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Eating full circle: Exploring consumers' sympathy for circularity in entomophagy acceptance

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ABSTRACT

Insect production is recently linked to circular economy' principles. The idea of circularity as a possible asset in consumer acceptance and adoption of eating insects, however, is understudied as yet. This paper is the first exploratory study of consumers' sympathy for circularity as a distinctive feature of insects as food and feed to their acceptance of eating insects (i.e., entomophagy). Being an innovative study, much attention is devoted to the elaboration of the questionnaire used. This study finds that consumer sympathy for entomophagy of the participants (N = 1055) in this study increases modestly, albeit statistically significant and in a robust way, as a result of providing information about environmental, circular benefits of entomophagy. It further demonstrates that sustainability-conscious consumers are not specifically sensitive to consuming insects, relative to those for whom sustainability plays a less important part in their lives. Another finding of this study is that information on circular benefits of insects as food does not just override feelings of disgust evoked by entomophagy. Finally, this study corroborates that processed insect-based foods in which insects are invisible are more acceptable than the consumption of whole insects.

1. Introduction

In recent times, the notion of circular economy and the idea of circularity as key to sustainable development have gained considerable traction and increasing interest by scholars as well as policymakers, politicians and industrial practitioners (European Commission, 2020; Geissdoerfer et al., 2020). In both production and consumption systems of a circular economy the life cycle of products is extended – by reducing material use, by redesigning products and processes to be less resource intensive, by recapturing 'used' resources to manufacture 'new' materials and products, by opting for durable products, etcetera. In practice circularity basically implies firstly that production and consumption activities move away from 'take-make-consume-throw away' patterns, and secondly that waste is reduced to a minimum. In other words, although definitions and interpretations of the circular economy and circularity vary significantly (Kirchherr et al., 2017), they have minimising resource exploitation and maximising waste prevention in common (Velenturf & Purnell, 2021). In the wake of circularity's importance and general characteristics, the academic field of insects as food for humans and feed for animals has started to position itself closer to circular discourses. As a token of this, several current studies in this research domain refer explicitly to circular merits and environmental sustainability gains of rearing insects (Ardoin & Prinyawiwatkul, 2021; Delgado et al., 2022; Derler et al., 2021; Guiné et al., 2021; Halonen et al., 2022; Kröger et al., 2022; Moruzzo et al., 2021b; Rumpold & Langen, 2020; Van Huis et al., 2021; for further uncertainties and complexities concerning sustainability assessment of producing insect-based foods, see Grabowski et al., 2022). With respect to sustainable benefits, it is emphasised that insect farming requires less water and land compared to livestock farming, and its greenhouse gas and ammonia emissions are much lower. More specifically with respect to circularity insects are being heralded as highly efficient in converting organic by-products and waste streams into high-quality animal-based protein. Particularly for this salient characteristic insects could be associated with much potential for contributing to the development of circular food supply chains (Lavelli, 2021) and circular business models (Madau et al., 2020).

While the connection between insect *production* and circular economy is cautiously made recently, the idea of circularity as a possible asset in *consumer* acceptance and adoption of eating insects has remained yet an under-examined topic to the best of our knowledge. In this respect the research domain of insects as human food and animal

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feed resembles studies on CE in which the role of consumption is lagging behind the scholarly attention given to the production side, and is recently catching up (see e.g., Dagevos & de Lauwere, 2021; Georgantzis Garcia et al., 2021; Gomes et al., 2022). Although the relatively low environmental impact of insects is occasionally included in studies on the human consumption of insects, i.e., entomophagy studies, as a consumer motive to try edible insects, a specific focus on circularity is currently missing (Dagevos, 2021). The present study aims to fill this knowledge gap with an exploratory analysis of consumers' sympathy for circularity as a distinctive feature of insects as food and feed to their acceptance of insect consumption. Is circularity a possible asset in entomophagy acceptance? Two additions to this study's aim and focus can be made. First, as this study is devoted to a new topic of interest as well as to the development of a survey to collect data, this suffices to term it exploratory. Although it is beyond the scope of this study to delve deeper into the nature of and discussions about exploratory analysis, we do believe that exploratory research is much more flexible than to be exclusively reserved for qualitative methods or exclude (working) hypothesis testing research from it by definition (Casula et al., 2021). Second, although the word sympathy is used and may be read here in terms of a favourable attitude, we believe sympathy is a somewhat more suitable word to use than attitude because it seems to fit better with the current state of affairs in which most people have not yet developed clear opinions and ideas about circularity in general and with respect to eating insects specifically. This 'vagueness' seems to be better represented by the word sympathy than attitude. But because this is a subtle difference, sympathy may be read synonymously with positive attitude.

To begin with, we concentrate on a few key determinants of consumer acceptability of insects as food, according to earlier research: environmental awareness, disgust and neophobia (Mancini et al., 2019b; Orsi et al., 2019; Schäufele et al., 2019).

Previous entomophagy studies have abundantly demonstrated that up to now most Western consumers are very reluctant to accept and adopt edible insects as food. Rather than being enthusiastic entomophagists, eating insects is frequently and by many considered taboo (Dagevos, 2021; Guiné et al., 2021). Unfamiliarity and lack of experience with edible insect consumption is a crucial aspect in this reluctance and rejection to the consumption of edible insects. More rational, information-based factors such as ignorance about eating insects and unawareness of possible environmental benefits of insects as food hinder the acceptance of entomophagy. We take the perspective of insects as an environmentally-friendly food option as a starting point. Findings of previous consumer studies on entomophagy acceptance have provided mixed results of perceived environmental sustainable benefits of insect-based foods as an important factor resulting in increased consumer interest in and acceptance of entomophagy (see e.g., Dagevos, 2021; Kröger et al., 2022; Naranjo-Guevara et al., 2021; Wendin & Nyberg, 2021). More positive outcomes on the relationship between environmental benefits and consumer acceptance of entomophagy are demonstrated in e.g., Halonen et al., 2022; Menozzi et al., 2017; Nyberg et al., 2020; Sogari et al., 2019a or Wendin et al., 2021. More pessimistic findings were established by e.g., Mancini et al., 2019a; Naranjo-Guevara et al., 2021; Orsi et al., 2019 or Lammers et al., 2019. Nevertheless, we suppose that consumers who are more concerned about the environment tend to have a higher interest in eating insects, given that despite the mixed findings the more prevailing outcome is that there is a positive relationship between the importance of environmental benefits to consumers and their level of acceptance for insect-based food products. Furthermore, circular merits of insect-based foods have the potential to contribute to a more sustainable society, and given that consumers associate the concept of a circular economy with terms like sustainability and environmentally-friendliness (Sijtsema et al., 2019), we expect that the more consumers find sustainability issues important, the more susceptible they are to information about insect-based foods' circular merits. Thus, we hypothesise that:

H_{1a} – The more important sustainability issues are to consumers the more likely they will opt for insect-based food products when offered.

H_{1b} – The more important sustainability issues are to consumers the more likely that they will be sensitive to entomophagy acceptance after being informed about circularity aspects of insect-based food products.

Another key factor influencing consumer acceptance to insects as food is of a more emotional origin. Disgust appeared to be an important affect-based response to eating insects that has been much-corroborated in entomophagy studies in the past few decades. For Westerners edible insects often evoke strong reactions of disgust. This emotional resistance is a consistently found barrier to the uptake of entomophagy in Western food cultures (e.g., Ardoin & Prinyawiwatkul, 2021; Florença et al., 2022; Hartmann & Siegrist, 2016, 2017; Mandolesi et al., 2022; Ruby & Rozin, 2019; Russell & Knott, 2021; Sogari et al., 2023; Wassmann et al., 2021). Disgust acts as a barrier for eating insects, because insects deviate from what most consumers have internalised to be 'normal food' (i.e., internalised norm; Koch et al., 2021). Consequently, the more consumers associate eating insects with disgust, the more information about circular aspects of insect-based foods might struggle to boost consumer acceptance.

