	χ^2 tests	FIZZ™ (France)
(McIlveen et al., 1999)	Fungal-fermented biomass (ingredient in meat analogues: filet-like pieces and mincemeat)	Assess the current situation regarding the availability and positioning of replacement products; determine how fungal-fermented products perform in "free-standing" products	Comparing samples for selected attributes, and considered individually in terms of overall quality. Each sample was evaluated for general consumer acceptability. Paired preference format to compare samples	- (12 participants; no information about age or gender provided)	Coded samples	Appearance, aroma, texture, flavor	Graphic line	–	IBM® SPSS®, version 6.1.3 (USA)
(Caparros Megido et al., 2016)	Insects (as an ingredient in meat analogues: burgers)	Test the level of sensory-liking of mealworms-based burger patties allowing us to hide insects and to present them in a familiar way	First order interaction (2 (gender) × 4 (preparation) × 2 (question 1) × 2 (question 4) × 2 (question 7)) analysis of variance to highlight factors potentially influencing (knowledge or previous experience) the hedonic evaluation of samples or a factor that was potentially influenced by the tasting session (perception); characterize influence on the hedonic evaluations; assess effect size to measure the magnitude of the differences found between genders	Non-trained (79 participants; 56% female, 44% male, 18–25 years, Belgian, 88% of Caucasian origin, 12% identified as African, Asian, and Latin American)	Water and neutral food to neutralize palate, screens/booths, size of sample pieces, served in random order, coded samples, information provision, consent, ethical approval	Appearance, odor/smell, taste, preference/liking/impression	Check-all-that-applies (CATA), hedonic, yes/no	Analysis of variance (ANOVA), Kruskal-Wallis test, Cohen's d index	Minitab®, version 16.0 (USA)
(Nemoto et al., 2020)	Fungal-fermented biomass (koji as an ingredient in kamaboko)	producing fermented *kamaboko* in *koji* with different grains and examine the differences in the products after up to 8 weeks of fermentation at 20 °C	Calculate significant differences	Semi-trained (31 participants; 65% female, 35% male, 20–24 years)	–	Aroma, texture, taste, aftertaste, acceptability	Numeric	Analysis of variance (ANOVA)	–
(Neville et al., 2017)	Fungal-fermented biomass (ingredient in meat analogues: sausages and burgers)	Two meat products (pork sausages and beef burgers, two meal formats familiar to UK meat consumers) with partial meat substitution were tested against commercial meat and meat-free products in order to determine consumer acceptance in relation to the two categories	Identify significant differences between samples for each of the terms included in the CATA questionnaire, generate a biplot representing the samples and the relationship between samples and the terms from CATA; one-factor analysis of overall acceptability scores and post-hoc analysis of the difference categories to identify significant groups in acceptability between samples; Identify consumer groups with different preference patterns; determining the frequency of use of each sensory attribute of CATA by counting the number of participants that used each term to describe samples; on responses to determine the drop in overall acceptability associated with deviation from the ideal for each of the sensory attributes in CATA; investigate the relationship between responses to CATA questions and the consumer groups identified in cluster analysis	Non-trained (106 participants; 55% female, 45% male,18–60 years	Diluted lime cordial, water and 5-minute breaks to neutralize palate, screens/booths, size of sample pieces, served one sample at a time in random order, coded samples, ethical approval	Appearance, texture, mouthfeel, flavor, taste, aftertaste	Check-all-that-applies (CATA), hedonic	Chocran *Q*, Correspondence analysis (CA), ANOVA with Tukey's HSD test, Agglomerative Hierarchical Cluster (AHC), Manual count, Penalty analysis, Multiple factor analysis	XLStat–Pro (France)

