European consumers' readiness to adopt insects as food. A review

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Abstract

Edible insects seem one of the more probable responses to the increased quantity of food proteins needed in future prospective related to the increase of human population, mainly in developing countries. Introduction of entomophagy in developed countries, especially in Europe and North America, could help this trend and drive the world food economy to reach that goal. Few articles were published on acceptability of edible insect in European countries, with a large variability of methodologies used. Furthermore, both structure and unstructured (or semi-structured) techniques were analysed and compared. Through this review article, we analysed the different methodologies conducted on European consumers and categorised the studies in relation to the type of analysis chosen, data collection and results obtained. Limitation of the research studies and future recommendations were explored leading to better investigate consumers' acceptance.

Keywords

Edible insect; entomophagy; disgust; food neophobia; acceptability; willingness to eat.

1. Introduction

Human consumption of insects could be one of the most solid answers to the increasing need of protein related to the increase of world population (van Huis et al., 2013). In fact, several benefits are related to their consumption. Indeed, insects could provide a large amount of suitable energy, such as fats and proteins, with a lower request of land and water and a better feed conversion efficiency than conventional farmed animals (Bukkens, 1997; Rumpold & Schlüter, 2013; van Huis et al., 2013). Moreover, this type of production could increase food yields at low environmental cost reducing emissions of greenhouse gases and ammonia and contribute to environmental sustainability through the conversion of bio-wastes into high protein food products (van Huis et al., 2013; Yen, 2009).

Insects are historically consumed in Asia, Africa, South-America and Central-America where they are farmed or harvested from the wild and are part of the traditional diet (van Huis et al., 2013).

Interest of insects as food is growing in Western countries in recent years (Jensen & Lieberoth, 2019; Lombardi, Vecchio, Borrello, Caracciolo, & Cembalo, 2019).

Novel food Regulation (EU) 2015/2283 (starting application 1st January 2018) introduced in the European Union the possibility to request the authority for commercialisation of products which have not been '*consumed to a significant degree within the EU before 15 May 1997*'. Furthermore, the EU legislator clarified the legal status of insects and their derived products, as reported in the recital 8 of the regulation *('… novel foods. Those categories should cover whole insects and their parts.*').

However, only a few EU countries equipped themselves with internal legislations regulating the trade of insect-based food. In particular some EU members, due to their national food agencies (Austria, Belgium, Denmark, Finland, Netherlands, and United Kingdom – before leaving EU), authorize companies to produce and sell insects as food, under the standard food safety requirements. Also, France and Germany started to partially legalize production and commercialization of edible insect. Switzerland, as non-EU country, legalized edible insects in 2017 with only some import restrictions. Also, Norway, as non-EU country, promulgated national rules (very closely to the EU regulation).

Food safety seems to be the main problem related to edible insects produced outside western countries, as consequence of less strict safety rules of original producers' laws. Facing the growing interest on insects consumption, the European Food Safety Authority (EFSA) promoted, through the Scientific Committee, an evaluation of the risk profile related to production and consumption of insects as food and feed (EFSA, 2015).

Due to the “asymmetry” of legislation only a few European based companies produce insects for human consumption (Shelomi, 2015) and the demand for the development and commercialisation of insect-based foods remains very low.

Despite the emphasis on the theme of insects as food, Western consumers and mainly European ones seem to be cautious to practice the consumption of insects (Anankware, Fening, & Obeng-Ofori, 2015; Hartmann, Shi, Giusto, & Siegrist, 2015; Verbeke, 2015).

An increasing number of studies in recent years are appearing based on the concept “the use of insects for foods”. In fact, in these studies many factors determine insect-based food acceptance (Sun-waterhouse et al., 2016). The main drivers of consumers’ choice are related to sociocultural and psychological characteristics of consumers (Hartmann et al., 2015; Meyer-Rochow, 2009; Tan et al., 2015) also thought given information about the positive effects of edible insects from sustainability and environmental perspectives (Hartmann, Ruby, Schmidt, & Siegrist, 2018; Kostecka, Konieczna, & Cunha, 2017). As well as, the choice are related to familiarity/well known product or the visual presence of insects (Barsics et al., 2017; Caparros Megido et al., 2014; Tan, Fischer, van Trijp, & Stieger, 2016; Tan, van den Berg, & Stieger, 2016; Verbeke, 2015).

Despite the recent increasing scientific studies, there are still some issues that remain to be explored. In fact, it is possible to observe that there is no homogeneity in the level of interest of scientific field on the theme of insects as food; there are several techniques used for analysing consumer behaviour; the results of the different studies are often controversial.

In this review article, we analysed the different methodologies conducted on European consumers and categorised the studies in relation to the type of analysis chosen, data collection and results obtained. Limitation of the research studies and future recommendations were explored leading to better investigate consumers' acceptance.

2. Methodology

2.1 Search procedure

The methodology of this study consists of a systematic review of the existing scientific literature on consumer behaviour to adopt insects in Europe. Specifically, we selected all studies published in peer-reviewed journals, using the main online databases such as ScienceDirect, Web of Science, JSTORE, Google Scholar (core collection) and a set of pre-defined keywords. The following search strings were used in order to maximise the return of relevant literature sources: “insect/s food” or “edible insect/s food” or “consumer insect/s food”.

The search was restricted according to the following criteria: 1) all studies published without restriction to the year of publication; 2) articles in scientific journals (short communications, abstracts, proceedings of conferences, projects documents, theses, books and reviews were not incorporated); 3) articles published in English language; 4) research studies on consumer behaviour conducted in European countries. No restrictions were set as authors' nationality.

Initially 244 scientific articles were gathered by online search. Following a read through the publication indicated that 104 articles did not correspond to the topic because they did not analyse the willingness of consumers to adopt insects or the factors capable to influence consumer acceptance. Thirty-four articles of 104 were then selected as performed on European consumers, then, during the revision of this manuscript, seven more articles were published and inserted in the review. The flowchart showed in Figure 1 summarize the study selection; inclusion and exclusion criteria are summarized in Table 1.

2.2 Database generation

We extracted the following information from these publications: 1) publication identification (authors, year and journal); 2) study characteristics (country studied, year of data collection); 3) target population; 4) type of activities conducted (discussion-test; information and pictures/products used in the study) (Table 2).

3. Overview of the scientific studies carried out in Europe

First, we explored the current readiness of consumer to accept edible insects in Europe through a general descriptive analysis of all included studies. Consumers' countries and authors' affiliations were summarised in Figure 2 as results of the forty-one articles identified and summarised using the classification scheme reported in Table 2.

Consumers of fourteen different countries (30% of Europe) were tested by their acceptability and a total of forty-six research studies were conducted. Indeed, five research studies (Hartmann et al., 2015; Lensvelt & Steenbekkers, 2014; Piha, Pohjanheimo, Lähteenmäki-Uutela, Křečková, & Otterbring, 2018; Tan et al., 2015; Verneau et al., 2016) compared behaviours of consumers located in different countries (also outside Europe such as Australia, Thailand and China).

An interest to collaborate is shown by researchers of different countries as well as a research interest to test insects acceptability in cross-countries studies.

In particular, regards the ONU European countries classification, ten studies interested consumers of Mediterranean Europe (Italy), twenty-five the Western Europe (Belgium, France, Germany and Netherland), five the North Europe (Denmark, Finland, Ireland and Sweden) and five the Eastern Europe (Czech Republic, Hungary and Poland) (Figure 2). Besides that, some countries showed a higher concentration of studies. In fact, the majority of these studies involved potential consumers coming from Netherlands (24%), Italy (22%) and Belgium (15%). The number of studies carried out in other countries is rather limited (one or two for each country), with the exception of four articles that reported data on Swiss consumers. Netherlands and Belgium were one of the first countries in Europe to include edible insects in food laws. Several farms and industries are actually located there and drove the research interests. Nowadays, insects products are sold in these two countries even if there is not a deep knowledge of consumers' response. The interest on Italian consumers could be reconducted to the strong attention and feeling on food in this country. Moreover, it is important to highlight that Italian consumers were the only ones studied in the Mediterranean Europe zone.

Authors' affiliations were located in fifteen European countries; no studies conducted entirely by research groups from outside Europe were found. A correspondence in terms of territoriality between the consumers tested and the research groups' affiliations was not always detected. As reported in Figure 2, zero studies were conducted on Spanish and British consumers even if researchers affiliated to these two countries published some articles (analysing consumers of other territories) (House, 2016; Pascucci & De-Magistris, 2013). On the contrary, German consumers were tested by researchers affiliated to other countries (Hartmann et al., 2015; Piha et al., 2018).