Feelings of disgust are close to fear of novel foods. This food neophobia has also been proved a significant factor in Western consumers' hesitation or avoidance to eating insects, next to disgust (e.g., Ardoin & Prinyawiwatkul, 2021; Kröger et al., 2022; La Barbera et al., 2018; 2020; Lammers et al., 2019; Lombardi et al., 2019; Sogari et al., 2019c; Verbeke, 2015; Wilkinson et al., 2018). Thus, disgust and neophobia are key factors in consumer aversion to eating insects (de Carvalho et al., 2020; Florença et al., 2022; La Barbera et al., 2020; Mancini et al., 2022; Ribeiro et al., 2022; Rumpold & Langen, 2020; Sogari et al., 2022, 2023; Videbæk & Grunert, 2020; Wendin & Nyberg, 2021). This entomophagy aversion – fuelled by disgust and food neophobia – opposes entomophagy acceptance. In accordance with findings that both the disgust and the cognate food neophobia factor have a significant negative effect on consumers' receptiveness to accept and adopt edible insects into their diet, we hypothesise that both seriously hamper entomophagy acceptance:

H_{2a} – The higher consumer aversion to eat insects or insect-based products the less likely they will opt for insect-based food products when offered.

H_{2b} – The higher consumer aversion is to eat insects or insect-based products the more difficult it will be to overcome their rejection to entomophagy even after being informed about circular aspects of insect-based food products.

The paper proceeds as follows. As the present work is, to the best of our knowledge, the first consumer study exploring circular aspects in entomophagy acceptance, we make ample room in Section 2 to elaborate on the development of the questionnaire that has been used. Section 3 presents the main results. Section 4 highlights the conclusions that can be drawn from this study and outlines a few limitations, and suggestions for future research.

2. Materials and methods

2.1. Questionnaire development

While studies with a focus on circular dimensions are emerging on the production side, the potential advantage of the circular nature of insect foods from a consumer point of view has so far been hardly investigated in contemporary entomophagy research. The present work's objective is to explore whether and to what extent circularity is a motivating factor in consumer acceptance of eating insects. Given this

research goal, we developed an extensive questionnaire covering statements about both main topics featuring in the hypotheses. First, consumer perspectives on sustainable food consumption and more general sustainability consumption issues were assessed by 18 items (Subsection 2.1.1; Table 1). The second part of the survey in turn is more specific (Subsection 2.1.2). It contained statements (25 items) with a focus on insect eating to assess participants' opinions about the practice of eating insects (entomophagy) (Table 2).

2.1.1. Statements on sustainability

Both sections of the survey contained statements adopted from extant literature. With respect to assessing the importance of sustainability to participants, first of all eight items from Haan et al. (2018) were selected which represent generic statements about sustainable consumption. Three statements (#3, #4, and #7) are about extending the lifespan and durability of consumer goods which refer to the circularity principle of maintaining/ prolonging product life. Two statements (#5 and #8) refer to the food domain and this forms a natural link to subsequent statements on food consumption.

In addition, we selected an item originated from Verbeke (2015) (#9) and we adopted two items from Rovai et al. (2021) (#10-#11) that explicitly refer to the environmental impact of food choices. This combines naturally with adopting the three sustainability statements by Niva and Vainio (2021) emphasising meat consumption (#12-#14). Taking insects as an alternative protein source to meat and against the background of studies referring to a possible relationship between entomophagy acceptance and meat attachment (Dagevos, 2021; Mancini et al., 2022; Sogari et al., 2022; Verbeke, 2015), it is interesting to incorporate such statements into the survey. As indicated, only two statements derived from Haan et al. (2018) are food-related.

Finally, we also wanted to include items that refer to one of the major topics of circularity in the field of food, viz, food waste. In research, policymaking and in household waste management, reducing wastage of food has become an established issue during the last decade (Aschemann-Witzel et al., 2015; Sijtsema et al., 2019). As a result, we selected four items used by McCarthy et al. (2020) for measuring awareness of food waste consequences (#15-#18).

Table 1
Items used for the assessment of (importance of) sustainable (food) consumption.

Statement	Source
1. I only buy sustainable products when they are on sale	Haan et al., 2018
2. I only purchase electrical appliances with a sufficient energy label	Haan et al., 2018
3. I buy second-hand clothes	Haan et al., 2018
4. I take worn-out shoes to the shoemaker's for repair	Haan et al., 2018
5. I eat as little meat as possible	Haan et al., 2018
6. I give money to a charity that finds sustainability important	Haan et al., 2018
7. I take old things to the thrift shop	Haan et al., 2018
8. In the supermarket, I make sure to buy sustainable brands	Haan et al., 2018
9. When I buy foods, I try to consider how my use of them will affect the environment	Verbeke, 2015
10. I am concerned about the environmental impact of the foods I eat	Rovai et al., 2021
11. I mostly eat a plant-based diet	Rovai et al., 2021
12. If people in the world ate less meat, there would be enough food for everybody	Niva & Vainio, 2021
13. To slow down climate change, meat consumption should be considerably reduced	Niva & Vainio, 2021
14. Meat production is unethical	Niva & Vainio, 2021
15. Food waste is a big environmental issue	McCarthy et al., 2020
16. Food waste in an important social issue (e.g., world hunger)	McCarthy et al., 2020
17. Foods are scarce over the world and should be consumed consciously	McCarthy et al., 2020
18. Foods are gifts of nature and have to be treated as such	McCarthy et al., 2020

Table 2
Items used for assessing aversion to eating insects.

Statement	Source
1. The idea of eating insects causes me disgust/repulsion	Moruzzo et al., 2021a
2. Insect consumption is not socially acceptable	Moruzzo et al., 2021a
3. I'm afraid insect-based foods have an unpleasant taste	Moruzzo et al., 2021a
4. I'm afraid insect-based foods have an unpleasant consistency	Moruzzo et al., 2021a
5. I think insect-based foods have poor hygiene	Moruzzo et al., 2021a
6. I think that eating insects is not suitable for our diet	Moruzzo et al., 2021a
7. I would be disgusted to eat any dish with insects	La Barbera et al., 2020
8. Thinking about the flavour that a bug might have sickens me	La Barbera et al., 2020
9. If I ate a dish and then came to know that there were insects among the ingredients, I would be disgusted	La Barbera et al., 2020
10. I would avoid eating a dish with insects among the ingredients, even if it was cooked by a famous chef	La Barbera et al., 2020
11. I would be bothered by finding dishes cooked with insects on a restaurant menu	La Barbera et al., 2020
12. I'd be curious to taste a dish with insects, if cooked well	La Barbera et al., 2020
13. In special circumstances, I might try to eat a dish of insects	La Barbera et al., 2020
14. At a dinner with friends I would try new foods prepared with insect flour	La Barbera et al., 2020
15. I think it is fine to give insect-based feed to fish that are farmed for human consumption	La Barbera et al., 2020
16. Using insects as feed is a good way of producing meat.	La Barbera et al., 2020
17.I feel bad about the idea of rearing insects for human consumption	Verbeke et al., 2015
18. I feel bad about the idea of using insects as an ingredient in animal feed	Verbeke et al., 2015
19. It is unlikely that I would eat meat of animals that have been fed insects	Kane & Dermiki, 2022
20. It is unlikely that I would eat whole insects	Kane & Dermiki, 2022
21. It is unlikely that I would eat foods containing disguised insect ingredients	Kane & Dermiki, 2022
22. I am ready to eat meat from animals raised on insect feed as soon as it is available on the market	La Barbera et al., 2021
23. I am ready to try edible insect foods as soon as they are available on the market	La Barbera et al., 2021
24. I am ready to include edible insect foods in my diet on a regular basis as soon as they are available on the market	La Barbera et al., 2021