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(Parniakov et al., 2018)	Algae (as an ingredient in chicken rotti)	Investigate the effect of the partial replacement of animal proteins by plant and algae-based proteins on physicochemical composition and amino acid profile of chicken rotti	Analysis of protein source and panelists as factors; reduce the number of variables and gain a better understanding of the data used in auto-scaled data	Trained (16 participants; 56% female, 44% male)	Water and neutral food to neutralize palate, screens/booths, coded samples	Acceptability	Numeric	Friedman two-way ANOVA, Principal Component Analysis (PCA), Two-dimensional factor plane	Statsoft Statistica version 7 (USA)
(Peinado et al., 2014)	algae	characterize five different brown edible seaweeds locally produced on the west coast of scotland (isle of bute), uk, in terms of chemical composition as well as sensory and volatile analyses; this information might be useful to evaluate their use as food ingredients and their potential contribution to the diet	Estimate the differences in composition; differentiate the varieties of samples based on chemical composition and volatile compound profile; Estimate the differences in composition of samples	Non-trained (21 participants; 43% female, 57 male)	Water and neutral food to neutralize palate	Odor/smell, taste, bitterness	Numeric	Analysis of variance (ANOVA), Principal Component Analysis (PCA), Friedman test	IBM® SPSS® (USA)
(Prabhasankar et al., 2009)	Algae (as an ingredient in pasta)	Identify a food-based application for edible Japanese seaweed in order to make it popular amongst non-seaweed eaters; and scientifically evaluate and demonstrate a functional product in advance of its potential (possible) commercial exploitation	Examination of significant differences between food and ingredient; mean separation in case of significance	Semi-trained (15 participants; no information about age or gender provided)	–	Appearance, texture, mouthfeel	Numeric	Analysis of variance (ANOVA), Duncan's multiple range test	StatSoft Statistica (USA)
(Ribeiro et al., 2019)	Insects (as an ingredient in cereal bars)	Assess the nutritional value and evaluate the sensory properties and consumer's acceptance of cereal and dry fruit bars incorporating whole ground or defatted crickets	Identify discriminating attributes among samples on CATA results; obtain a representation of the samples and descriptors; evaluating overall liking and willingness to eat (FACT scale); identify significant correlations between samples and attributes	Non-trained (70 participants; 66% female, 34% male, 20–56 years))	Screens/booths	Appearance, texture, odor/smell, flavor, aftertaste	Check-all-that-applies (CATA), Food Action Rating Scale (FACT), hedonic	Chocran *Q*, Correspondence analysis (CA), Wilcoxon signed rank test, Multi-dimensional Alignment (MDA)	XLStat (USA)
(Rodríguez De Marco et al., 2018)	algae (as an ingredient in pasta)	characterize dry pasta elaborated with *nannochloropsis* sp. and to determine the amount of microalgae biomass that could be incorporated in dry pasta to improve its nutritional quality through the addition of omega-3 lc-pufas and phenolic compounds, without affecting both the quality and the acceptability of the final product	Identify significant differences between samples for each attribute evaluated by CATA questions; obtain a bidimensional representation of the samples and descriptors	Non-trained (71 participants; 61% female, 39% male, 22–60 years)	Water to neutralize palate, size of sample pieces, served in random order, coded samples	Appearance, color, texture, odor/smell, flavor, taste, acceptability, acceptance	Check-all-that-applies (CATA), hedonic	Chocran *Q*, Correspondence analysis (CA)	XLStat, version 2014.6.2 (France)
(Sahni et al., 2019)	Algae (as an ingredient in cookies)	Evaluate microalgae meal as an alternative food ingredient in cookies by studying the effect of replacement of refined wheat flour with microalgae meal on the pasting properties of the flour blends and physical, chemical, sensory and textural characteristics of the developed cookies	Determine statistical significance	Semi-trained (10 participants; 50% female, 50% male, 22–52 years)	Water to neutralize palate, coded samples	Appearance, texture, flavor, taste, acceptability	Hedonic	ANOVA with Tukey's HSD test	IBM® SPSS®, version 22.0 (USA)