Looking at the timeline, the first studies were carried out on Dutch and Belgian consumers between 2012 and 2014 (Caparros Megido et al., 2014; de Boer, Schösler, & Boersema, 2013; Lensvelt & Steenbekkers, 2014; Pascucci & De-Magistris, 2013; Schösler, Boer, & Boersema, 2012; Vanhonacker, Van Loo, Gellynck, & Verbeke, 2013). In 2015, the number of articles per year increased (Hartmann et al., 2015; Sheppard & Frazer, 2015; Sogari, 2015; Tan et al., 2015; Verbeke, 2015) to reach the maximum number in 2016 (Balzan, Fasolato, Maniero, & Novelli, 2016; Caparros Megido et al., 2016; Cicatiello, De Rosa, Franco, & Lacetera, 2016; Gmuer, Nuessli Guth, Hartmann, & Siegrist, 2016; Hartmann & Siegrist, 2016; House, 2016; Laureati, Proserpio, Jucker, & Savoldelli, 2016; Schouteten et al., 2016; Tan, Fischer, et al., 2016; Tan, van den Berg, et al., 2016; Verneau et al., 2016). At the end of our online research and peer review process

(November 2018) nine articles were published in 2017 issues (Barsics et al., 2017; Bartkowicz, 2017; Gere, Székely, Kovács, Kókai, & Sipos, 2017; Kostecka et al., 2017; Le Goff & Delarue, 2017; Marberg, van Kranenburg, & Korzilius, 2017; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017a; Sogari, Menozzi, & Mora, 2017; Tan, Verbaan, & Stieger, 2017), eight more were inserted in 2018 issues (Adámek, Adámková, Mlček, Borkovcová, & Bednářová, 2018; Fischer & Steenbekkers, 2018; Hartmann et al., 2018; La Barbera, Verneau, Amato, & Grunert, 2018; Piha et al., 2018; Schlup & Brunner, 2018; Sogari, Menozzi, & Mora, 2018; Van Thielen, Vermuyten, Storms, Rumpold, & Van Campenhout, 2018) and two in 2019 issues (Jensen & Lieberoth, 2019; Lombardi et al., 2019).

4. The different techniques employed

Research studies reviewed used both structured techniques and unstructured/semi structured techniques, with several different approaches inside each type of methodology. Some authors mixed the two types of techniques in order to gain more profit by their trials (Table 2).

4.1 Structured techniques

Inside structured techniques, it is possible to find different parameters while the majority of the papers is based on online surveys. These online surveys involved a sample of participants very complex and diversified. Most of the participants are randomly recruited online (de Boer et al., 2013; Gere et al., 2017; Schösler et al., 2012; Vanhonacker et al., 2013; Verbeke, 2015).

In some cases, subjects were recruited using specific channel. Gmuer et al. (2016) used the panel provider Respondi AG, the Swiss citizen pool of which consists of approximately 20,000 members. In Hartmann et al. (2018, 2015) Internet panels from commercial providers of sampling services were used for recruiting the study participants (Germany: Respondi AG; China: InterfaceAsia Holden). In the work of Sheppard & Frazer (2015), participants were a convenience and snowball sample recruited through social media including Facebook, Twitter and Reddit.

In other cases, through the sampling method used to distribute the survey, participants were not chosen completely randomly. In the work of Lensvelt & Steenbekkers (2014), respondents were selected by using the social network of one of the researchers and an email was sent to contacts containing a link to the survey and asking to share with other people (snowball effect). Moreover, the survey was also shared on Facebook.

In Piha et al. (2018) an online survey was conducted in Finland, Sweden, Germany, and the Czech Republic. Social media were chosen to share the link (e.g., Facebook, LinkedIn) using local universities' organisational consumer databases. Furthermore, the questionnaire was distributed in cafeterias, restaurants, and other public facilities and was asked to the university students to invite other people to respond.

Postal survey was used only by Schlup & Brunner (2018) that distributed 2400 15-page long pencil-and-paper questionnaire in random households in the German and French speaking parts of Switzerland.

Not online surveys were performed on a various range of consumers (Bartkowicz, 2017; Cicatiello et al., 2016; Kostecka et al., 2017), on university students-staff alone (Laureati et al., 2016; Menozzi et al., 2017a) or mixed with people not linked with the university (Tan, van den Berg, et al., 2016; Tan et al., 2017).

Pictures or images of insects and insect-base products were also used in some cases to give an example of the food typology (Cicatiello et al., 2016; Gmuer et al., 2016; Hartmann et al., 2015; Jensen & Lieberoth, 2019; Piha et al., 2018; Schösler et al., 2012; Sheppard & Frazer, 2015; Tan, van den Berg, et al., 2016; Tan et al., 2017) and/or a description text was used (de Boer et al., 2013; Sheppard & Frazer, 2015).

Information about entomophagy or insects future prospective were provided in the majority of the articles that report an introduction section to the questionnaire (Hartmann et al., 2015), only Gere et al. (2017) stated the decision to avoid to give new information to the consumers tested.

Beside non-physical participation (online survey) also many authors invited participants to taste some products (Table 2). The tasting activity was organized in different ways, for example after an information session on entomophagy.

Information session was used as a preliminary phase to give new information to the consumers (Sogari et al., 2017) or, as in Barsics et al. (2017), was used as main research factor. Indeed, Barsics et al. (2017) tested how information session could affect tasting experience in two groups of students, from which one tasted the product before the information session and the other group did the opposite. Similarly, (Lombardi et al., 2019) tested how information could influence the perception of well-known products added with insects, such as cookies and chocolate, and as information on the benefits of insects consumption increased insect-based products willingness to pay.

Tasting experiences were made on different products, such as cooked insects (different cooking methods and flavouring; Caparros Megido et al., 2014; Jensen & Lieberoth, 2019; Sogari, 2015) or on food that contain insect-base products as ingredients (tortillas, chocolate bars or cookies, burgers/meatballs; Hartmann & Siegrist, 2016; La Barbera et al., 2018; Lombardi et al., 2019; Menozzi et al., 2017a; Schouteten et al., 2016; Sogari et al., 2017, 2018; Tan et al., 2017; Verneau et al., 2016). Two articles reported the use of faux insect-base food; Barsics et al. (2017) labelled the same bread as with insect or without insect; Tan, Fischer, et al. (2016) formulated different burgers with variable percentages of breadcrumbs, tofu and hazelnut mixed with beef and labelled them as lamb brain, frog meat and mealworms.

Effects of information and taste could be also mixed as reported by Schouteten et al. (2016). These authors tested both the influence of information (blind *vs.* informed condition) and the effect of tasting experience (expected condition *vs* informed condition) in a trial with insects as meat substitute in burger.

Laureati et al. (2016) used an informational text and different pictures of products containing insects as ingredient (whole insect and flour) to analyse through a visual hedonic quantification the participants responses.

4.2 Unstructured, semi-structured techniques

The evaluation of insects as food was performed twice both via focus group and via semi-structured interviews (Table 2). The main difference between focus group and individual interview is the possible interaction between members of a focus group that could help participants to link concepts and encourage the discussion. On the other hand, semi-structured interviews give the possibility to the interviewer to explore particular theme and deeply investigate the participant responses. Both the techniques were used by different authors with very different aims.

Focus groups were used by Balzan et al. (2016) whom interviews five groups of young Italian people without giving any information on entomophagy and showing pictures of insects and product containing insects. The principal aim of this research was to explore the psychosocial determinants associated with edible insects consumption. Differently, Tan et al. (2015) conducted focus groups across two cultures (one who eat insects, Thailand, and one who does not, Netherlands), with the aim to investigate how cultural exposure and individual experience could affect the willingness to eat insects. In order to study this effect, focus groups of each country

were composed by eaters and non-eaters and pictures of different grade of effectiveness were showed (visible, covered, invisible insects).

Semi-structured interviews were chosen as method by House (2016) and Marberg et al. (2017). House (2016) interviews thirty-three Dutch consumers of the Insecta range of insect-based convenience foods made with *Alphitobius diaperinus* larvae (Damhert Nutrition, Heusden-Zolder, Belgium).

The interview's core was structured in order to ask the reason why consumers buy that product, how do they eat it and if they enjoy them and would buy it again.

Marberg et al. (2017) interviewed nineteen people all related to edible insect field, except for two respondents. In particular, participants were experts, stakeholders (breeders), industry experts, researchers, government officials, and livestock farmers. Following the specific knowledges of these participants, the interview questions were structured to report and resolve weaknesses and threats of this sector, as well as, highlight strengths and opportunities.

Choice experiment is the most widely used stated preference multi-attribute method in valuing products or attributes. In Tan, Fischer, et al. (2016) choice experiment was mixed with tasting of burgers faux labelled as beef added with 25% of lamb brain, frog meat or mealworms. In the first part of the trial, the participants were asked about taste expectation, the appropriateness of the burger mix as well as their willingness to eat them. Pascucci & De-Magistris (2013) used choice experiment to evaluate the effect of three levels of information (no specific, neutral and positive) along with four attributes (price, visibility of the insect, logo and omega 3 concentration) on an insect-base product consumed in the Netherlands (looked similar to sushi).

Particular quantitative methods were used by Le Goff & Delarue (2017) and Verneau et al. (2016). Non-verbal evaluation of acceptance was performed by Le Goff & Delarue (2017) by recording with cameras the spontaneous reactions of two groups of people. Both the groups tested the same chips seasoned with taste of barbecue and chicken as congruent flavours, and with taste of strawberry and blackcurrant as incongruent flavours. In order to study the effect of eating an insect-base product and the effect of the congruent/incongruent flavour, samples were faux labelled as "protein-enriched" or "insect protein-enriched". The non-verbal data were then analysed and codified in duration and valence of positive and negative expressions.