2.1.2. Items on eating insects

With respect to assessing participants' stance to insects as food and feed, we included two relevant and recently introduced instruments: the Insect phobia scale (IPS) by Moruzzo and colleagues (2021a), and the Entomophagy attitude questionnaire (EAQ) developed by La Barbera and colleagues (2020). We included all items of both IPS (#1-#6) and EAQ (#7-#16) because of previous validation, although some of the items included in these scales overlap somewhat (#1 and #7; #2 and #8). To the original items of IPS and EAQ we added two items that were inspired by Verbeke and colleagues (2015) (#17-#18) and three items inspired by Kane and Dermiki (2022) (#19-#21) respectively, as well as included three additional items from La Barbera et al. (2021) (#22–#24). In case of the modified statements based on Verbeke et al. (2015) and Kane and Dermiki (2022) we had the opportunity to opt for a negative or positive wording and we choose for a negative formulation of the statement (I feel bad…; It is unlikely…) to limit the number of statements that have to be analysed reversely (reverse-coded items are: #11-#15 and #22–#24). With respect to item #22 we note that in the original study by La Barbera and colleagues (2021) this item has been

broken down into four items referring to meat from different animals (more specifically: beef, pork, chicken, fish). Next to items #15 and #16, the inclusion of the items #22 and #18-#19 was supported by paying attention to so-called indirect entomophagy too. Eating insects indirectly refers to eating products of animals fed with insects (Higa et al., 2021; La Barbera et al., 2020; 2021), in contrast to direct entomophagy which is about eating whole and visible (item #20) or processed and unrecognisable insects (items #3-#5 by Moruzzo et al. seem to refer more to insects 'in disguise' than the items #11-#13 and #23–#24 by La Barbera et al. that remain more indefinite about how (un)processed insect foods and dishes are). Both direct and indirect entomophagy are relevant to the present work, as will be clarified further below.

The fact that direct entomophagy covers both eating unprocessed insects and the consumption of foods containing insect-based ingredients takes us directly to making a comment about the emphasis we put on the latter in the remainder. Entomophagy studies have concluded frequently that the practice of eating whole, unprocessed insects is highly unacceptable to Western food consumers until now (e.g., Florença et al., 2022; Kauppi et al., 2019; Mancini et al., 2019a; Ribeiro et al., 2022; Schösler et al., 2012; Sogari et al., 2019b). On the other hand, studies suggest that consumers are more open to accept and adopt familiar foods, like candy bars, burgers, shakes or bread and pasta, containing invisible, processed insects (e.g., Dagevos, 2021; Halonen et al., 2022; Hartmann & Siegrist, 2017; Orsi et al, 2019; Mancini et al., 2022; Naranjo-Guevara et al., 2021; Rumpold & Langen, 2020). The strategy of eating insects in processed food products has recently been coined 'entomophagy by stealth' (Dagevos, 2021), and insect-containing foods are widely believed to make a promising contribution to raise familiarity and acceptability of (direct) entomophagy, i.e., insects as food – next to feeding animals with insects (indirect entomophagy, i.e., insects as feed) (Dagevos, 2021; La Barbera et al., 2020; Mancini et al., 2022; Onwezen et al., 2019).

In line with the two modified statements based on Verbeke and colleagues (2015) about participants' feelings to insects as food and feed, we included a statement from Onwezen and colleagues (2019) that was used to measure positive and negative emotions to entomophagy to put emphasis on affective responses. In the survey itself the following statement was positioned after the IPS-items (#1-#6) and before the EAQ and additional items (#7-#24):

> 25. When I think of eating insects, I feel … happy, satisfied, proud [positive emotions] … guilty, angry, sad [negative emotions] Onwezen et al., 2019

2.1.3. *The idea of 'eating full circle'*

After the aforementioned 25 statements, survey participants were presented with a short story, created by the authors, about a fictitious fast-food restaurant owner who finds it important that the restaurant becomes more circular (see Textbox 1). The idea to include coffee grounds to grow oyster mushrooms on next to food waste stream to use as feed for insect rearing was inspired by recent consumer studies taking both plant-based and animal-based alternative proteins into account (Dagevos, 2021, p. 255; Onwezen et al., 2021, p. 5). The short story ends with the request to imagine that the participant is visiting this restaurant with a variety of insect-based food options on the menu. The term 'eating full circle', as we would like to term it, was not explicitly used in the information provided to the survey participants. The idea behind it was explained to them by the description in Textbox 1 and the illustration as depicted in Fig. 1. Finally, the key question is raised about how likely or unlikely it is that one would opt for these food choices, using a 7-point scale (1 = 'Very unlikely', 7 = 'Very likely').

2.1.4. *Insect 'fast' foods on the menu*

A total of 18 product variations were included in this study, which were all invented by the authors. Each of the 16 insect-based and 2 insect-free (3A and 5A, Table 3; Fig. 3) 'fast' foods could be ordered in the fictitious fast-food setting we developed (Table 3 shows all the food products included in the survey and Fig. 3 shows the way they were symbolised and presented to participants). Most of the insect-based products on offer represent invisible entomophagy, presenting insects "in a non-confronting form", to put it in terms of Nguyen and colleagues (2022, p. 9): ground insects are integrated into familiar ready-to-eat

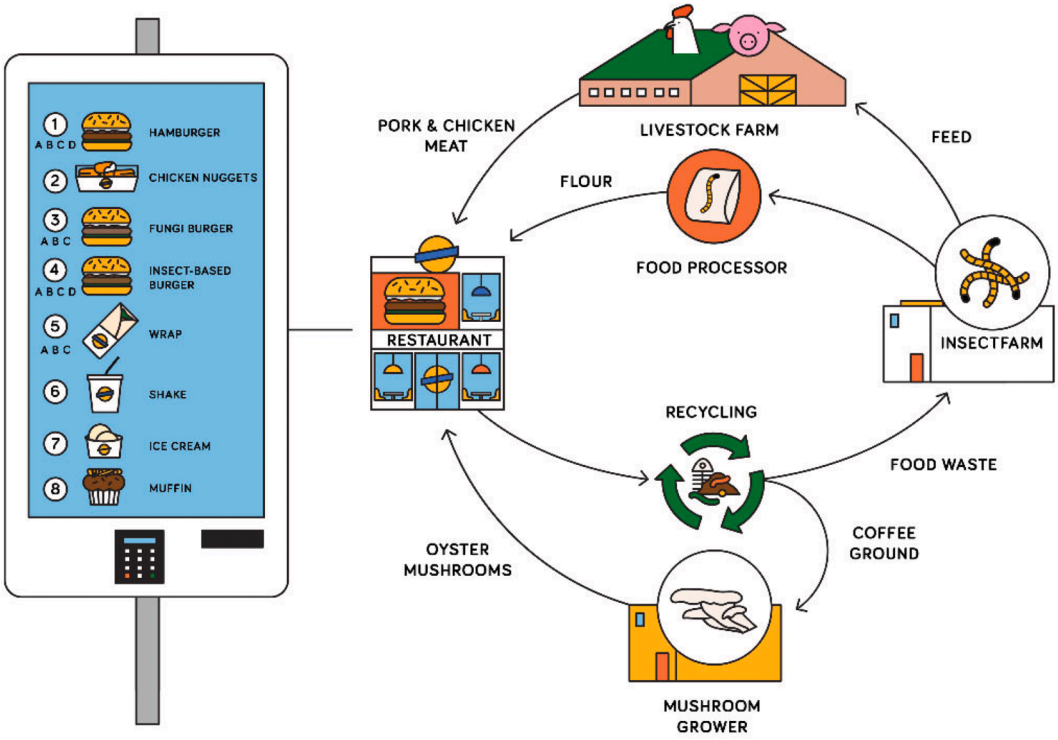

Fig. 1. Infographic.

