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Consumer Attitudes and Acceptance of Insects as Food and Feed: A Review

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Edible insects are considered as a promising alternative for meat-derived protein to meet increasing human demand for meat over the world. Despite the evident benefits in regard to human health (nutritious with high fat and mineral) and the environment (less gas emission and fewer usages of water and cultivated land), introducing and publicizing insects as a new kind of food have faced huge obstacles in both developed and developing countries. There has been a lack of reviews focusing on consumer attitudes and behavior (willingness to consume or acceptance) toward eating insects as food and feed. Based on an analysis of 50 originally peer-reviewed articles on reliable journals from the year 2013 to 2020, this work summarizes consumer acceptance of insects as food and feed and systematizes factors driving or deterring consumers to consume these foods. Further recommendations for future research are also proposed.

Key words: consumer acceptance, edible insects, food neophobia, insect food, insects as feed

INTRODUCTION

The history of eating insects as food by humans begun several centuries ago (Dobermann *et al.*, 2017). It is estimated that around 2000 insect species are consumed by humans in the world (Jongema, 2015; Van Huis, 2013). While edible insects have been widely used as an important source of protein and micronutrients in some African and Asian developing countries, it seems much more limited in developed counterparts (Western countries) (Dobermann *et al.*, 2017; Imathiu, 2020; Raheem *et al.*, 2018).

In recent years, the consumption of insects as food and feed has attracted great attention from scholars and the public, especially in Western countries. Establishing a culture or practice of eating insects, referred to as entomophagy, becomes more significant in such nations when insect food is considered a good alternative for consuming meat from livestock animals (Hartmann and Siegrist, 2016; Tuccillo *et al.*, 2020; Verbeke, 2015). In addition to providing rich protein sources, entomophagy brings several other benefits to humans and the environment when producing insects for human eating causes less environmental pollution and requires less water usage and land (Van Huis *et al.*, 2013, Verbeke, 2015). Attempts to incorporating insects as food in the diet and making this eating culture more popular in Western society can be facilitated due to the shortage of animal-based protein caused by the worldwide population of 9 billion in 2050 (Imathiu, 2020; Raheem *et al.*, 2018).

Despite these benefits of entomophagy mentioned above, the uptake of insect food into tables remains huge challenging in Western countries (Van Huis, 2015;

Verbeke, 2015). Spreading edible insects as food to become a regular protein source replaced for meat also seems difficult in developing nations (Imathiu, 2020). Although there was a long history of using insects as food in Asian and African countries, the regular consumption of this food seems to happen in small communities (i.e., minority or rural/mountainous areas). Several reasons explain why insect food is not easy to become the main diet in both developed and developing nations. In a recent decade, an increasing number of studies exploring consumer perceptions, evaluations, attitudes and acceptance of insect food, especially in European nations. Based on various approaches, survey techniques and analytical methods, the prior studies identified several factors affecting consumer willingness to eat insect food such as food neophobia (reluctance to try new or unfamiliar food), food disgust, socio-demographic characteristics (gender, age, and education), price availability of insect food, etc (Chang *et al.*, 2019; Clarkson *et al.*, 2018; Lombardi *et al.*, 2019; Orsi *et al.*, 2019; Tuccillo *et al.*, 2020; Verbeke, 2015).

Few reviews on consumer attitudes and behavior toward insect food/feed have been done in both developing and developed countries. A review by Mancini *et al.* (2019) focused on European consumers, which raised questions related to the acceptance of insect food in other countries. Meanwhile, some other reviews placed more emphasis on the benefits of insect food (Dobermann *et al.*, 2017; Imathiu, 2020; Rumpold and Schlüter, 2013). Importantly, to the best of our knowledge, there has been a lack of a clear summary (based on existing literature) to conclude whether or not consumers accept or refuse eating insect food and how the acceptance level differs among whole insect food, insect-based food, and insects as feed. In addition, it requires a comprehensive review about factors motivating or challenging consumer acceptance of insect food as Sun-Waterhouse *et al.* (2016) urged more research on psychological and cultural drivers of eating insects.