Verneau et al. (2016) used the Implicit Association Test (IAT) in order to analyse respectively the response of Italian and Danish consumers to different videos. The control group watched a video about benefits of introducing tablets in school, the other two groups watched respectively one

video on societal benefits or individual benefits of introducing insect's protein into human diet. Furthermore, after the test, a chocolate bar enriched with cricket protein were given to the participants; two weeks after authors contacted participants and asked if they ate the bar and if yes how much of it they ate. Then asked again some intention items used in the first evaluation (if they will introduce insect's protein into their diet, if they will suggest that to friends and relatives and if they would buy insect-base products).

The same method was used in a following article by La Barbera et al. (2018) in which the researchers deeply studied the impact of food neophobia and disgust on the intention to eat insect-base food, and how disgust was related to implicit attitude towards insects on Italian consumers.

5. The targeted populations analysed

Based on the methodology used, researchers collected the data in several different ways. A large range of variability was highlighted in the number of consumers tested. Table 3 reports the information about consumers provided by articles that used structured techniques. Naturally, consumers' age and gender were investigated by 100% of the studies. Age was related to the typology of consumers: sometimes the research groups decided to involve only a specific type of consumers (mostly young, such as students) and sometimes the samples resulted very complex and diversified (especially in surveys).

Other different information about the consumer samples was used but not included in all the tests. A particular attention has been given to school education and to the presence of vegan or vegetarian consumers. Some studies tried also to understand if consumers had previous experiences on insects. Various studies used incentive as initial motivation in trying insect, even if authors did not declare to be founded by specific financial resources. Only two articles reported specific financial support, specific for these research field (Gere et al., 2017; Piha et al., 2018).

6. Important drivers of consumers' choice

6.1 Consumers' sociocultural and psychological

The large variability of articles' aims and methods had a strong impact on the results obtained and no general remarks could be formulated. Research purposes and key findings of the 41 analysed articles are reported in Table 4.

Few articles reported a high degree of acceptability, in particular Caparros Megido et al. (2014) and Sogari et al. (2017) showed that consumers that had a particular interest in entomology or food science (studies conducted in and insectarium and on students of Gastronomy and Food Science university course, respectively) could be considered as early adopters and easily start entomophagy. Generally, it seems that the most reliable early adopters are young men with a high educational level. (Fischer & Steenbekkers, 2018) reported that in 2014 45% of the interviewed Dutch students of Wageningen University had already tested insects and they would be willing to eat them again (68%). Country food culture and other people opinions could significantly become a barrier to start entomophagy (Hartmann et al., 2015; Sogari, 2015; Sogari et al., 2017; Tan, van den Berg, et al., 2016), and social appeal seems to enhance likelihood to take the first bite (Sheppard & Frazer, 2015).

The mixed effect of culture and social appeal it is also shown by the different responses obtained between the first studies and the most recent ones. Indeed, studies conducted in the Netherlands and Belgium between 2010 and 2011 (de Boer et al., 2013; Schösler et al., 2012; Vanhonacker et al., 2013) reported the negative response of the consumers to the possible using of insects as meat substitute. However, as both the countries few years later started to legalize edible insects and now are recognized as European leaders in this field, the perception of entomophagy changed and consumers are now more positive about the topic (Barsics et al., 2017; Caparros Megido et al., 2014; Schouteten et al., 2016; Tan, Fischer, et al., 2016; Tan et al., 2017; Verbeke, 2015). This hypothesis find a support in the recent article of (Van Thielen et al., 2018), who report the consumer acceptance of foods containing edible insects in Belgium two years after their introduction to the market. Similarly (Adámek et al., 2018) reported that also Czech consumers are willingness to eat energy and protein bras that contain cricket powder.

This advance in cultural adaptation by northern European countries generate also a lack of homogeneity in the European zone, with a lower acceptability reported in the Central, Mediterranean or Western countries. Piha et al. (2018) reported how Finnish and Swedish consumers had more positive attitude that Germans and Czechs. Lack of information and cultural readiness were also highlighted in Switzerland, Poland and Italy with a large variability of responses and miscellaneous results (Bartkowicz, 2017; Cicatiello et al., 2016; Gmuer et al., 2016; Hartmann & Siegrist, 2016; Kostecka et al., 2017; Laureati et al., 2016).

When insects were proposed as substitute on meat in burgers or patties, the response was variable in relation to the aim of the article. Generally, the most recent articles reported a positive

approach to this modification, with the condition that consumers were well informed and conscious about the advantages of insects *vs* meat production (Caparros Megido et al., 2016; Gere et al., 2017; Schouteten et al., 2016; Tan, Fischer, et al., 2016). (Hartmann et al., 2018) reported that Swiss peoples evaluate consumers that eat insects equivalent to vegetarian and thus more health-conscious, environmentally friendly, imaginative, brave, interesting, and knowledgeable than meat consumers.

Indeed, perception of other people could play a major role in consumers behaviour. As reported by (Sogari, 2015) and (Sogari et al., 2017) negative opinions of family members and friends may prevent Western consumers from eating insects. These evaluations are in agreement with (Jensen & Lieberoth, 2019) who showed how in collective tasting session, that were the social norms to influence consumers' willingness to eat insects even more than individual perception.

Studies on the effects of information and communication highlighted that they could stimulate and enhance willingness to eat (Barsics et al., 2017; Lombardi et al., 2019; Verneau et al., 2016) even more if accompanied to the opportunity of try insects (Lensvelt & Steenbekkers, 2014).

Studies on the consumers' environmental awareness highlighted that the information on the small environmental impact and the sustainability of the insects production could affect positively the acceptance of the consumer to consume this alternative product (Hartmann & Siegrist, 2018). Indeed, in a study conducted by Hartmann & Siegrist (2018) who examined how participants in Switzerland evaluated the personality of other Swiss people who consumed insect-based products, the consumers of insect and vegetarian products were described as being "environmentally friendly". The relevance assigned by the consumer to produce with respect to natural resources was supported in an article of Kostecka et al. (2017). The authors examined opinions of selected Polish consumers regarding to their acceptance of insect-based food. For this purpose they interviewed people grouped for age and gender, most of which, to the question if it is important that the food is produced in an environmentally friendly way, answered in the affirmative way.

The perception that the insects production has positive effect on the environment and consequently the most important outcome of eating products containing insect was confirmed also by the results obtained, in Italy, by Menozzi et al. (2017).

6.2 Familiarity, visibility, taste and price

In addition to comments illustrated in the above section, could be useful to understand which attributes linked to the product examined in different studies (taste, visibility, familiarity) could

help people (of Western cultures) to overcome their reluctance to eat insects. Appropriate food formulation and processes could facilitate insects acceptance; incorporating insects into popular or conventional consumer foods (Hoek et al., 2011) or creating insects food ingredients for specific dishes or processed foods (Sun-waterhouse et al., 2016) could influence consumer response.

A lot of studies analysed the consumer acceptance related to the integration of insects into well-known products (Caparros Megido et al., 2014; Hartmann et al., 2015; Tan et al., 2015, 2017; Tan & House, 2018; Tan, van den Berg, et al., 2016; Van Thielen et al., 2018).

In particular, in a study of Hartmann et al. (2015), the Germans were more willing to eat insects incorporated into familiar foods and flavour profiles (e.g., cookies). At the same time the food industry should focus on processed insect-based foods within a familiar product category or flavour profile, which would presumably reduce neophobic reactions and lead to a higher willingness to eat.

At the same time a familiar preparation (e.g meatballs, butter cookies) in combination with invisible incorporation of the insects can increase willingness to taste (Tan et al., 2015, 2017). Incorporating the insects into a familiar and liked product generally improved the willingness to try an unfamiliar species, as the familiarity with certain components and the overall visual appeal could give positive sensory expectations.

Van Thielen et al. (2018), during a research developed in Belgium, two years after the introduction into the market of edible insects and food containing insects, found that a hamburger is considered to be suitable for inclusion of insects from a consumer point of view, because the hamburger is a familiar and well-liked product.

Caparros Megido et al. (2014) underline that the overall acceptability of insects depended only on the preparation method. Firstly, insects were more perceived as an appetizer (for 37% of the consumers), probably due to their small size and original form. Then, people were found to accept insects addition to their main dish (26%) or as a dessert (23%).

The integration of insect-based foods into existing diets (e.g. foods as pasta, bolognaise sauces, cookies and potato chips) is easier (House, 2018), rather than trying to imitate existing insect-based dishes from elsewhere. Sometimes, however, combining insects with familiar carrier product is not sufficient to increase the acceptance of insects (Tan, van den Berg, et al., 2016).

Another important aspect that characterizes the consumer acceptance is related to the exploration about the level of insects visibility in the food. In this context, in which edible insects are still an unconventional food, visibility of insects inside a meal play a major role in consumers

acceptability. Some researches were conducted in order to evaluated different perception of two version of the same products, one with visible insect as ingredient and the other in which the insects were invisible (Jensen & Lieberoth, 2019; Tan et al., 2015; Tan, van den Berg, et al., 2016). All these studies concluded that meals with visible insects were rejected more than meals were the insects were still present but not visible.