Textbox 1
– Story line.

The owner of a fast food restaurant finds it important to operate its business in an environmentally-friendly manner. The decision is made to, from now on, bring the food waste from the kitchen and leftovers from the restaurant to an insect farm so that these can be used as feed for insects, instead of being disposed of. The coffee ground from the fast food restaurant also no longer will be disposed of as residual waste; from now on, this coffee ground goes to a mushroom grower who can use this to grow oyster mushrooms on.

The fast food restaurant becomes more circular when its waste is used for novel food production (in a circular economy resources are continually used again, which limits the amount of waste). Compared to for instance cows or pigs, insects efficiently convert leftovers into high-quality proteins and their greenhouse gas emissions are limited. Also, little space and water are needed to farm insects. Because insects can be produced in a sustainable and circular fashion, the restaurant owner has decided to supply the insect farm with raw materials.

To complete the circle both the insect farm and mushroom grower will supply raw materials to the restaurant so that various products can be made that return on the restaurant's menu. This way, the waste of the fast food restaurant is used to make products that are sold in the same restaurant. As a result, there are several options on the menu of products that contain insects.

After you have read this text and have a look at the corresponding figure (i.e., Fig. 1), please imagine that you are visiting this restaurant that has a menu containing multiple insect-based products. The following questions are about how (un)likely it is that you choose for each of these 18 products.

Table 3
'Fast' foods included in Eating full circle survey.

Description	Image
1. Hamburger (meat is from pigs fed with insects / bun is made from wheat flour)	1A
2. Hamburger (meat is from pigs fed with insects / bun contains 10 % insect flour)	1B
3. Hamburger (meat is from pigs fed with insects / bun contains 50 % insect flour)	1C
4. Hamburger (meat is from pigs fed with insects / bun is made from wheat flour/burger is garnished with mealworms)	1D
5. Chicken nuggets (meat is from chicken fed with insects)	2
6. Fungi burger (bun is made from wheat flour)	3A
7. Fungi burger (bun contains 10 % insect flour)	3B
8. Fungi burger (bun contains 50 % insect flour)	3C
9. Insect burger (bun is made from wheat flour)	4A
10. Insect burger (bun contains 10 % insect flour)	4B
11. Insect burger (bun contains 50 % insect flour)	4C
12. Insect burger (bun is made from wheat flour / burger is garnished with mealworms)	4D
13. Wrap filled with oyster mushrooms (tortilla is made from wheat flour)	5A
14. Wrap filled with oyster mushrooms (tortilla contains 10 % insect flour)	5B
15. Wrap filled with oyster mushrooms (tortilla contains 50 % insect flour)	5C
16. Shake (with insect protein powder)	6
17. Ice cream (contains fat from insects)	7
18. Muffin (with insect flour / garnished with a fried locust)	8

food products. In the special case of a fast-food restaurant the processed insect-based options consisted of burgers, wraps, and nuggets representing 'main courses' and savoury dishes, and ice cream, shake and muffin representing 'desserts' and sweets. The decision to include primarily foods with 'disguised' insects – mostly in the form of insect flour – was motivated by today's scholarly estimation that entomophagy by stealth is a more realistic strategy to enhance consumer acceptance to a larger audience than the promotion of whole and visible insects as food. The idea to concentrate on insect flour as well as insect-based protein powder was inspired by studies such as Higa et al. (2021); Kröger et al. (2022); Naranjo-Guevara et al. (2021); Ruby and Rozin (2019), and Wendin et al. (2021). The thresholds of 10 % and 50 % were chosen by the authors, and partly based on findings by Higa et al. (2021) about participants' becoming uncomfortable to eat foods containing around 25–30 % black soldier fly flour. We decided to go about 20 % lower and 20 % higher respectively.

Next to the inclusion of multiple fast foods in which insects have been processed in unidentifiable form, three products with visible insects have also been included in order to pay attention to this form of direct entomophagy too. The example of the hamburger garnished with mealworms (1D, Table 3; Fig. 3) is taken from a study by Mandolesi et al. (2022). In our modification of this example we made it a combination of direct and indirect entomophagy by adding that the hamburger is made from meat of animals fed with insects. The realism in this example lies in the fact that yellow mealworms are the first approved insect for human consumption in the European Union since June 2021. And it is realistic in this example as well as the other example of indirect entomophagy, i.e., the chicken nuggets, that the meat from animals fed with insects is from pigs or chickens. In contrast to herbivorous cows, eating insects is part of the natural behaviour of chickens and pigs, and feeding insects to chickens and insect proteins to pigs is allowed and applied in current practice. The second and third example of visible insect eating take the two forms of direct entomophagy together: an insect-based burger garnished with mealworms (4D, Table 3; Fig. 3) varies on the theme of the just mentioned meat burger with mealworms on top, and a muffin made with insect flour and a fried locust on top (8, Table 3; Fig. 3) nicely combines entomophagy by stealth and a popular way of eating insects in various parts of the non-western world. In addition, the latter product refers to the fact that later in 2021 and after mealworms also locust was authorised as an insect for human consumption in the European Union (Delgado et al., 2022; Kröger et al., 2022; Mancini et al., 2022; Sogari et al., 2022).

2.2. Study procedure and participants

A total of about 2000 participants were recruited in The Netherlands by a market research agency. Data were collected on two different moments in time (T1, T2): of the 1405 participants who completed the web-based survey at T1, 1055 participants also completed the T2 survey. The reported findings relate to the 1055 participants that completed both surveys. The average age of the 1055 participants was 49.3 years (SD = 16.4), with 48.9 % of the participants being female, and 51.1 % male. The sample was representative for the Dutch population in terms of sex, education level and income level. In terms of age, the market research agency was asked to slightly oversample the age group 18–34 years (+25 % compared to what would be representative in The Netherlands) at the expense of the age group 65 + years, given the study's focus on a fast food setting which typically have a relatively young clientele: 30 % of the participants were aged 18–34 years, 49 % were aged 35–64 years and 21 % fell in the age group 65 + years. Informed consent was obtained from all participants, and the study was approved by the Ethical Committee of Wageningen University & Research.

In the T1 survey, participants were asked to imagine that they visited

a fast food restaurant which has several insect-based products on the menu. Along with this instruction participants saw two figures, one of the restaurant and one of a self-ordering kiosk which displayed the (different types of) insect-based products that the restaurant patrons could choose from (Fig. 2, which was also shown used in T2 as part of the infographic of Fig. 1). Subsequently, participants were asked the question 'How (un)likely is it that you choose for the following products?' (1 = 'Very unlikely', 7 = 'Very likely'), a question participants had to answer for all 18 products listed in Table 3. This constituted the first measurement of participants' purchase intention of the insect-based products (T1 purchase intention). The market research agency was instructed to invite the same participants for the T2 survey, a minimum of one week after their completion of the T1 survey. In the T2 survey, participants first had to respond to the items as listed in Table 1 and Table 2 to complete the various survey scales used to assess (the importance of) sustainable (food) consumption in participants' lives and their aversion to eating insects. After completing these survey scales, participants read the story about sustainable benefits of insect foods and the idea of 'eating full circle' (Textbox 1) and the corresponding information about the circular aspects of the products as depicted in the infographic (Fig. 1). This was followed by the same purchase intention question as in T1, once again for all 18 products listed in Table 3; this constituted the second measurement of participants' purchase intention of the insect-based products, this time after having read about the products' circular aspects (T2 purchase intention). The idea of asking participants the same set of questions twice and introduce an infographic in between, was inspired by Rovai et al. (2021).