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Therefore, this work aims to provide a review of consumer attitudes and acceptance of insects as food and feed more clearly, with an emphasis on factors influencing the willingness to consume insect food in the world. Then we propose suggestions for designing better further research on consumer behavior toward eating insects as food and feed.

METHODOLOGY

Search procedure

This study collected existing (original) research papers on consumer attitudes and acceptance to try/eat/buy insects as food and feed. It means that all prior reviews, proceedings and abstract papers were not included in our current analysis. All the original research papers were published in the English language in peer-reviewed and reliable journals from 2013 to 2021 through using online databases such as ScienceDirect and Google Scholar.

In the first phase, a set of main keywords used to search relevant articles included “insect (s) food”, “insect (s) feed”, “consumer attitudes insect food/feed”, “consumer acceptance insect food/feed”, “edible insects”. Based on these keywords, we screened 122 papers on the search engines. Of these work, only 50 original papers were kept for this review. Meanwhile, we removed 72 papers (16 reviews, 32 abstracts and proceedings, 24 not related to consumer aspects).

Data analysis

We used descriptive statistics as the main method of this review. Main information of the previous studies was extracted and reported including (i) insects as food or feed, (ii) surveyed countries, (iii) types of participants, (iv) modes of survey, (v) types of insect food/feed, main analytical methods, (vi) main results (i.e., acceptance or refusal of insect food and factors affecting consumer attitudes and willingness to consume insects

as food and feed).

RESULTS AND DISCUSSION

Some main characteristics of previous studies on insect food/feed

Of 50 selected papers, 70% were done in Western countries, including Netherlands (16%), Italy (16%), Belgium (12%), Germany (12%) (Table 1). Most prior studies (84%) focused on insects as food (whole insect or insect-based ingredients), while only 12% examined insect feed. Seventy-eight percent of previous studies recruited consumers as the research targets through face-to-face interviews or online/web-based/email surveys. Meanwhile, students were invited to participate in the experiments (i.e., in the laboratories of university campuses) with real taste to evaluate sensory perceptions or attitudes toward insect food. In addition, about one-third of the prior studies used visual aids (insect food images or videos) during surveys. About the analytical methods, various analyses were used such as T-test, ANOVA, logistic regression, multiple linear regression, choice experiment, Structural Equation Modeling (SEM). The details of research targets, modes of surveys, and analytical methods were displayed in Table 2.

Consumer attitudes and acceptance of insect food

Overall, only around 31% of the previous studies reported that consumers had positive attitudes and/or accepted insects as food/feed. Meanwhile, 37% confirmed unreadiness to try or buy insect food. Notably, there were significant disparities in consumer acceptance or refusal of insect food across ways of insect processed. Specifically, 8% of studies confirmed that consumers were likely to accept whole insects as food. Meanwhile, 35% concluded that a high rate of consumers agreed to try food containing insect-based ingredients, and 100% reported the willingness to consume insects as feed (Table 3).