A lot of these studies have found that consumers form Western cultures are more willing to consume the processed product than the whole insect (Barsics et al., 2017; Caparros Megido et al., 2016; Gmuer et al., 2016; Hartmann et al., 2015; Hartmann & Siegrist, 2016; Jensen & Lieberoth, 2019; Laureati et al., 2016; Lensvelt & Steenbekkers, 2014; Pascucci & De-Magistris, 2013; Schösler et al., 2012; Sogari et al., 2018; Tan et al., 2015, 2017; Tan, Fischer, et al., 2016; Tan, van den Berg, et al., 2016; Van Thielen et al., 2018; Verbeke, 2015; Verneau et al., 2016).

Same important results have been emerged in the studies of Caparros Megido et al. (2016, 2014), Tan, Fischer, et al. (2016), Gmuer et al. (2016) and Verneau et al. (2016) that demonstrate how incorporating ground insects invisibly within food products increase the acceptance of insect-based foods. Indeed, consumers could become more receptive to trying insects or other unusual foods if they are not perceptible from visual point of view.

These findings highlight the possibilities for a future prospective utilization of edible insects as ingredient, but the time is still young to reach high level of consumers acceptance.

Indeed, it is important to keep in mind that, the invisibility of insects in the food could improve willingness to accept insects by consumers, however their presence as ingredient in the food could be considered a contamination of the original food and become a possibility of rejection. In fact, Tan, van den Berg, et al. (2016) demonstrate that consumer acceptance is not simply achieved by the invisibility of insects in food. Tan et al. (2017) reported that “invisibility” is an aspect can could improve willingness to buy a novel food, but only if consumers are really motivated to try it. Another important aspect has been analysed by House (2018) that argue “The insect- based cuisine itself would also probably need to be singular and distinctive; it cannot just be an existing cuisine with insects invisibly added”. Regarding this, House (2016) affirms that “for those wishing to develop foods with insects as an invisible ingredient, it is important to remember that consumers who want a product with an invisible protein source need a reason to choose one with insects rather than another ingredient”.

As the same time in order to discover whether attitudes towards the insect food could be linked to the taste, a lot of studies have adopted a sensory-driven approach and included tasting sessions

(Hartmann & Siegrist, 2016; Menozzi et al., 2017a; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017b; Schouteten et al., 2016; Sogari, 2015; Sogari et al., 2018; Tan, Fischer, et al., 2016; Verneau et al., 2016).

In general attitude towards entomophagy increases after a taste activity (Lensvelt & Steenbekkers, 2014). As mentioned in Hartmann & Siegrist (2016), regardless of the type of preparation, after tasting the majority of over 25s said they would be prepared to eat of cook the insect in the future.

As regards this activity, Hartmann & Siegrist (2017) underline the importance of crating memorable experiences to help the willingness to consume insects. It is important to show insects dishes at food events (Deroy, Reade, & Spence, 2015; Sogari et al., 2017), offer insect dishes at high-end restaurants (Balzan et al., 2016; Looy, Dunkel, & Wood, 2014), provide recipes (Deroy et al., 2015; van Huis et al., 2013), offer cooking classes and featuring insects on cooking programs (Myers & Pettigrew, 2018).

Price is also included in several studies, Bartkowicz (2017) and Lombardi et al. (2019) affirmed that low price encourages consumers to consume insects. On the contrary, Pascucci & De-Magistris (2013) reported that consumers are willing to pay more for insect-base products than conventional ones, and Cicatiello et al. (2016) revealed a no significative result by using price as explanatory variable in a logistic regression.

7. Conclusions and future recommendations

Edible insects could be on European tables in a near future and be part of a world response to the request of new protein sources. As shown in this review, in the last years, researchers started to study of European consumers' behaviour about edible insects. Despite the advances in research, the potential of insects as food is still poorly understood. Of course, these are preliminary results coming from different exploratory researches but deeper investigations on this topic are necessary. Indeed, it is possible to highlight some limitations concerning the different purposes and methodologies of the studies, that make results comparison difficult: data are collected using different kind of methodologies but the majority of these are not specific for novel foods.

At the same time some studies only included limited (small number of consumers) and/or specific target groups (e.g students and younger adults) that do not represent the real potential consumers.

The tasting is introduced in a few case studies, moreover, a lot of studies concerning acceptance of food containing edible insects investigate consumers' opinion only on two of the four P's of the Marketing mix (only Price and Product, but not Place and Promotion).

Another limitation of the studies is that the surveys used the terms insects, which evokes association with visible and whole insects. Evans et al. (2015) reported that "words and concepts used to describe insects and the human practices surrounding them are still rudimentary, compared to the diversity of the organisms themselves and the existing complexity and rapid evolution of the practices they aim to describe".

Authors focus their attention to the use of word entomophagy often referred to human insect-eating practices and is directly related to the diversity of insect species, which an imprecise use of taxonomic categories can obscure. They also focused on terms insects and Insecta that in the context of food and feed would be used as precisely as possible. Indeed, the importance of name and label is highlighted by Mielby & Frøst (2010) and Wansink, van Ittersum, & Painter (2005) that asserted how the naming and descriptive labelling of novel or familiar dishes have been shown to strongly influence their appeal. At this regards Tuorila, Meiselman, Cardello, & Lesher (1998) observed that the association of novel foods to familiar foods within current diets could also improve the willingness to try them.

Despite these limitations, some useful indications may be drawn from the different studies presented in this paper. These first indications may be useful specially to plan further studies on the topic.

These studies should aim to better investigate consumers' feelings, beliefs, attitudes, and motivations to choose insect-based food; applying, for instance, specific methodologies for novel foods (House, 2018), more representative sample of potential consumers (Myers & Pettigrew, 2018), more correct terminology (Evans et al., 2015; Van Thielen et al., 2018) and sensory evaluations (Lombardi et al., 2019). Finally, In order to support the growing of entomophagy and insect industry further studies might be focus on the others two P's of the Marketing mix (Promotion and Place regarding consumption moment, purchase occasion, usage situation linked to the knowledge level of the product) and the cost-analysis research comparing blended well-known product and no blended product.

Another issue that may be developed in future research is the willingness to introduce insects in the daily diet as in most of the studies entomophagy is addressed as a novelty, and the willingness of the people to eat insects for the first time is assessed.

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Table 1. Inclusion and exclusion criteria used for article selection.

Inclusion Criteria
-Full text paper published in peer-reviewed journal in English language
-Focus on consumer willingness to adopt insects capable to influence their acceptance
- Keyword used: insect/s food; edible insect/s food; consumer insect/s food
Exclusion criteria
- Abstract, proceedings, project documents, theses, books, reviews
- Research studies conducted outside Europe

Table 2. Summarise of reviewed articles.

Authors, year	Country	Technique; year data collection	Sample; female; mean age (range); education; occupation	Discussion-Test	New information	Pictures/Products
Adámek et al., 2018	Czech Republic	Survey; 2017	N = 96; 18%; ns (predominantly 20-29); ns; ns	-questionnaire	Respondents got the information that was a sensory assessment of energy bars with the addition of cricket flour	Protein-energy bars: -Peanut butter and cinnamon with cricket flour -Dark chocolate and sesame with cricket flour -Pineapple and coconut with cricket flour -Dark chocolate and orange with cricket flour -Peanut butter, cherry and cacao (containing also cricket flour) -Cranberry, blueberry and pistachio (containing also cricket flour) -Kale, green tea, seaweed and ginger (containing also cricket flour)
Balzan et al., 2016	Italy (Padua)	Focus groups; ns	N = 32; 65.63%; 24.5 (20-35); ns; 72% students with part-time occupation plus employees in several jobs	-participants saw and touched insect-based food -video -visual appearance, preparation, and price	No information to participants about entomophagy and their knowledge came from previous individual experience only	Pictures: -Cheddar cheese larvets -Lollipops -Chocolate covered scorpion -Salt infused with chilli and agave worm -Dried crickets -Baked grasshoppers -Toasted scorpions
Barsics et al., 2017	Belgium (Namur)	Tasting, hedonic; ns	N = 135 dived in two groups; 28%; 19.4 (17-25); undergraduate students; ns	-group A tasting then information session* (N = 67) -group B information session* then tasting (N = 68)	*Information session on entomophagy (45-minute oral presentation with visual support)	Not real insect product, bread faux-labelled as containing an insect product Two bread samples, one of which was announced as containing insect-based food
Bartkowicz, 2017	Poland (Tri-city)	Survey; 2015	N = 788; 75%; ns (36% ≤20, 37% 21-40 and 27% ≥41); 12% vocational, 54% secondary, 34% higher; ns	-questionnaire		
Caparros Megido et al., 2014	Belgium (Waremme)* *Conducted in an insectarium	Tasting, hedonic; ns	N = 189 agreed on 384; 44%; ns (9.5% <13, 30% 13-18, 17% 19-25, 27% 26-45, 17% ≥45); ns; ns	-questionnaire -hedonic test -questionnaire		-House crickets baked 200 °C for 15 min -House crickets boiled 8 min -Mealworms baked at 200 °C for 7 min -Mealworms boiled 6.5 min -Crushed mix (1:1) of baked house crickets and mealworms -Baked mealworms flavoured with vanilla -Baked mealworms flavoured with paprika -Baked mealworms dunked in chocolate