2.3. Data analysis

The researchers obtained an anonymised data set from the market research agency. First, the means of the purchase intention for the various (types of) insect-based products presented to participants, both before (T1) and after (T2) they were informed about the circular aspects of insect-based foods, were calculated. To test for statistical differences between T2 and T1 purchase intentions per type of product, paired samples t-tests were used. In addition, descriptive statistics were computed using means (M) and standard deviations (SD) for the different variables predicting purchase intention insect-based products. Associations between these variables were tested using Pearson correlation coefficients. Finally, two regression analyses were conducted, respectively to examine the extent to which the various types of importance of sustainable (food) consumption (i.e., importance of sustainable consumption, attention to the environmental impact of food choices, awareness of food waste consequences) and various types of participants' aversion to eating insects (i.e., insect phobia, emotions associated with eating insects, and disgust and interest based on the Entomophagy attitude questionnaire (EAQ-disgust, EAQ-interest)), predict (1) participants' purchase intention for the insect-based products before the circularity information of the products (T1) and (2) the change in purchase intention for the insect-based products after this circularity information, relative to beforehand (Δ T2 - T1). The first regression analysis is used to test H1A and H2A, while the second regression analysis is used to test H1B and H2B. For the regression analyses, total scores were calculated as the average of the average purchase intention scores for each of the 18 products. All statistical analyses were conducted using SPSS (Statistical Package for the Social Sciences) version 25.0 software.

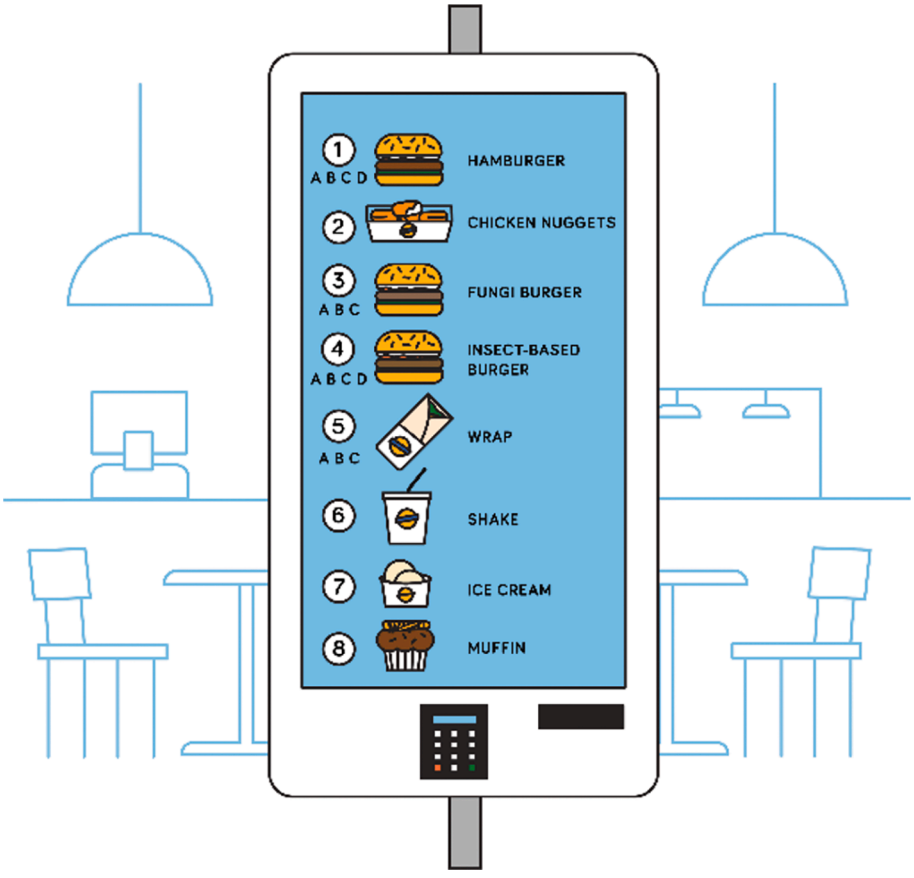

Fig. 2. Insect-based products on the menu.

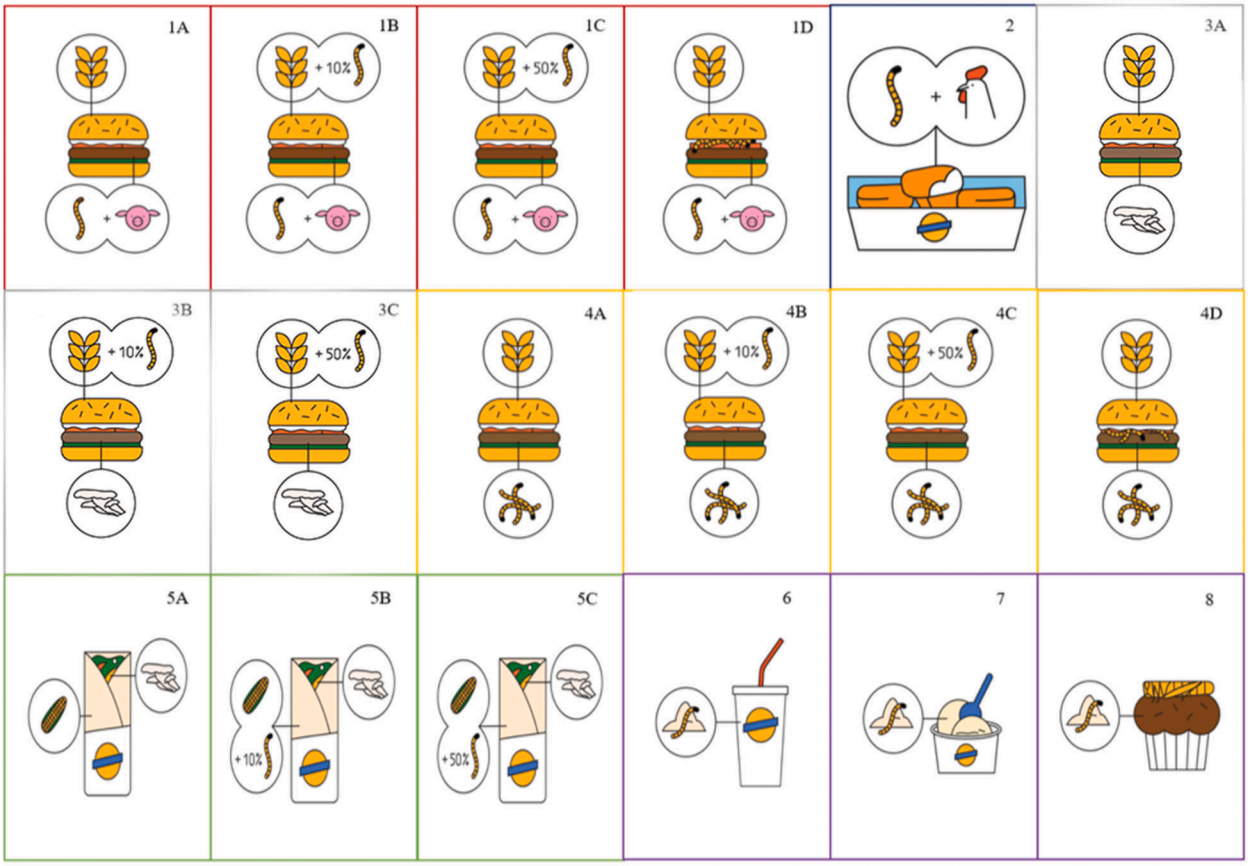

Fig. 3. Images of product choices on the menu.

3. Results

3.1. Consumer choice for insect-based fast foods

Table 4 shows the average purchase intention for the various (types of) insect-based products presented to participants, both before (T1) and after (T2) they were informed about the circular aspects of insect-based foods. Across all products the purchase intention is significantly higher after participants read the information about the products' circular aspects (T2) relative to before (T1), as indicated by the paired samples t-

Table 4
Purchase intention insect-based products on T1 and T2 (i.e., before and after being informed about circularity aspects of insect-based food).