Table 1. Characteristics of previous studies

	Number of studies		Top specific countries surveyed	References used in this review
	n	%		
Countries			Netherlands (16%), Italy (16%),	Alemu <i>et al.</i> (2016), Ankamah–Yeboah <i>et al.</i> (2018), Balzan <i>et al.</i> (2015), Barsics <i>et al.</i> (2017), Berger <i>et al.</i> (2019), Castro and
–Western	35	70	Belgium (12%), Germany (12%), Australia (8%),	Chambers IV (2019), Chang <i>et al.</i> (2019), Chia <i>et al.</i> (2020), Cicatiello
–Non Western	9	18	Kenya (8%),	<i>et al.</i> (2016), Clarkson <i>et al.</i> (2018), Delicato <i>et al.</i> (2020), Domingues
–Both	5	12	US (6%)	<i>et al.</i> (2020), Fischer and Steenbekkers (2017), Gere <i>et al.</i> (2017),
Insect food/feed				Gmuer <i>et al.</i> (2016), Goff and Delarue (2017), Hartmann and Siegrist
–Insect food	42	84%		(2016), Hartmann <i>et al.</i> (2015), House (2016), Hwang <i>et al.</i> (2020),
–Insect feed	6	12		Lammers <i>et al.</i> (2019), Lensvelt and Steenbekkers (2014), Liu <i>et al.</i>
–Both	2	4		(2019), Llagostera <i>et al.</i> (2019), Lombardi <i>et al.</i> (2019), Manditsera <i>et al.</i>
				(2018), Mancuso <i>et al.</i> (2016), Megido <i>et al.</i> (2016), Menozzi <i>et al.</i>
				(2017), Meyer–Rochow and Hakko (2018), Onwezen <i>et al.</i> (2019), Orsi
				<i>et al.</i> (2019), Palmieri <i>et al.</i> (2019), Pambo <i>et al.</i> (2018a), Pambo <i>et al.</i>
				(2018b), Piha <i>et al.</i> (2018), Ruby <i>et al.</i> (2015), Schaufele <i>et al.</i> (2019),
				Sogari <i>et al.</i> (2019), Tan <i>et al.</i> (2015), Tan <i>et al.</i> (2016), Tan <i>et al.</i>
				(2017a), Tan <i>et al.</i> , (2017b), Tuccillo <i>et al.</i> (2020), Verbeke (2015),
				Verbeke <i>et al.</i> (2015), Verneau (2015), Wilkinson <i>et al.</i> (2018), Woolf
				<i>et al.</i> (2019)

Source: Own calculation from the listed references

Table 2. Surveyed targets, modes of surveys, real tasting (experiments), and analytical methods

	n	%
Surveyed target		
– Consumers	39	78
– Students	10	20
– Both	1	2
Modes of survey		
– Face to face	14	28
– Online/web-based/email	23	46
– Experiment	13	24
Real tasting		
–Yes	15	30
–No	35	70
Main analytical methods		
– Choice experiment	3	6
– Descriptive statistics/qualitative analysis	6	12
–T-test/ANOVA/Chi-square	16	32
– Regression (Linear/logistic)	15	30
– SEM	6	12
– Others	3	6

Source: Own calculation from the listed references

Note: n (number of prior studies used in this review).

Table 3. Consumer acceptance of insects as food and feed

Types of insect food (n* = 65)	Likely to accept	Unlikely to accept	Unknown/unreported/unclear
Whole insects as food	8%	60%	32%
Food with insect-based ingredients	35%	27%	38%
Insect as feed	100%	0%	0%

Source: Own calculation from the listed references.

Note *n =65 because some previous studies examined both whole insects and insect-based ingredients

The percentage of consumers who were willing to accept insect food varied largely among individual research. While many work reported a low acceptance level (i.e., 12.8% of consumers in Verbeke *et al.*, 2015; 16% in Clarkson *et al.*, 2018; 22% in Palmieri *et al.* 2019) 31% in Cicatiello *et al.*, 2016), few showed high possibilities to consume insect food (i.e., 78% in Megido *et al.*, 2014).

Main motives and barriers driving consumers to try/consume insects as food and feed

Spreading the consumption of insect food in Western society has faced several difficulties. Several factors from socio-demographic, psychological to cultural and communication influence consumer attitudes and behavior to accept insects as food and feed.

Food neophobia and food disgust

Food neophobia, which refers to the fear of eating/trying new or unfamiliar food, was one of the most essential factors affecting the consumption of insects as food. Meanwhile, disgust is examined as an adaptive functional system protecting against pathogen infections (Curtis *et al.*, 2011). Disgust related to insect food is human consideration of insects as being inappropriate for human consumption (Tan *et al.*, 2016). Food disgust and neophobia are related to each other but not the same (La Barbera *et al.*, 2018). Many studies verified the negative impacts of food neophobia and food disgust on consumer acceptance and considered these factors as the main barriers for consumers to adopt insect food (Chang *et al.*, 2017; Clarkson *et al.*, 2016; Fischer and Steenbekkers, 2017; Hartmann *et al.*, 2015; Lammers *et al.*, 2019; Liu *et al.*, 2019; Lombardi *et al.*, 2019; Schaufele *et al.* 2019; Orsi *et al.* 2019; Verbeke, 2015).