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(Schouteten et al., 2016)	Insects (as an ingredient in meat analogues: burgers)	Investigate and compare the acceptance of a food product containing edible insects as an alternative to meat- and plant-based products, by young adults	A comparison of data for the terms associated with the samples under a condition (emotional and sensory data were treated as CATA by only using the frequency of selection); repeated measures performed to blind, expected and informed liking, perceived quality and perceived nutritiousness scores to determine whether samples were evaluated as different from each other; examine how expectations on the information influenced the informed liking scores by investigating differences between expected and blind (E–B), informed and blind (I–B) and informed and expected (I–E) conditions; performed on the informed liking scores for samples, between participant groups who participated in the blind test and those who did not; pairwise comparison between samples for each CATA term during a specific condition, and emotional associations with a product under different conditions; compare the use of sensory CATA terms for each sample between evaluation conditions	Non-trained (53 participants; 36% female, 64% male, mean age 27)	Size of sample pieces, served in random order, coded samples, information provision	Color, aroma, texture, flavor, taste, aftertaste, prefer-ence/liking/impression	Emo-sensory wheel, Rate-all-that-applies (RATA), hedonic	Chocran *Q*, Analysis of variance (ANOVA), paired *t*-tests, *t*-tests, McNemar-test	IBM® SPSS®, version 22 (USA)
(Singh et al., 2015)	Algae (as an ingredient in biscuits)	Develop high fiber and high protein biscuits and optimization of process by standardizing the levels of spirulina powder, sorghum flour, and guar gum; determine their effects on various parameters such as sensory (color intensity, flavor, sweetness, graininess and crispiness), textural (hardness and fracturability) and functional (antioxidant activity) attributes that influences the eating quality of biscuits	Optimization of high fiber and high protein samples for textural, antioxidant and sensory properties; study the relationship between the responses and 3 factors (ingredients) and fit the model by multiple regression and analyze the response surfaces. Response surfaces were drawn by plotting y as a function of two variables by keeping the third variable constant. The regression analysis of the responses was conducted by fitting linear and quadratic models as suitable in the case of the respective responses	Semi-trained (10 participants; no information about age or gender provided)	–	Color, texture, flavor, taste	Numeric	Central composite rotatable design (CCRD) based on response surface methodology (RSM), Second-order polynomial model	Design Expert®, version 8.0.4 (USA)

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(Skrzypczyk et al., 2019)	Algae	Determine if a selection of endemic temperate Australasian sea- weeds compare favourably (both nutritionally and in palat- ability) with commercially available edible seaweed species	Determine which samples significantly differed from each other in terms of overall satisfaction; determine the differences in scores of the attributes identified by SIMPER amongst samples using one-factor; assess differences in the degree to which participants liked the suite of general attributes of each sample and whether these were influenced by the overall satisfaction with samples; visualization of untransformed attribute scores for samples and like category based on Euclidean distances; tests for homogeneity of dispersions within species groups using with distance to centroids; assess the contribution of individual attributes to the separation of specific species compared to commercially available species used for each sample	Non-trained (40 participants; 50% female, 50% male, 18–70 years, mixed cultural backgrounds)	Water to neutralize palate, screens/booths, served in random order, coded samples	Appearance, color, texture, odor/smell, flavor, taste	Hedonic	ANOVA with Tukey's HSD test, Multivariate analyses, PERMDISP, Non-metric multidimensional scaling (NMDS), Similarity percentages (SIMPER)	SYSTAT version 13.1, PRIMER 6 version 6.1.1 and PERMANOVA+ version 1.0.5
(Sogari, 2015)	Insects	investigate the main reasons behind the rejection of edible insects of food in Western countries in order to stimulate the consumption of edible insects in the future	Open ended questions in the questionnaire asking participants which insects they ate and the reason why they did not eat them; which insect they preferred; sensory characteristics they tasted (flavor and texture); and opinions about how they estimate their family and friends would perceive the introduction of eating edible insects into their diet	- (46 participants; no information about age or gender provided)	–	Taste, preference/liking/impression	Likert	Content analysis technique	–
(Stephan et al., 2018)	Fungal-fermented biomass (ingredient in meat analogue: sausages)	Determine the texture, color, and sensory qualities of the basidiomycetous mycelia together with various vegetable proteins in a vegan boiled sausage system	One-way with pairwise post-hoc test analysis where the independent variable was the protein source and the comparison variables were the different proteins with the control and each sample, respectively; determining standard deviations and variance	Semi-trained and non-trained (345 participants; no information about age or gender provided)	–	Color, texture, mouthfeel, odor/smell, flavor, taste	Hedonic	ANOVA with Tukey's HSD test, Grubbs outlier tests	–
(Stévant et al., 2018)	Algae	Characterize and compare the quality of S. latissima stabilized by different drying methods, i.e., convective air-drying (referred to as air- drying) at different temperatures compared to freeze-drying	Detect significant differences among treatment groups regarding individual quality parameters, using one-way R function aov; and post-hoc comparisons of significance using R function Tukey HSD; detect differences in color characteristics on correlation matrix, in which variables of different scales are standardized using (R function prcomp); testing for homogeneity of variances	Trained and semi-trained (8 participants; 31–60 years)	–	Aroma, texture, odor/smell, flavor, taste, bitterness	Continuous non-structured	ANOVA with Tukey's HSD test, Principal Component Analysis (PCA), Levene's test	R version 3.4.1 (Austria)