Product	Purchase intention T1	Purchase intention T2	Difference T2 - T1	LLCI	ULCI	*t*	p-value
Hamburgers							
Wheat flour	3.92	4.48	0.56	0.45	0.67	10.36	< 0.001
10 % insect flour	3.26	3.80	0.54	0.45	0.64	11.04	< 0.001
50 % insect flour	2.97	3.55	0.58	0.48	0.67	11.93	< 0.001
Insect garnish	2.30	2.71	0.41	0.45	0.67	8.60	< 0.001
Chicken nuggets	4.54	4.90	0.36	0.26	0.47	6.87	< 0.001
Fungi burgers							
Wheat flour	4.44	4.79	0.35	0.24	0.45	6.67	< 0.001
10 % insect flour	3.36	3.68	0.32	0.23	0.41	6.94	< 0.001
50 % insect flour	3.12	3.42	0.30	0.21	0.38	6.75	< 0.001
Insect burgers							
Wheat flour	2.57	2.87	0.30	0.21	0.39	6.50	< 0.001
10 % insect flour	2.60	2.93	0.33	0.24	0.41	7.26	< 0.001
50 % insect flour	2.50	2.82	0.32	0.23	0.40	7.40	< 0.001
Insect garnish	2.13	2.30	0.17	0.10	0.25	4.68	< 0.001
Wraps							
Wheat flour	4.28	4.58	0.30	0.19	0.39	5.71	< 0.001
10 % insect flour	3.25	3.57	0.32	0.22	0.41	6.68	< 0.001
50 % insect flour	2.99	3.33	0.34	0.25	0.42	7.70	< 0.001
Desserts							
Shake	3.09	3.41	0.32	0.22	0.41	6.48	< 0.001
Ice cream	3.25	3.60	0.35	0.25	0.44	6.98	< 0.001
Muffin with insect garnish	2.14	2.30	0.16	0.09	0.24	4.33	< 0.001
All products	**3.15**	**3.50**	**0.35**				

Nb. Paired samples *t*-test between T2 and T1 purchase intentions per insect-based product; LLCI = Lower level of 95 % confidence interval; ULCI = Upper level of 95 % confidence interval.

tests (see Table 4 for all statistics). Thus, the information on circularity of the food production slightly, but significantly increased participants' intention to purchase the variety of insect-based products after participants read about the products' circular aspects. Furthermore, inspection of the 95 % confidence intervals (CIs) indicates that the purchase intention increase is greatest for the product category hamburgers, relative to the other product categories (fungi burgers, insect burgers, chicken nuggets, wraps, desserts). This is indicated by the lack of overlap in CIs between hamburgers relative to the other types of products, following the procedure of Julious (2004) and Cumming (2009) which indicates that the overlap between 95 % CIs should be less than a half the length of one arm, to state that the predictive ability between factors is significantly different. Following this same procedure, Table 4 also shows that the circularity information had relatively little impact on products with (visible) insect garnish, compared to the other (types of) insect-based products, as the increase in purchase intention was relatively low for products with (visible) insect garnish.

3.2. Descriptive statistics and correlations

Table 5 shows the means, standard deviations and zero-order correlations among all variables included in the models. The construct with the highest mean score was found to be in awareness of food waste consequences ($M = 5.32$). This score, which is well above the midpoint of the scale (which is a score of 4), suggests that participants are well aware of the consequences of food waste. The other statements on sustainability (i.e., importance of sustainable consumption, attention to the environmental impact of food choices) received average scores just below the midpoint of the scale. The mean scores on insect phobia and disgust and interest based on the Entomophagy attitude questionnaire (EAQ-disgust, EAQ-interest) were also around the midpoint of the scale. The mean scores on emotions associated with eating insects were relatively low, for positive as well as negative emotions.

When looking at the correlations, Table 5 shows that purchase intention for the insect-based products at T1 is moderately to strongly correlated with all study variables. However, when looking at change in purchase intention for the insect-based products after circularity information (Δ T2 - T1), we see that the three variables related to various types of importance of sustainable (food) consumption (i.e., importance of sustainable consumption, attention to the environmental impact of food choices, awareness of food waste consequences) are no longer correlated with purchase intention. Also for the other variables the strength of the correlation is levelling off. Finally, an interesting finding is that the change in purchase intention (Δ T2 - T1) is negatively correlated with purchase intention at T1, implying that a positive change is more likely for those with lower scores on purchase intention at T1.

3.3. Regression analyses

Table 6 shows the results of the regression analysis in which participants' purchase intention for the insect-based products before the circularity information of the products (T1) was regressed on the different explanatory variables.

Combined, the predictors explained 55.0 % of the variance (Adjusted R_2) in participants' intention to purchase insect-based products on T1 (Table 6). No relation was found between on the one hand participants' perceived importance of sustainable consumption ($\beta = < 0.01$, $t(1046) = 0.06$, $p = .955$, 95 % CI [-0.08, 0.08]) and the level of attention

Table 6
Summary of multiple regression analysis for variables predicting purchase intention insect-based products on T1 (before circularity information provision).

	Purchase intention insect-based products T1 (before information about circular aspects of products)					
	β	*t*	*Sig.*	*95 %CI for β*	*Cohen f2*	*VIF*
Importance sustainable consumption	< 0.01	0.06	0.955	[-0.08; 0.08]	0.000	1.92
Attention environmental impact of food choices	0.05	1.59	0.113	[-0.01; 0.11]	0.001	2.14
Awareness food waste consequences	0.06	2.42	0.016	[0.01; 0.13]	0.003	1.48
Insect phobia	-0.20	−5.02	<0.001	[-0.25; -0.11]	0.011	3.58
Positive emotions	0.12	4.46	<0.001	[0.07; 0.19]	0.009	1.76
Negative emotions	< 0.01	-0.14	0.892	[-0.05; 0.04]	0.000	1.30
EAQ – disgust	-0.04	-0.87	0.387	[-0.09; 0.04]	0.000	4.86
EAQ – interest	0.45	11.95	<0.001	[0.39; 0.55]	0.065	3.37
Sex	-0.07	−3.08	0.002	[-0.34; -0.08]	0.004	1.28
Age	0.01	0.37	0.709	[-0.00;0.01]	0.000	1.27

Notes. Adj.$R^2 = 0.550$, $F = 129.66$ ($p < .001$).

Table 5
Descriptive statistics and inter-correlations among study variables.

	*M**	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Purchase intention T1	3.14	1.40	–											
Δ Purchase intention (T2 – T1)	0.35	0.89	-0.21**	–										
Importance sustainable consumption	3.71	1.02	0.21**	0.01	–									
1. Attention environmental impact of food choices	3.60	1.46	0.21**	-0.001	0.64**	–								
2. Awareness food waste consequences	5.32	1.21	0.13**	-0.01	0.48**	0.53**	–							
Insect phobia	4.37	1.53	-0.64**	-0.11**	-0.25**	-0.30**	-0.09**	–						
Positive emotions	2.17	1.34	0.51**	0.08*	0.31**	0.28**	0.14**	-0.54**	–					
Negative emotions	2.26	1.43	-0.18**	-0.09**	0.12**	0.12**	0.07*	0.19**	0.11**	–				
EAQ – disgust	3.74	1.98	-0.65**	-0.20**	-0.22**	-0.25**	-0.09**	0.83**	-0.52**	0.29**	–			
EAQ – interest	4.15	1.38	0.70**	0.23**	0.14**	0.09**	0.03	-0.71**	0.52**	-0.32**	-0.81**	–		
Sex	1.49	0.50	-0.09**	0.09**	0.20**	0.18**	0.10**	0.02	-0.04	0.02	-0.002	-0.05	–	
Age	49.66	16.64	-0.08**	-0.01	0.01	-0.10**	0.04	0.13**	-0.04	0.05	0.15**	-0.14**	-0.41**	–