Cultural characters

There have been some studies on cross-cultural differences in consumer attitudes and acceptance of insect food. In a global survey done in 13 different countries (Castro and Chambers IV, 2018), based on the percentage of consumers who were willing to try insect food, three groups of countries were classified as unwilling (Japan, around 20%), moderately willing (Russia, India, Spain, Australia, US, UK, South Africa, China, and Brazil, 30 – below 50%) and willing (Thailand, Peru, and Mexico, over 50%). In another work, people in Asian countries (i.e., Thai Lan and China) were found to have a more favorable attitude and higher possibilities to accept insect food (both processed and unprocessed) than those in Western nations (Hartmann *et al.*, 2015; Tan *et al.*, 2015).

Effects of cultural differences on consumer preference for insect food occurred among areas/countries within the Western region. There was a significant difference in consumer attitudes toward willingness to buy (WTB) insect food between Northern and Central Europe in the work of Piha *et al.* (2018). This difference was also found among countries in the same region. For instance, Danish people had higher intention and behavior to buy insect food than Italians in the work of Verneau (2016).

Rural-urban difference in consumer attitudes and acceptance of insect food has been paid little attention by researchers. Manditsera *et al.* (2018) revealed more percentage of people in rural areas eating insect food than those in urban (89.7% vs. 80%) areas. Also, rural respondents (63.9%) consumed insects more regularly than those in urban (14.5%).

Species of insects, visibility of insect food, and ways of insect-based food processed

Although several kinds of insects can be consumed by humans, some popular insects are much more easily accepted, such as grasshoppers, crickets and mealworms (Fischer and Steenbekkers, 2017).

Effects of species of insects during food processing

on consumer attitudes and acceptance have been explored by previous work. Schaufele *et al.* (2019) found that consumers preferred grasshoppers to mealworms. Tuccillo *et al.* (2020) also ranked consumer preference insect food from the highest to lowest as crickets, bee larvae/grasshoppers, mealworm/silkworms, and giant water bugs.

Food with whole insect food was found to cause consumers more negative reactions and less readiness to consume than insect-based ingredient food (Goff and Delarue, 2017; Hartmann and Siegrist, 2016; Hartmann *et al.*, 2015; Lammers *et al.*, 2019). For instance, Lammers found that while only 16% of participants were ready to consume unprocessed (whole) insect food, 42% accepted to consume burgers with insect-based ingredients. Lensvelt and Steenbekkers (2014) also concluded that the participants were more willing to eat insects mixed than to eat them individually. However, a study in Kenya (Alemu *et al.*, 2017) revealed no significant difference in reaction to the whole and processed termites.

In addition, the ways of processing insect food influenced largely consumer liking and buying. Meyer-Rochow and Hakko (2018) reported that people would be more accepted if insects were processed into flour or pastes without any image of insects displayed in the packages. Similarly, incorporating insects into familiar products (e.g., biscuits) or cooked meals facilitated the uptake of insect food into people's diets (Wilkinson *et al.*, 2018). The level/amount of insects incorporated into food as ingredients also affected consumers' liking level. For instance, in the work of Delicato *et al.* (2020), participants reduced their liking level when adding more the amount of insect fat replaced for butter in bakery products.

Safety perception of insect food and the role of information provision

Consumer worry about the safety of insect food was likely to prevent his/her motivation to consume this food. Diseases and allergic reactions were perceived to be caused by food containing ingredients from insects (Castro and Chambers IV, 2019). The fear of being harmful to health also occurs with insects as feed. For instance, Verbeke *et al.* (2015) mentioned that consumers were concern about the risk of allergens caused by insects used as animal feed.