Caparros Megido et al., 2016	Belgium (Woluwe-Saint-Lambert)	Tasting, hedonic; 2014	N = 79 agreed on 159; 56%; ns (18-25); ns; 100% students	-questionnaire -hedonic test -questionnaire	Brief presentation of the testing session with schedule and duration and the potential presence of insects	Four different burger patties: -Unflavoured ground beef -Mealworms-beef -Green lentils -Mealworms-green lentils
Cicatiello et al., 2016	Italy (Viterbo)	Survey; 2015	N = 201; 55%; 43 (14-78); 19% lower, 49 secondary, 32% university degree; ns	-questionnaire (if never eaten insect pictures were showed)		Pictures: -Insect-based preparation comparable to sushi -Street food stand with fried insects -Skewers with pupae -Plate with larvae and pupae with some vegetables -Meat burger with some larvae on the top
de Boer et al., 2013	Netherlands	Online survey; 2010	N = 1083; 50%; 49.5 (18-92); 24% primary and lower secondary, 51% upper secondary, 25% tertiary level; ns	-questionnaire on meat protein substitute		Text descriptions of snacks: -Lentils or beans -Insects, such as locusts -Seaweed, such as nori -Partly meat and partly a meat substitute (which was left unspecified)
Fischer & Steenbekkers, 2018	Netherlands (Wageningen)	Online survey; 2014	N = 140; 54%; 24.9 (ns); ns; 100 % university students	-questionnaire	Participants were informed that insects are eaten in 130 countries in the world, there are over 2,000 species of insects that can be eaten	
Gere et al., 2017	Hungary	Online survey; 2016	N = 400; 65%; 25.5 (ns); 45% lower, 55% higher; 44% students, 46% employed, 1% unemployed	-questionnaire (insect as meat substitute)	Participants were not informed about entomophagy or any other meat substitute prior to filling the questionnaire	
Gmuer et al., 2016	Switzerland (German speakers)	Online survey; ns	N = 428; 51%; 45.2 (20-70); 5.8% lower, 54.7% middle, 39.3% higher (22.9% college or university)	-questionnaire -photo (1 of 4) -questionnaire		Pictures: -Tortilla chips made of cricket flour -Tortilla chips containing deep-fried cricket bits -Snack consisting of tortilla chips and deep-fried crickets -Deep-fried crickets
Hartmann et al., 2015	Germany; China	Online survey; 2014	N = 502; 52%; 44.3 (20-69); 7.6% lower, 60.4% middle, 31.9% higher; ns	-questionnaire on meat substitute with pictures -questionnaire on a drink with silkworm protein	Participants were informed prior to the questioning the following ideas about insects: they are a good source for high-value protein; their production requires little space; their feed conversion is efficient; and the eating of	Pictures: -Deep-fried silkworms -Deep-fried crickets -Chocolate chip cookies based on cricket flour

					insects provides benefits in terms of sustainability Respondents were informed prior to this question that silkworm protein is a by-product of silk production and has various health benefits, such as helping to lower cholesterol and slow the aging of the brain	
Hartmann & Siegrist, 2016	Switzerland (Zurich)	Tasting; 2015	N = 104 divided in two groups; 53%; 33.8 (18-65); ns; ns	-control group, tortilla with corn flour (N = 53) -experimental group, tortilla with cricket flour, corn flour, beans and chia seeds (N = 51) -questionnaire -tasting -questionnaire	Participants in the experimental group were fully aware that the sample chips included cricket flour	-Tortilla made with corn flour -Tortilla made with cricket flour, corn flour, beans and chia seeds
(Hartmann et al., 2018)	Switzerland (German speakers)	Online survey; 2016	N = 598; 52%; 45 (20-69); ns; low 4.8%, middle 53% and high 42%	-questionnaire about impression on three shopping list (beef – vegetarian – insect)		
		Online survey; 2017	N = 617; 51%; 45 (20-69); ns; low 4.4%, middle 55% and high 40%	-questionnaire about impression on three chosen menu (beef – vegetarian – insect)		
House, 2016	Netherlands	Semi-structured interviews; 2015	N = 33; ns; ns (ns); ns; ns	-interviews		
(Jensen & Lieberoth, 2019)	Denmark (Aarhus)	Online survey, Tasting	N = 189; 84%; 22 (ns); ns; 100% university students	-tasting -questionnaire		-Roasted mealworms Pictures: -Spring rolls with visible mealworms -Spring rolls with invisible mealworms -Buttermilk soup with visible mealworms -Buttermilk soup with invisible mealworms
Kosteckа et al., 2017	Poland (Podkarpackie Region)	Survey; ns	N = 210; 50%; ns (33% 18-29, 33% 30-55, 33% >55); 1.4% lower, 41.5% secondary, 25.8% higher; ns	-questionnaire		
La Barbera	Italy	Implicit Association	N = 118; 47%; 23.9 (ns); ns; 100% university students	-computer questionnaire "Insects *vs* flowers" IAT	Recruitment through announcements on the	-Chocolate bar with peanuts enriched with proteins from crickets

et al., 2018		Test/Tasting; ns		-chocolate with crickets as incentive -two weeks after the end of the experimental sessions, participants were contacted, and a short questionnaire was administered about the chocolate	university notice boards, which invited students to participate in a behavioural economics experiment, with no other information on the content and procedure	
Laureati et al., 2016	Italy (Milan)	Survey; ns	N = 341; 65%; 31.9 (18-80); ns; university students and employees, consumers from outside the university	-questionnaire	University students and staff more involved in the topics of insects and sustainability since these topics are studied, investigated, and debated in University courses	
		Visual hedonic; ns	N = 68 (of the above 341); 62%; 21.4 (ns); secondary; university students	-questionnaire (above, survey) -pictures and information -questionnaire	Information about entomophagy, its potential and the low environmental impact	Pictures: -Biscuits made using insect flour -Chocolate-coated grasshopper -Cereal bar containing insects -Apple salad containing insects -Tequila containing a larva -Risotto containing maggots -Maggot cheese -Lollipops containing larvae
Le Goff & Delarue, 2017	France (Massy)	Non-verbal evaluation of acceptance; ns	N = 100 divided in two groups; 67%; ns (18-64); ns; staff and student of AgroParisTech	-control group, flavoured potato chips called ‘‘protein-enriched products” (N = 50) -insect group, flavoured potato chips called ‘‘insect protein-enriched products” (N = 50) -Filmed while tasting	The information was given at the very last moment when the cameras were already recording (when they sat and were ready to start the experiment) in order to ensure we could capture the most spontaneous reactions	Not real insect product, plain chips flavoured with barbecue, chicken, strawberry and a blackcurrant flavours
Lensvelt & Steenbekkers, 2014	Netherlands; Australia (Perth)	Online survey*; ns *also tasting in Australia	N = 134; ns; ns (ns); ns; ns	-questionnaire	In the email the rationale of the survey was briefly explained	
Lombardi et al., 2019	Italy (Naples)	Survey; 2017	N= 200; 40%; 20.5 (63% 18-20); ns; 100% university students	-questionnaire -information session (round one) -questionnaire -information session (round two)	In the first round, participants were provided with general information about the products (general information condition) In the second round, the sample was randomly divided	-Fusilli pasta with mealworms -Lemon-flavored cookies with mealworms -Bar of dark chocolate with mealworms *vs* the same products without mealworms

				-questionnaire	into two groups of the same size, and different information concerning the introduction of insects into human diets was disclosed to each group (full information condition; benefits for the individual *vs* benefits for the community)	
Marberg et al., 2017	Netherlands	Semi-structured interviews; ns	N = 19; ns; ns (ns); ns; various	-interviews		
Menozzi et al., 2017	Italy (Parma)	Survey; ns	N = 231; 62%; 23.6 (ns); ns; university students	-questionnaire		
		Tasting, hedonic; ns	N = 53 agreed on 231; ns (ns); ns; university students	-questionnaire (above) -taste -questionnaire		-Chocolate chip cookie containing an amount (10%) of cricket flour
Pascucci & De-Magistris, 2013	Netherlands (Wageningen, Utrecht and Den Bosch)	Choice experiment; 2011/12	N = 122 divided in three groups; 43%; ns (47% 18-35, 13% 35-54, 27% 55-64, 5% >64); 57% high school; ns	-baseline group, no specific information was given -treatment 1 group, "neutral" information about insect-based products -treatment 2 group, "positive frames" about insect-based products -four attributes: price (1.50, 2.50, 3.50 and 4.50 euros), insect visible/not visible, logo and omega 3		Pictures -Product that looks like a sushi, which is usually eaten in some Dutch restaurants
Piha et al., 2018	Finland; Sweden; Germany; Czech Republic	Online survey; 2016	N = 887 (232 Finland; 198 Sweden; 236 Germany; 221 Czech Republic); 60%; 38.6 (49% 17-34, 36% 35-55, 15% 56-96); 7% primary, 36% secondary, 57% higher; ns	-questionnaire with pictures		Pictures with short written descriptions of the products: -Crunchy crickets for a snack with dipping sauce -Chicken-mealworm nuggets -Mix of ground ants and blueberries -Giant mealworm wok -Crushed mealworms with chilli -Cricket-rye snacks
Schlup & Brunner, 2018	Switzerland	Postal survey; 2015	N = 379; 54%; 53 (ns); low 5%, middle 38%, high 57%; ns	-questionnaire	An introductory section briefly informed participants about the recent media attention given to insects	
Schösle	Netherlands	Online survey;	N = 1083; 50%; 49.5 (18-92);	-questionnaire with food		Pictures:

r et al., 2012		2010	24% primary and lower secondary, 51% upper secondary, 25% tertiary level; ns	choice (pictures), meat substitute		-Omelette -Pasta with pesto from nuts and herbs -Tivall minced-meat, made from soy and tomato sauce -Moroccan Couscous with chick peas and vegetable -Stir-fry with Seitan -Tivall steak -Asian stir-fry with tofu and vegetables -Tofu snack -Pizza containing protein derived from insects -Indian lentil meal (Daal) -Fried locust with chocolate coating -Locust salad -Salad with fried mealworm
Schouteten et al., 2016	Belgium (Ghent)	Tasting, hedonic; ns	N = 47 (53); 36%; 27 (ns); ns; ns	-tasting unbranded products (blind condition)		-Plant-based burger, 19% vegetable protein (soy and wheat) -Meat-based burger, 80% meat (71% chicken and 9% pork) -Insect-based burger, 31% mealworms
		Expected and informed conditions; ns	N = 38; ns; ns (ns); ns; ns	-information about main composition of the burgers -questionnaire (expected condition) -tasting -questionnaire (informed condition)	The label 'burger prepared with insects' was accompanied by the statement 'Insects are a good source of high-value proteins, their production requires little space, their feed conversion is efficient, and therefore eating insects provides benefits in terms of sustainability. Also, edible insects have been approved for human consumption by the Federal Agency for the Safety of the Food Chain (FAVV) in 2014 in Belgium	
Sheppard & Frazer, 2015	Ireland	Online survey; ns	N = 352 divided in two groups; 60%; 35.24 (18-68); ns; ns	-group A, short text (intellectual appeal) explaining some info and benefits to eating crickets -group B, a one-minute video (social appeal) of individuals eating and talking about a bar made from cricket flour -questionnaire (A+B)	Group A text Group B video	Picture of a cricket-based product (A+B) Video (B) After text or video Pictures of cricket bar and a whole cricket

				-text or video (A or B, respectively) -questionnaire (A+B)		
Sogari, 2015	Italy (Parma)	Tasting, hedonic; 2015	N = 46*; ns; ns (ns); ns; ns *participants at a "bug banquet"	-taste -questionnaire (semi-structured open-ended responses)	The nutritional and the environmental benefits of entomophagy were explained	Insects roasted in oven with added salt -House cricket (*Acheta domesticus*) -Wax moth larvae (*Galleria mellonella*) -Grasshoppers (*Calliptamus italicus*)
Sogari et al., 2017	Italy (Parma)	Tasting, hedonic; 2015	N = 109; 53%; ns (18-25); ns; university students of Gastronomy and Food Science courses of the Department of Food Science	-questionnaire -tasting -questionnaire	Introduction of culture aspects about entomophagy with a short text aimed to give to all participants some basic information on the subject, taking into account the low level of knowledge on the topic	-Cookie made by replacing 10% of the traditional flour with cricket flour
(Sogari et al., 2018)	Italy (Parma)	Tasting, hedonic; ns	N = 88; 51%; ns (18-40); ns; university students (80%) and faculty members	-questionnaire -tasting (75% taste both products, 19% only the insect-based jelly and 6% did not try either product) -questionnaire		-jelly with a visible cricket -jelly with a processed cricket
Tan et al., 2015	Netherlands (Wageningen); Thailand (Sakon Nakhon)	Focus group; ns	N = 29; 62%; 38* (20-65*); ns; ns * mixed data of Dutch and Thai participants	Within each culture, two individual experience were represented as eaters and non-eaters -focus group with pictures		Pictures: Visible insects -Fries grasshoppers with chili and salt -Mealworm muffins with chocolate pieces Covered insects -Crickets fritters with roasted peanuts -Chocolate-coated grasshoppers Invisible insects -Giant water bug chili paste -Butter cookies with ground beetles
Tan, van den Berg, et al., 2016	Netherlands (Wageningen)	Survey; ns	N = 976; 66%; 44.8 (18-94); 18% secondary, 82% tertiary; 39% students or employees of Wageningen University	-questionnaire (pictures of carrier) -introduction text -questionnaire (pictures of carriers + mealworm)	Introduction text on mealworm: mealworms are insects that can be sustainably produced and are rich in proteins. Insects are regularly consumed by people in many countries, but their consumption is not yet so known in the Netherlands. Recently, insect-based products are being sold in Dutch supermarkets	Pictures: Mealworm products 3 factors at 2 levels -Mealworm visibility (visible/invisible) -Flavour of carrier product (savoury/sweet) -Origin of carrier product (Western/Asian) Carrier -Beef stew as savoury Western -Curry as savoury Asian -Brownie as sweet Western -Spice cake as sweet Asian
Tan,	Netherlands	Tasting,	N = 103; 40%; 22.9 (ns); ns; ns	-questionnaire (image of a		Not real insect products

Fischer, et al., 2016	(Utrecht)	Choice experiment; ns		grilled beef burger patty) -tasting -questionnaire		Four label descriptions (100% beef or 75% beef and 25% lamb brain, 25% frog meat or 25% mealworms) The three novel ingredients were not actually incorporated into the samples, instead, plant based ingredients (breadcrumbs, tofu, hazelnut) were added in sufficient amounts to create perceivable differences in taste and texture
Tan et al., 2017	Netherlands (Wageningen)	Survey; ns	N = 135; 80%; 33.0 (18-65*); 90% tertiary; ns	Willingness (W) and unwillingness (UW) to taste -questionnaire (pictures, W+UW) -tasting (informed, W) -questionnaire (W+UW)		-Original meatballs (50% beef - 50% pork) -Mealworm meatballs (substitution with 30% mealworm) -Original drink (sweet strawberry orange dairy drink with suspended cereal bits) -Mealworm drink (added 5% mealworm)
		Tasting, hedonic; ns	N = 79; 68%; 50.9 (18-35*); 68% tertiary; ns *range age mixed of willing and unwilling to taste			
Vanhonacker et al., 2013	Belgium (Flanders)	Online survey; 2011	N = 221; 64%; 41.3 (36% 18-30; 18% 31-45, 31% 46-60, 15% >60); 23% no higher, 77% higher; ns	-questionnaire		
Van Thielen et al., 2018	Belgium	Telephone survey; 2016	N = 388; 50%; 31% 18-35; 40% 36-54; 29% 55-69); ns; ns	-questionnaire		
Verbeke, 2015	Belgium (Flanders)	Online survey; 2013	N = 368; 61%; 42 (18-79); 75% higher; ns	-questionnaire	participants were informed that insects ‘‘are a good source of high-value proteins, their production requires little space, their feed conversion is efficient, and therefore the eating of insects provides benefits in terms of sustainability	
Verneau et al., 2016	Denmark; Italy	Implicit Association Test; ns	N = 264 Denmark: N = 136; 61%; 23.3 (ns); ns; university students Italy: N = 128; 71%; 23.9 (ns); ns; university students	-videos (three different groups - two related with insect and one not related as control) -computer questionnaire "Insects *vs* flowers” IAT -chocolate with crickets as incentive -two weeks after the end of		-Chocolate bar enriched with proteins from crickets

	the experimental sessions, participants were contacted, and a short questionnaire was administered about the chocolate	

Table 3. Main information requested to consumers, use of incentive and percentages of article financed.

Discriminant	Sex	Age	Occupation	Education	Economic status	Vegetarian/Vegan	Ancestry	Previous knowledge	Previously eaten	Meal buyer	Product price	Incentive	Financial
Number*	35	35	11[a]	18[b]	5[c]	14[d]	2[e]	11[f]	15[g]	2[h]	9[i]	10[j]	4[k]
%	100%	100%	31%	51%	14%	40%	6%	31%	43%	6%	26%	28%	11%

*Discriminant of Balzan et al., 2016; House, 2016; Le Goff & Delarue, 2017; Marberg et al., 2017; Tan et al., 2015; Verneau et al., 2016 were not summarised in this table.

[a]Cicatiello et al., 2016; de Boer et al., 2013; Fischer & Steenbekkers, 2018; Jensen & Lieberoth, 2019; La Barbera et al., 2018; Laureati et al., 2016; Lombardi et al., 2019; Schouteten et al., 2016; Sogari et al., 2017, 2018; Tan, van den Berg, et al., 2016.