Notes. M = mean, SD = standard deviation; * $p < .05$; ** $p < .01$.

participants pay to the environmental impact of their food choices (β = 0.05, t(1046) = 1.59, p =.113, 95 % CI [-0.01, 0.11]), and on the other hand participants' purchase intention of the insect-based products on T1, though this was hypothesised (H_{1A}). The only type of sustainability factor that predicted purchase intention on T1 was survey participants' level of awareness of food waste consequences: the higher this level of awareness regarding the consequences of food waste, the higher participants' purchase intention of insect-based products on T1 (β = 0.06, t(1046) = 2.42, p =.016, 95 % CI [0.01, 0.13]), in line with H_{1A}. Overall, these findings indicate that a greater perceived importance of sustainable (food) consumption in participants' lives does not necessarily equate to a higher purchase intention for insect-based products. Furthermore, as was hypothesised in H_{2A}, the weaker participants' level of insect phobia is, the higher their purchase intention for insect-based products on T1: β = -0.20, t(1046) = -5.02, p <.001, 95 % CI [-0.25, -0.11]. Similarly, the more participants associate eating insects with the experience of positive emotions, the higher their purchase intention for insect-based products on T1: β = 0.12, t(1046) = 4.46, p <.001, 95 % CI [0.07, 0.19]. Additionally, the findings indicate that the more interest participants have in insect consumption (i.e., a higher score on EAQ-interest), the higher their purchase intention on T1: β = 0.45, t(1046) = 11.95, p <.001, 95 % CI [0.39, 0.55]. However, the extent to which participants associated eating insects with specifically disgust (EAQ-disgust; β = -0.04, t(1046) = -0.87, p =.387, 95 % CI [-0.09, 0.04]) or with more generic negative emotions (β = < 0.01, t(1046) = -0.14, p =.892, 95 % CI [-0.05, 0.04]) both were not significantly associated with participants' purchase intention. Thus, we found partial support for H_{2A}. Finally, we found that sex (dummy coded) has a significant effect, implying that men tend to have a higher purchase intention on T1: β = -0.07, t(1046) = -3.08, p =.002, 95 % CI [-0.34, -0.08].

Table 7 shows the results of the regression analysis with the change in purchase intention for the insect-based products after this circularity information, relative to beforehand (Δ T2 - T1) as outcome variable.

Combined, the predictors explained 7.6 % of the variance (Adjusted R^2) in participants' change in intention to purchase insect-based products after versus before being informed about the circularity aspects of the insect-based foods (Table 7). For the outcome variable, the difference score was computed between the purchase intention on T2 and the purchase intention on T1 (thus, a positive difference score implies that the purchase intention was higher after having read the circularity information (T2), compared to before (T1)). No significant relation was found between the included indicators of perceived importance of sustainability issues (importance sustainable consumption, attention to environmental impact food choices, awareness of food waste consequences) and the degree of change in participants' purchase intention across insect-based products (see Table 6 for all statistics). Thus, a greater importance of sustainable (food) consumption in participants' lives is not translated into a higher purchase intention for insect-based products after having read information about the products' circular aspects, though this was expected (H_{1B}). This suggests that the circularity information of the insect-based products is not more likely to provide a boost to participants' purchase intention of the products, when sustainability plays a more important part in participants' lives. Furthermore, the lower participants' level of disgust is regarding insect consumption (i.e., lower scores on EAQ-disgust; β = -0.18, t(1046) = -2.75, p <.001, 95 % CI [-0.14, -0.02]), the higher participants' purchase intention on T2 relative to T1, in line with H_{2B}. The regression analysis also revealed an unexpected finding with regard to the role of consumer aversion to eat insects, as participants with a higher level of insect phobia had a higher purchase intention on T2 relative to T1 (β = 0.19, t(1046) = 3.33, p <.001, 95 % CI [0.05, 0.17]), in the opposite direction as was hypothesised (H_{2B}). More generic positive and negative emotions that participants associate with eating insects were not significantly related to the degree of change in purchase intention after having read about the circular aspects of the insect-based products. In sum, only very limited support for H_{2B} was found: the extent to which consumers are averse to eating insects was of limited influence on the extent to which their purchase intention for the insect-based products changed after being informed about circular aspects of these products. Furthermore, the findings indicate that the more interest consumers have in insect consumption (i.e. higher score on EAQ-interest), the greater consumers' increase in purchase intention after having read about the circularity aspects of the insect-based products: β = 0.27, t(1046) = 4.92, p <.001, 95 % CI [0.10, 0.24]. Finally, we also saw effects for sex and age. With respect to the first, women show a greater consumers' increase in purchase intention after having read about the circularity aspects of the insect-based products: β = 0.14, t(1046) = 4.05, p <.001, 95 % CI [0.13, 0.36]). With respect to the latter, participants with a higher age had a higher purchase intention on T2 relative to T1: β = 0.09, t(1046) = 2.58, p <.001, 95 % CI [0.001, 0.01]).

Table 7
Summary of multiple regression analysis for variables predicting change in purchase intention insect-based products (after versus before circularity information provision).

	Δ Purchase intention insect-based products (T2 – T1)					
	β	*t*	*Sig.*	*95 %CI for β*	*Cohen f2*	*VIF*
Importance sustainable consumption	-0.04	-0.92	0.356	[-0.10; 0.04]	0.001	1.92
Attention environmental impact of food choices	0.01	0.22	0.829	[-0.05; 0.06]	0.000	2.14
Awareness food waste consequences	-0.01	-0.39	0.698	[-0.06; 0.04]	0.000	1.48
Insect phobia	0.19	3.33	<0.001	[0.05; 0.17]	0.010	3.58
Positive emotions	-0.03	-0.87	0.385	[-0.07; 0.03]	0.001	1.76
Negative emotions	0.02	0.46	0.648	[-0.03; 0.05]	0.000	1.30
EAQ – disgust	-0.18	−2.75	0.006	[-0.14; -0.02]	0.007	4.86
EAQ – interest	0.27	4.92	<0.001	[0.10; 0.24]	0.022	3.37
Sex	0.14	4.05	<0.001	[0.13; 0.36]	0.015	1.28
Age	0.09	0.258	0.010	[0.001; 0.01]	0.006	1.27

Notes. Adj.R^2 = 0.076, F = 9.69 (p <.001).

4. Discussion and conclusions

It has been often observed in behavioural research that environmental concerns can be important motives but frequently not sufficient to change consumer choices significantly, because other factors can override such environmental concerns and act as a barrier towards (more) environmentally-friendly (food) consumption. Likewise, providing information is frequently proposed to increase consumers' willingness to behavioural change in a desired direction, but this also seldom prove to be sufficient. This study partially corroborated such findings. Providing information about environmental, circular benefits of entomophagy led to statistically significant increases in participants' intentions to opt for insect-based (fast) food products, though in absolute terms in most instances the increase was relatively modest. On the positive side, the information about the circular aspects of the insect-based foods did lead to an increased purchase intention for all insect-based products (even the ones with visible insect garnish, though the increase was lowest among these type of products). This suggests that even though providing information about environmental, circular benefits of entomophagy only modestly boosts purchase intention, it does so in a quite robust fashion across insect foods.