Gere *et al.* (2017) verified that many consumers did not have adequate knowledge about the benefits of insect food and hesitated to consume this kind of food. Thus, providing information on insect food to the public is important to change consumer perception as recommended by Barsics *et al.* (2017). Alemu *et al.* (2016) also recommended that it is required to provide more information and quality assurance related to insect-based food, which was combined with officials and media recommendations and product labels.

Past eating

Eating experience plays a vital role in motivating consumers to consume insects as new food. Fischer and

Steenbekkers (2017) reported that 68% of consumers who had eating insects before would be willing to eat again, with some popular insect food such as grasshoppers, crickets and mealworms. Meanwhile, all of those who have never tried eating insects before did not want to consume these food. Similarly, previous eating experiences were an important driver of consuming insect food in Italy, which is found in the work of Palmieri *et al.* (2019).

Taste

Consumers seem to keep skeptical about eating new food such as insect food. However, with their curiosity combined with having chances to taste insect food, consumers' minds can be changed positively. By applying the theory of planned behavior (TPB), Menozzi *et al.* (2017) reported that consumer attitudes and intention to consume insect food increased after they tasted this food. In another study in Belgium (Megido *et al.*, 2016), the authors also concluded that insect tasting is important to make people familiar with insect food. This conclusion is in line with the findings of Pambo *et al.* (2018b), who confirmed the role of real taste in persuading consumers to eat insect food. Lensvelt and Steenbekkers (2014) also highlighted as "...It seems more important to encourage people to make "the first step" and get them acquainted with eating insects rather than only providing information". The changes in consumer expression had been explored more clearly in the work of Goff and Delarue (2017), who conducted an experiment to evaluate reactions of consumers before and after tasting insect food. The authors concluded a higher positive expression of consumers about insect food after tasting the food.

Familiar food with insect-processed ingredients

Processing insects into an appropriate product has been also essential to keep consumers consume insect food. Tan *et al.* (2017a) found that insect food properties affected consumers' sensory perceptions. Then the authors stressed that willingness to consume insect food depended on the food appropriateness (Tan *et al.*, 2017a). In another work, these authors confirmed again the effect of insect food appropriateness on consumer acceptance that an appropriate product context improved the expected sensory-liking and willingness to buy mealworm products (Tan *et al.*, 2017b).

Information provision

Many consumers do not have adequate knowledge about insect food due to the lack of information. Thus, communication on the benefits of insect food can be effective to improve consumer acceptance of this food (Verneau *et al.*, 2016). The positive effect of information on the nutritional value of insect-based food on consumers' attitudes through officials was also verified by the work of Alemu *et al.* (2017). Another way to affect consumer evaluations of insect food was through peer and expert influence as recommended by Berger *et al.* (2019).

Socio-demographic factors

Effects of socio-demographic variables on consumer attitudes and readiness to adopt insects as food and feed were not found to be much significant in prior work. While some work verified that gender, age, and education influenced consumer acceptance of insect food, other studies could not confirm these effects.

Gender

Some research found the gender difference also leads to the difference in accepting insects as food. For instance, males were more likely to accept insect food (Schaufele *et al.*, 2019; Tuccillo *et al.* 2020; Verbeke, 2015). Lammers *et al.* (2019) also pointed that men had more intention to eat the unprocessed insects than women.

In addition, the perception of insect food varies differently between men and women. In a study on the effects of information provision on consumer attitudes, Barsics *et al.* (2017) found that men’s evaluations of overall linking and flavor scores were more significantly influenced by information provision about insect food. Similarly, Ruby *et al.* (2015) concluded that men had a higher willingness to try insect food than females did. However, in a global survey, Castro and Chambers IV (2018) reported no correlation between gender and willingness to eat insect food.

Age

Young people (especially attached with males) will be more ready to consume insect food (Verbeke 2015). By contrast, older people tended to consume more insect food in a study in Asian countries such as China (Liu *et al.*, 2019). In another study, Lammers *et al.* (2019) found that age did not influence consumer

acceptance of insect food.