[b]Barsics et al., 2017; Bartkowicz, 2017; Caparros Megido et al., 2016; Cicatiello et al., 2016; de Boer et al., 2013; Gere et al., 2017; Gmuer et al., 2016; Hartmann et al., 2018, 2015; Kostecka et al., 2017; Pascucci & De-Magistris, 2013; Piha et al., 2018; Schlup & Brunner, 2018; Schösler et al., 2012; Tan, van den Berg, et al., 2016; Tan et al., 2017; Vanhonacker et al., 2013; Verbeke, 2015.

[c]Bartkowicz, 2017; Laureati et al., 2016; Pascucci & De-Magistris, 2013; Schlup & Brunner, 2018; Vanhonacker et al., 2013.

[d]Bartkowicz, 2017; Caparros Megido et al., 2016; Cicatiello et al., 2016; de Boer et al., 2013; Gmuer et al., 2016; La Barbera et al., 2018; Schlup & Brunner, 2018; Schösler et al., 2012; Schouteten et al., 2016; Sheppard & Frazer, 2015; Tan, van den Berg, et al., 2016; Tan et al., 2017; Van Thielen et al., 2018; Verbeke, 2015.

[e]Barsics et al., 2017; Cicatiello et al., 2016.

[f]Barsics et al., 2017; Bartkowicz, 2017; Caparros Megido et al., 2014, 2016; Kostecka et al., 2017; Schlup & Brunner, 2018; Sheppard & Frazer, 2015; Sogari, 2015; Tan, Fischer, et al., 2016; Tan et al., 2017; Verbeke, 2015.

[g]Barsics et al., 2017; Caparros Megido et al., 2016; Cicatiello et al., 2016; Fischer & Steenbekkers, 2018; Gmuer et al., 2016; Hartmann et al., 2015; Hartmann & Siegrist, 2016; Kostecka et al., 2017; La Barbera et al., 2018; Lensvelt & Steenbekkers, 2014; Piha et al., 2018; Schlup & Brunner, 2018; Sheppard & Frazer, 2015; Sogari, 2015; Van Thielen et al., 2018.

[h]Schlup & Brunner, 2018; Vanhonacker et al., 2013.

[i]Bartkowicz, 2017; Cicatiello et al., 2016; Lensvelt & Steenbekkers, 2014; Lombardi et al., 2019; Pascucci & De-Magistris, 2013; Schlup & Brunner, 2018; Tan, Fischer, et al., 2016; Tan et al., 2017; Van Thielen et al., 2018.

[j]de Boer et al., 2013; Gmuer et al., 2016; Hartmann et al., 2015; Hartmann & Siegrist, 2016; La Barbera et al., 2018; Lombardi et al., 2019; Schösler et al., 2012; Tan, Fischer, et al., 2016; Tan et al., 2017; Vanhonacker et al., 2013.

[k]Gere et al., 2017; Lombardi et al., 2019; Piha et al., 2018; Van Thielen et al., 2018.

Table 4. Researches purposes and main results.

Authors, year	Research purposes	Research main results
Adámek et al., 2018	determine if energy and protein bars enriched with edible insect are acceptable as novel food for consumers from the Czech Republic	-changes in public attitudes to eating edible insects were confirmed; -bars are acceptable to the Czech consumer as a novelty food; -respondents did not refuse the possibility of conscious consumption of edible insects in the future.
Balzan et al., 2016	explore the readiness of young Italian people to consume insects and the psychosocial determinants associated with edible insect consumption	-even though with some uncertainty, there are some people prepared to consume insects; -the aspects most frequently cited as a motivation for rejecting insects besides disgust are appearance, odours and taste. Lack of practice in preparation is a major barrier to consumption; -to expand consumption participants suggested an active role for public health institutions.
Barsics et al., 2017	examine how a broad-based information session can affect consumers' perceptions and attitudes about an edible insect product	-the nature of the bread samples, although declared as differing, had little impact on the overall scores obtained; -the most commonly involved factor affecting the scores assigned was gender; -although most participants assigned similar scores to both breads, score variation between the two bread samples differed depending on whether the tasting occurred before or after the information session.
Bartkowicz, 2017	evaluate the attitudes towards entomophagy and the factors determining the intention to eat insects	-one third of respondents reported willingness to try the products of edible insects; -the gender and age significantly differentiate of the answer (men were significantly more curious than women and young consumers below 20 years of age demonstrated a negative attitude); -in the study 80,2% of the respondents indicated appearance as a factor discouraging consumption.
Caparros Megido et al., 2014	determine the potential of insects to replace and/or complement the traditional protein sources. The acceptance is measured by un-structed hedonic test	-the overall acceptability of insects depended only on the preparation method; -after tasting, the majority of over 25s said they would be prepared to eat or cook insects in future; -sustainability, reducing pollution and other benefits derived from insect foods could also convince consumers besides those with adventurous tastes.
Caparros Megido et al., 2016	assess the level of sensory-liking of hybrid insect-based burgers. The acceptance is measured by hedonic test with a comparison of different products	-appearance, taste and smell of beef burgers were better rated than those of the mealworm/beef combination and the mealworm/lentil combination as well as the lentil-only patty; -men rated the insect hybrid burger more positively than women; -people with previous entomophagy experience was limited but that they gave globally higher ratings to all preparations.
Cicatiello et al., 2016	investigate how potential consumers from Southern European countries might respond to entomophagy	-31% of the sample (55% of which were females, with an average age of 43 years old) with a positive attitude towards eating insects; -the two main barriers to insect consumption are the idea that food safety is not guaranteed and the appearance of the insect-based preparation.
de Boer et al., 2013	examine the relationship between motivational differences in food orientation and the choice of snacks made from crickets and other meat-free alternatives (e.g. seaweed, beans)	-4% chose the insect snack; -no influence of gender, educational background, age or number of meat days/week; -consumers who were high on meat were less likely to choose the snacks from lentils and seaweed.
Fischer & Steenbekkers, 2018	investigate the ways in which Dutch consumers, with and without insect tasting experience, are more or less willing to eat different insects	-insects promoted in the market were more preferred than the less marketed insects; -subgroup of preferred insects was formed by participants with experience in eating insects.
Gere et al., 2017	understand the readiness of Hungarian consumers (East-Central Europe) to adopt insects	-insect-based food might attract consumers who seek new food choice options and who intend to reduce meat intake; -in Hungary there is limited information available about entomophagy (almost 60% of the respondents stated that they have heard about eating insects and do know what it means); -less 11% of the respondents did not know about insects, soy, algae and whey as an alternative protein source, respectively.

Gmuer et al., 2016	obtain a detailed picture of the negative and positive emotional experiences that potential consumers may expect from consuming snacks that contain insects the products and willingness to eat	-crickets alone and a mix of unprocessed crickets and chips triggered the most negative emotion profile (e.g. irritated, disgusted, uneasy, strange); -emotion profile was associated with a willingness to eat.
Hartmann et al., 2015	investigate peoples' opinions and attitudes towards insect food	-lowest willingness to eat for unprocessed insects, highest willingness to eat for processed insects (this difference in the degree of processing was irrelevant in the Chinese sample); -higher willingness to eat if already had experience in eating insects and low food-neophobic tendencies; -no gender differences.
Hartmann & Siegrist, 2016	define what might help consumers choosing to eat an insect product for the first time	-significant influence of experimental manipulation, when controlled for covariates; -willingness to eat was associated with food neophobia, having eaten insects already in the past, disgust sensitivity in relation to animal food contamination; -positive eating experience with product from processed insects increases willingness to eat unprocessed insects.
(Hartmann et al., 2018)	examine how participants in Switzerland evaluate the personality of other Swiss people who consume insect-based products	-consumers of insect and vegetarian products were perceived as more health-conscious, environmentally friendly, imaginative, brave, interesting, and knowledgeable than meat consumers; -vegetarian and insect alternatives were evaluated as healthier than the meat option.
House, 2016	analyse how an overall positive experience may help growing accustomed to insect food products.	-repeat consumption of Insecta products was relatively low, with the majority of participants having tried Insecta once (58%) or more than once but not regularly (18%); -the consumption of Insecta products at least semi-regularly was relatively low (24%), with the highest consumption being once every two weeks, weekly, or twice a week (all 3%); -the most common way in which Insecta products were eaten was part of the traditional 'aardappel-vlees-groente' (potato-meat-vegetable) meal configuration.
(Jensen & Lieberoth, 2019)	investigate the effects of fear of contamination and perceived social eating norm	-dissociation between trait-level disgust and perceived infectability, and, then insect eating disgust; -perceived social norms significantly influenced individuals' willingness to eat insects.
Kostecka et al., 2017	examine opinions of selected Polish consumers related to their acceptance of insect-based food as an alternative source of nutrients	-majority of the participants reported they had never tried edible insects (89.5%); -among those who had consumed insects (10.5%) 7.2% tried this type of food only once; -the survey participants are rather sceptical about insect-based meals or even use of insects as animal feed.
La Barbera et al., 2018	analyse the impact of food neo-phobia and disgust on the intention to eat insect-based food, and look at how disgust is related to implicit attitude towards insects	-Food Neophobia Scale (FNS) significantly correlates with intention but not with disgust; -there is a significant indirect effect of implicit attitude on intention mediated by disgust; -explanatory power of disgust is considerably higher than the explanatory power of food neophobia.
Laureati et al., 2016	investigate the willingness of Italian consumers to adopt insects, suitable candidates for providing sustainable animal proteins, as part of animal and human diets	-respondents were clearly not ready to accept insects as food (21.1%), whereas a major positive trend was observed regarding their use as feed (53% of the consumers); -the principal factors affecting the Italian consumers' readiness to adopt insects as food and feed were age, gender, cultural background and food neophobia; -subjects' involvement in sustainability issues did not play a role in the acceptance of insects.
Le Goff & Delarue, 2017	assess consumers' non-verbal reactions to insect-based products	-before tasting, insect-based products provoked much more negative expressions; -during tasting, insect-based products provoked less positive facial expressions; -consumers reject the idea of tasting chips but seem to accept it after the first bite, indicating that western society might be willing to take a first step towards insect consumption, at least as processed food.
Lensvelt &	provide insight into which factors are	-38% did not eat the insect products;