This result gives reason to continue to follow up on the suggestion made in various entomophagy studies about the potential and positive impact of information about beneficial environmental aspects of eating insects on enhancing consumer acceptance and adoption of insect consumption. At the same time is the modest effect of providing information consistent with the mixed results obtained in entomophagy studies so far, as indicated in the Introduction. In addition, it is good to emphasise that we did not use a control group at T2 that was asked to respond once again to the same purchase intention question as in T1 for all 18 products (Table 3) without presenting the items on (the importance of) sustainable (food) consumption (Table 1) and on reluctance to eating insects (Table 2), and without presenting the story (Textbox 1) and the infographic (Fig. 1). In principle, then, the differences between T1 and T2 in intentions to purchase insect-based foods could also have been influenced by familiarity and salience due to participation in T1. Although it is important to point at this limitation of the present study, it seems realistic to anticipate that this influence is probably negligible because the relevant insect-based products are not yet available and could, for instance, not be tasted after T1 and before T2. Another reason to believe that the information provided at T2 makes the difference in consumer intentions at T2 in comparison to T1 stems from the fact that information about circular aspects of insects as food and feed, and insect production and consumption as parts of a sustainable circular economy may be expected to be relatively new and unknown information to many people at this time.

The latter is somewhat reflected in the results too, as consumers who were more aware of environmental issues and more receptive to sustainable (food) demonstrated no special increase in sensitivity to consuming insects after being informed about circular merits of insect foods, relative to those for whom sustainability plays a less important part in their lives. This finding offers little support to the assumption that the frontrunners of entomophagist enthusiasts will be people concerned about environmental sustainability and/or have a flexitarian diet. However, one of the limitations of the current research was that it did not focus on consumer segmentation or early adopters like other studies in the entomophagy domain (e.g. Brunner & Nuttavuthisit, 2020; Ribeiro et al., 2022; Rovai et al., 2021; Verneau et al., 2020). Despite the fact that substantial work has been done on sociodemographic and personality factors related to consumer acceptance of eating insects (see Kröger et al., 2022 for an overview), future research on entomophilic and entomophobic consumers based on sociodemographic and/or psychographic segmentation variables remains warranted. Furthermore, another reason we did not find that consumers who view themselves as more 'green' are more susceptible to circular merits of insect-based foods is that we included a relatively large amount of factors in our predictive model. In terms of predictive ability, this also provided more opportunity for other factors to override sustainability factors, most notably the affect-based factors, such as disgust. This was also seen in research of Lammers et al. (2019) who found that consumers' level of sustainability consciousness did not override disgust feelings in predicting consumers' willingness to eat insects. Our work extends these findings of Lammers et al. (2019), as it showed that more sustainability conscious participants are not necessarily more susceptible to circularity information of insect-based foods. Besides, our work demonstrated that affect-based factors determine to a larger extent how susceptible consumers are to such (cognitively-oriented) information, as shown in the extent to which purchase intention of insect-based foods is altered after reading circularity information. More recently, the finding of Simeone and Scarpato (2022) that consumers who are more aware of environmental problems and having a greater sensitivity to sustainable diets proved unwilling to accept the consumption of insects, is not an unexpected outcome in the light of our findings.

An unexpected outcome though concerning the role of affect-based factors was also obtained: the stronger consumers' level of insect phobia was, the more susceptible they appeared to be to circularity information (i.e. the higher their purchase intention on T2, relative to T1). Several factors could have played a role. First, as can be seen in the Variance Inflation Factors (VIFs) in Tables 6 and 7, the level of multicollinearity between insect phobia and the two elements from the Entomophagy attitude questionnaire (EAQ; La Barbera et al., 2020) was quite high, though still just under common threshold for VIFs to be considered acceptable (O'Brien, 2007). Still, the relatively high multicollinearity might have played a role in why insect phobia was surprisingly positively associated with the change in purchase intention, while disgust was positively associated with the change in purchase intention, as we expected. Second, the insect phobia scale is relatively novel, and even though the scale has been validated (Moruzzo et al., 2021a), the current study shows that the level of distinguishment from other related concepts, most notably from the EAQ, is relatively low. Future research can further examine how the insect phobia scale can best be included in studies, next to other affect-based factors concerning consumer acceptance of insect-based foods.

A finding much more consistent with previous entomophagy research is about increasing consumer readiness to eat insect (fast) foods when insect ingredients were integrated into common carrier products. The idea of entomophagy by stealth (Dagevos, 2021) as a marketing strategy to reach larger groups of consumers finds support in results obtained in this study: disguised insects were perceived as less confronting and more appealing than visible insects as part of a fast food product. Consumer intention to opt for a product garnished with whole insects was lowest and showed the smallest increases between T1 and T2. Of course, further differentiation is possible. With an occasional exception for mealworms and fried locust insects were lumped into one category in the current work. Particularly when more insects species will be allowed for human consumption in Europe, the need to explore various types of insects more specifically will undoubtedly grow. In anticipation, multiple studies already point out that consumer readiness to eat different types of insects may vary (e.g. Fischer & Steenbekkers, 2018; Russell & Knott, 2021; Videbæk & Grunert, 2020). The current work was limited in this respect.

To address other limitations of the present study, it is instructive to further investigate whether entomophagy acceptance differs between savoury or sweet insect-based foods (Rovai et al., 2021; Lombardi et al., 2019) or between food products associated with a particular mealtime or meal course (Halonen et al., 2022). In this study we included both savoury and sweet foods as well as selected main course products and desserts – in the setting of a fast food restaurant. This did not provide much evidence to conclude that consumer purchase intention differ much across the 18 food options on the menu. The main difference concerned fast foods with insects in disguise versus products with whole insects on top (<3, Table 4). Products 1A and 2 (Table 3; Fig. 3) based on indirect entomophagy as well as the two 'insectless', plant-based options (3A and 5A, Table 3; Fig. 3) had the highest purchase intention scores (>4, Table 4).

Making insect foods appealing and accepted is not only a matter of the degree of visibility, but also of the practical availability of desirable and palatable insect-based food products (Dagevos, 2021; Fischer, 2021; Kröger et al., 2022; Sogari et al., 2022). Material infrastructures and arrangements are helpful in shaping to change Western societies, like the Netherlands, that are now primarily entomophobic to become more entomophilic. Future entomophagy research should put more emphasis on enabling or impeding circumstances of the food environment with respect to consumer acceptance and adoption of eating insects - particularly when insect foods have become more available and entomophagic acceptance and adoption processes have started to mainstream a little more in the food market and food culture (Dagevos, 2021). However, as long as the situation is characterised by a lack of readily available insect foods on the market or on the menu consumers have little to no opportunity to get to know these products, to gain taste experiences, to try suitable insect foods or to (learn to) prepare these themselves at home and adjust insect foods in their daily food practices. Increased availability will facilitate acceptance and adoption of insects as food. Fischer

(2021) rightly adds to this that for insect foods to become appealing alternatives it is necessary not only to concentrate on how to overcome rejection and resistance to eat insects but also to emphasise product property benefits (e.g. taste, price, health) which are desirable from a consumer point of view. Related to this is that prior studies have pointed out that potential entomophagists may be (taste-oriented) consumers interested in a sense of adventurousness that surrounds entomophagy and attracted by eating insects out of curiosity and/or variety seeking (Ardoin & Prinyawiwatkul, 2021; Dagevos, 2021; Rovai et al., 2021). Changing finally and for a moment from such 'egocentric' motives to 'ecocentric' considerations: moral, animal welfare concerns could become an ethical barrier to consumer acceptance and adoption of insects as food or feed in upcoming years (Russell & Knott, 2021). In other words, this study with its primary focus on circular benefits examined one of the possible drivers of consumer acceptance of insects as food or food source. This first exploratory study demonstrated that circularity information generates at present only a modest increase in consumers' intention to opt for insect-based products. However, as the circular economy further evolves and circularity gains publicity and importance, it would not surprise when circular benefits of eating insects will become a much more important and convincing argument in food consumer choices.

CRediT authorship contribution statement

Hans Dagevos: Conceptualization, Methodology, Writing – original draft, Visualization. **Danny Taufik:** Conceptualization, Methodology, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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