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(Tan et al., 2017)	Insects (as an ingredient in meatballs and in sweet dairy milk)	gain a better understanding of how an appropriate product could influence the acceptance of a novel food like insects	Analysis of CATA to test for significant differences between frequency data for each sensory attribute across samples; analysis of ingredient and product type effects on sensory-liking of samples; and purchase frequency and product type effects on willingness to purchase food; analysis with independent samples for differences between responses of willing and unwilling tasters; analysis of changes in sensory-liking and willingness to buy upon tasting; analyze relations between measures; assess the predictive effects of the product type, food appropriateness of ingredient, and sensory-liking on the willingness to buy products once and regularly; visualize how products are relatively positioned, and to explore differences between the sensory perceptions of willing and unwilling tasters; Participants were asked to write down their reason for not regularly consuming the food in question	Non-trained (135 participants; 80% female, 20% male, 18–65 years)	Water and neutral food to neutralize palate, screens/booths, size of sample pieces, served one at a time in random order, identified samples, consent, ethical approval	Texture, flavor, aftertaste	Check-all-that-applies (CATA), hedonic	Chocran *Q*, Analysis of variance (ANOVA), paired *t*-tests, *t*-tests, Pearson's product moment correlations, Bonferroni corrections, Hierarchical linear regressions, Correspondence analysis; Qualitative data content analysis including categorized coding according to sensory-, product-, individual- and context-related findings, further sub-divisions of categories into codes, and tabulating of frequencies	–
(S. S. Wang et al., 2019)	Fungal-fermented biomass (fermented soybean paste)	Investigate the relationship between the quality and key chemical characteristics of red salty rice miso	Determine significant differences between samples; Conducted on the correlation matrices between chemical and sensory data using mean values	Trained and non-trained (9 participants; 22% female, 78% male)	–	Appearance, aroma, texture, taste, acceptability	100-point classification test	Student's *t*-test, Principal component analysis (PCA) with principal component regression (PCR)	IBM® SPSS®, version 22 (USA)
(Wronkowska et al., 2015)	Fungal-fermented product	Obtain the chemical and sensory characteristics of products after the fermentation of the raw and roasted buckwheat by *R. oligosporus*	Testing effects of two parameters: kind of product (P) and fermentation process (F) or their interactions (P × F); Post-hoc comparison	Non-trained (50 participants; 52% female, 48% male, 22–24 years)	–	Appearance, color, odor/smell, taste, aftertaste, acceptability	Hedonic	Analysis of variance (ANOVA), Fisher's Least Significant Difference Test	StatSoft Statistica, version 7.1 (USA)

*Only the number of participants in a tasting but does not consider the number of participants in other parts, such as surveys.

**Texture includes the characteristics 'firm', 'chewy/crispy', 'grainy', 'smooth/spongy', and 'strand quality; odor/smell includes the characteristics 'ethanolic', 'flowery', 'burnt', 'fruity' and 'caramel-like'; flavor includes the characteristics 'nutty' and 'strange or off-flavor'; taste includes the characteristics 'sour', 'umami', 'salty', 'sweet' and 'astringency'.

*** nine studies used 5-point hedonic scales, one study used 6-point hedonic scales, and sixteen studies used 9-point hedonic scales; 5-point and 7-point Likert scales were used in one study each; four studies used 0–10 numeric scales and two studies used 0–9 numeric scales.

****The chosen significance level was 0.05 in all reviewed studies that disclosed this information.

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