Steenbekkers, 2014	effective to influence consumer acceptance of entomophagy among participants	-only survey respondents with a neutral attitude to entomophagy tasted the products; -attitude towards entomophagy more positive after tasting.
Lombardi et al., 2019	assess consumers preferences for specific insect-based products *vs* conventional products	-different carriers generate different results -information affected consumers perceptions
Marberg et al., 2017	analyse the legitimation process of an emerging novel food sector in the European Union	-twelve of the interviewees indicated that the Netherlands is uniquely positioned to become a leader in insect protein innovation due to its expertise in climate control, farming, and logistics; -according to eleven interviewees, one of the main drivers of the insect sector is sustainability and the need for sustainable protein alternatives; -the interviewees indicated that multinationals are observing the market but are not yet actively participating in it at this time. More cooperation with NGOs (nongovernmental organizations) is anticipated.
Menozzi et al., 2017	investigate how potential consumers from Southern European countries can respond to entomophagy	-a moderately positive attitude toward the behaviour, a moderately negative social pressure, and a generally positive perceived control over eating products containing insect flour in the next month; -positive correlation between intention and gender was detected, indicating that male respondents had higher intention to eat products containing insect flour in the next month, compared to females; -the Theory of Planned Behaviour (TPB) model accounted for 78% of the variance in intention and 19% of the variance in behaviour.
Pascucci & De-Magistris, 2013	analyse whether information bias is affecting consumers' WTP (willingness to pay) for radical insect-based food	-even if consumers were framed both neutral or positive information about the consequences of consumption of insect-based products, their WTPs for insect-based attributes were not statistically different from those ones who did not receive any kind of information about the insect; -consumers were willing to pay a premium price of 1.31€ for a box of 4 sushi insect-based products when the logo "Chrysalide" is shown and they were willing to pay 1.55€ more for a box of 4 sushi insect-based products when they knew that the product contained Omega 3; -consumers were willing to pay 7.40€ less (thus they were willing to be compensated) for the products with visualization of the insect.
Piha et al., 2018	investigate how consumer knowledge influences willingness to buy (WTB) insect food products	-Northern European consumers might be more positively inclined towards and feel more knowledgeable about insect food; -in Central Europe, product-related experiences and food neophobia are superior predictors to subjective and objective knowledge; -consumers in Northern Europe generally have a more positive attitude towards insect food than consumers in Central Europe.
Schlup & Brunner, 2018	examine the predictors that are currently used to explain the willingness to consume insects	-the percentage of men (26%) who have already consumed insects is twice as high as it is for women; -prior consumption, salience, healthiness, convenience and gender were the strongest positive predictors of participants' WTC (willingness to consume); -food neophobia, food technology neophobia and the perceived healthiness of meat were all significant negative predictors of participants' WTC.
Schösler et al., 2012	clarify attitudes towards various substitution options and identify pathways towards the (partial) substitution of meat in the future	-consumers' acceptance of insect-based meals was lower when insects were visible. Likelihood of acceptance increases with a decreasing degree of perceptibility of the whole insect (impressive legs and antennae above all); -low probability of preparing dishes oneself; -menus with visible insects were more positively rated by men than by women.
Schouteten et al., 2016	examine the overall liking, perceived quality and nutritiousness, and the emotional and sensory profiling of three commercially available burgers (insect-based)	-10% did not eat the insect burger in the non-blind test; plant and insect-based burgers were more negatively rated in terms of taste than meat-based burgers; -sensory quality of insect burgers have potential for improvement; -information communication about contents positively influenced evaluation of insect burger.
Sheppard &	analyse disgust specific to eating crickets,	-members of the social appeal group had a significantly greater change in likelihood of eating a cricket bar, but not a whole cricket;

Frazer, 2015	how it can be reduced, and whether this varies with age and gender	-compared to male participants, female participants rated themselves less likely to eat a whole cricket or a cricket bar; older participants were less likely to eat a whole cricket or a cricket bar.
Sogari, 2015	investigate the main reasons to stimulate the consumption of edible insects in the future	curiosity and environmental benefits are the most important factors in motivating the consumption of insects in the future; -the majority of respondents stated that entomophagy would not be endorsed and supported by family and/or friends; -the importance of others' opinions (especially a negative attitude) is a strong barrier to approach and to introduce entomophagy in the Western diet.
Sogari et al., 2017	investigate the expectations about entomophagy from a specific target group composed by people studying Gastronomy and Food Science	-47% foresees that entomophagy might become a culinary trend in Italy, while the other half states that it would not be "successful", "appropriate" or "exciting"; -67.5% indicated they would taste edible insects if they had the opportunity, 25.0% would not and only 7.5% would be undecided; -more than half of those surveyed indicated the practice of introducing insects in the diet would not be approved and supported by their family members and/or friends.
(Sogari et al., 2018)	investigate how sensory-liking attribute perceptions (appearance, taste and organoleptic characteristics) change between a readily visible *vs* a processed insect product	-texture and appearance of the insect are perceived as stronger barriers than the taste attribute; -both unprocessed and processed insect-based products generate more positive perceptions after tasting compared to expectations.
Tan et al., 2015	investigate individual perception of insects-based food in countries with different cultural exposure with regard to this issue	-the appropriateness of the preparation method is important for the acceptance of insect-based food.
Tan, van den Berg, et al., 2016	examine how the product preparation, familiarity and individual traits (e.g. food neophobia) influence the consumer acceptance of insects as food	-product acceptance was not increased by combining with familiar carrier products, however was strongly influenced by perceived appropriateness of carrier products; -even if visually identical, mealworm preparations were always rated worse than the original not containing insects; -further incentives relating to the appearance of food are required to motivate consumers to eat insects.
Tan, Fischer, et al., 2016	explore how the levels of sensory-liking and food appropriateness contribute to the willingness to eat unusual foods	-willingness to eat was strongly influenced by perceived low (cultural) appropriateness of ingredients; -negative taste expectations because of unusual ingredients were not associated with reduced taste evaluation after tasting; -even if sensory evaluation was positive, this did not lead to an increase in acceptance of the unusual ingredients.
Tan et al., 2017	understand how more appealing products could be developed, and whether that is sufficient to encourage consumption of a culturally unusual food	-using a familiar and liked product preparation could help to increase trial intentions, but the product should also be appropriate and taste good if it is to be regularly consumed; -correlations showed that familiarity and sensory-liking only partially related to product appropriateness, which may explain why adding familiar and liked ingredients do not always increase the willingness to eat a novel food; -given the strong positive correlations between experienced sensory liking and willingness to buy, a more disappointing taste experience would lower intentions to buy, but the converse is not necessarily true.
Vanhonacker et al., 2013	analyse opportunities and bottlenecks of some alternative and more sustainable food choices	-lowest acceptance of insect proteins compared to insect-free alternatives; -insect consumption motivated only by sustainability considerations seems not to be a promising option; -only 5% of consumers willing to try insects.
Verbeke, 2015	investigate the readiness of consumers to adopt insects in a Western society	-19% agree, 16% unsure, 65% disagree; -gender, previous insect consumption, food neophobia, food technology neophobia and awareness; -19% of respondents being "willing or ready" to adopt insects as a meat substitute.
Verneau et al., 2016	investigate the possibility to foster people's willingness to eat insect-based food through communication	-80% of participants indicated that they ate the bar; -information provision positively influenced intention and consequently behavior; negative implicit attitudes did not weaken the effect; -information communication about individual and social advantages of insect consumption can positively influence willingness to eat.

Van Thielen et al., 2018	updated and representative insight into the Belgium consumers acceptance of edible insect after two years of their introduction into the market	-79% were aware of the fact that foods with insects can be bought; -11.2% had already eaten foods with processed insects; -31.8% had no experience but were willing to try; -57% had no experience or interest in tasting such products; -potential consumers accepted invisible processed mealworms in different ways in several products (energy shakes, energy bars, burgers, soup, sandwich spreads, unfried snacks and fried snacks).

Figure 1. Flowchart of phases of the systematic review.

Figure 2. Consumers' and authors' affiliations countries of the reviewed articles.

Numbers on each country (a-b) represent the number of articles conducted on resident consumers (a) and the number of authors affiliation (b). If in one article different authors had the same country of affiliation the country was counted ones.