Education

Few studies examined the impact of education on consumer acceptance of insect food. Highly educated consumers tended to accept eating insect food more easily than low ones (Cicatiello *et al.*, 2016). However, no significant effect of education was found in the work of Lammers *et al.* (2019).

Steps to incorporate and popularize insect food products

Based on the factors influencing consumer attitudes and behavior toward eating insect food mentioned above, we propose steps to incorporate and popularize insect food products in consumers’ diets in Fig. 1. Accordingly, the first step is to design insect food products that are appropriate and attractive to consumers. This requires the selection of popular insects easily accepted by people across their personal and cultural characteristics. Processing insects to become food must meet the requirement of food safety as suggested in previous work (Imathiu *et al.*, 2020; Rumpold and Schlüter, 2013). It is also important to produce insect food based on the texture, smell, color and visibility of insects that make and attract people more familiar with this kind of food. Importantly, the information of these insect food products should be traceable and transparent with clear labels or quality claims. The second step is to successfully introduce to early adopters by offering them a chance to taste and try eating insect food. This stage requires a comprehensive evaluation of consumers’ perception, attitudes and readiness to accept insects as food based on their socio-demographic and psychological-cultural characteristics. Proper communication strate-

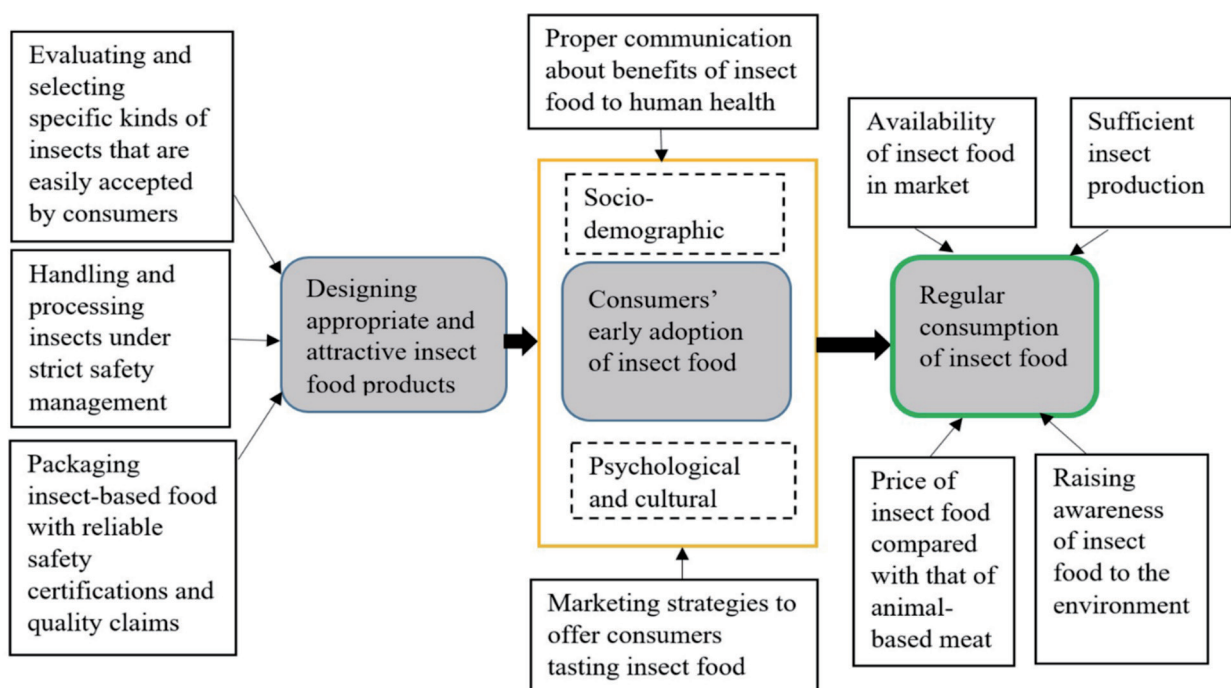


Fig. 1. Steps to incorporate insect food into consumers’ tables.

gies about the benefits of insect food to human health should be implemented efficiently and widely to the public as recommended by Verneau *et al.* (2016). In the final phase, more efforts should be placed to encourage early adopters to become regular eaters of insect food. To do this, maintaining a sufficient supply of edible insects and displaying insect food to markets (i.e., in shops or supermarkets as suggested by Alemu *et al.*, 2016) is vital. The price of insect food in comparison with that of domestic animal-sourced protein is also needed. At this stage, the environmental benefits of entomophagy to the public should be highlighted, which facilitates consumers to maintain eating insect food in a long-run period.

Suggestions for further research on insect food

Further understanding about consumer behavior to consume new food such as edible insects is needed. Based on this review, some below suggestions are recommended for research on this field in the future. First, it is urgent to have more research on the popularity of eating (regular consumption) insect food in Eastern areas (Asian, African, and Latin American countries) where people are more familiar with insect food, which is also recommended by other scholars (Dobermann *et al.*, 2017). This is expected to find possible ways to commercialize insect food production in such countries. Second, differences in consumer attitude and acceptance of insect food across geographical or cross-cultural sites (i.e., urban vs. rural, Eastern vs. Western countries) in relation to personal/psychological characteristics (high vs. low food neophobia or food disgust) should be more explored. Estimating the confounding effects of these factors could better understand and identify market segments for insect food businesses. Third, further research on consumer attitudes and acceptance of insect food with certified and non-certified by safety certifications/quality labels needs to be done. When many consumers (especially in Western countries) keep food neophobia and food disgust caused by their fear of food insect safety (Imathiu, 2020), the role of safety certifications or quality labels toward consumer acceptance of insect food should be paid much attention. Forth, it is needed to have more research on the impact of specific insect species used in insect food on consumer attitudes and acceptance. This facilitates to design appropriate and attractive insect food for both early adopters and regular consumers. Finally, the competitiveness of insect food (i.e., in terms of price, deliciousness, availability and convenience) compared with traditional food (pork, chicken, beef) should be more concerned. Currently, consumers still prefer livestock animal-based meat to insect food. Thus more research is highlighted to evaluate willingness to pay for insect food attributes in comparison with such traditional food.

LIMITATIONS AND CONCLUSION

Despite our efforts to provide a review of consumer attitudes and acceptance of insect food worldwide, some

limitations are unavoidable and need to be mentioned. This review only gathers the latest original articles in English languages in the period of 2013 – 2020, which left some other studies outside these criteria. Another limitation is related to the complex of previous work in terms of objectives and methodologies, which makes it difficult to synthesize findings of such papers into visual basic statistics on tables or figures. Also, bias in targeted-area surveys (many Western vs. few Eastern countries) limits us to make the comparison in consumer behavior between two different cultural regions.

Based on the existing literature on consumer behavior toward insect food, this review confirms that almost work focused on insects as food in Western countries. Generally, Western consumers exhibit negative evaluations and low readiness to adopt insect food compared with Eastern counterparts. Food neophobia and food disgust are considered as the main barriers to the uptake of this food into the human diet in Western society. Cultural differences, insect species, visibility of insect food, ways of processing insect food, perception of insect food safety also influence consumer willingness to eat insect food. Designing appropriate and attractive insect food products with publicizing the benefits (especially to human health) of this food more widely are essential to early adopters. Meanwhile, establishing competitiveness about prices and availability/convenience in providing insect food compared to traditional animal-derived meat should be much emphasized to develop regular consumers of such food.

AUTHOR CONTRIBUTIONS

Hai Minh NGO designed the analysis, collected prior studies and analyzed the data, wrote and finalized the manuscript. Masahiro MORITAKA designed the analysis, supervised data collection, provided critical suggestions on data analysis, revised and finalized the manuscript.

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