Research Article

Nada Mallah Boustani, Raquel P. F. Guiné*

Exploring innovative food in a developing country: Edible insects as a sustainable option

https://doi.org/10.1515/opag-2022-0287
received January 28, 2024; accepted April 4, 2024

Abstract: Today's consumers are becoming more aware of what they eat and the benefits that a healthy diet can provide. Edible insects (EIs) have recently been proposed as a sustainable, protein-rich alternative food source. Consumers' adoption of insects as part of their diet may be influenced by their awareness of this source of food. In this context, the current study investigated the level of knowledge about EI in a developing country, with the goal of understanding how Lebanese people perceive EI as food, as well as whether there are any sociodemographic or socioeconomic differences in their knowledge and motivation to accept EI as food. This was a cross-sectional study conducted using a questionnaire survey of 357 Lebanese participants. Basic descriptive statistics were employed to analyze the data, which were supplemented with statistical tests such as ANOVA for comparisons between three or more groups with post hoc to examine any group differences and Cronbach's alpha to assess internal scale reliability. The search for differences according to sociodemographic and socioeconomic characteristics showed significant differences between age groups and levels of education. Additionally, the results showed that the items used to assess the EI dimensions scale have a very high internal consistency, with the lowest being nutritional aspects (α = 0.669) and the highest being health effects (α = 0.797). This work is relevant because it highlights the EI food dimensions that influence people's acceptance in Lebanon, which is facing social and economic crises while highlighting many age inequalities and education level differences. Based on the findings, individual EI dimensions were discovered, allowing for strategies deployment to effectively improve knowledge and eventually respond to a Sustainable Development Goal objective even in a nation where this is not a traditional practice.

Keywords: edible insects, sustainability, sociodemographic characteristics, socioeconomic variables, Lebanese consumers, questionnaire survey

1 Introduction

Insects have been used as a wide variety of food items throughout human history, showing up as snacks, side dishes, and even major courses [1]. Insects were an essential component of diets in parts of Africa, Latin America, and Asia, providing not only food but also acting as therapeutic ingredients and treats [2,3]. Approximately 2,100 species of edible insects (EIs) are thought to have been eaten [4]. Even in light of this historical background, eating insects is still widely seen as an unusual food source, though certain societies tolerate it better than others.

Studies reveal that differences in culture have a big impact on how different people feel about eating insects [5]. Notwithstanding these cultural quirks, insects have drawn interest as a possible future food source. Food made from insects is known to be more efficient than animal products when it comes to price, nutritional value, and other aspects [6]. Notably, EIs are a significant source of protein; several have a protein level of more than 50% [7].

The first food and drink items containing insect components were introduced to the European market in 2014, and they began to acquire considerable popularity in 2018. Although entire insects are used in certain goods, most use powdered insects as an additional component in pasta, bread, energy bars, crackers, protein drinks, chocolate bars, and spreads [8]. Given that insects are still viewed as unusual and innovative meals in this region, adding them as "invisible" components to well-known items may increase their acceptance among Western customers [9]. On June 1, 2021, the first rule (EU) 2021/882 was issued, allowing the commercialization of dried yellow mealworms [10].

*** Corresponding author: Raquel P. F. Guiné**, CERNAS-IPV Research Centre, Polytechnic University of Viseu, Campus Politécnico, Repeses, 3504-510, Viseu, Portugal, e-mail: raquelguine@esav.ipv.pt
Nada Mallah Boustani: Faculty of Business & Management, Saint Joseph University, Social Science Campus, Beirut, Lebanon; Laboratory of Economics, Finance, Management, and Innovation (LEFMI), Amiens, France, e-mail: nada.mallahboustany@usj.edu.lb

Research institutes and the food sector are interested in EI for several reasons. First off, compared to traditional animal protein sources like beef, pig, and chicken, the production of insects has a far smaller environmental effect, resulting in a reduction in greenhouse gas emissions from all other food sources [11]. Furthermore, while meat consumption is concentrated in wealthier countries, it is also increasing in emerging nations as incomes rise [12]. Growing insects, on the other hand, is considered sustainable because it requires less water and land and emits less greenhouse gases [13]. Furthermore, insects are recognized as a valuable source of protein with a favorable amino acid profile, high in unsaturated fatty acids, and a variety of minerals and vitamins [9].

Despite its many advantages, the EI industry confronts a number of problems. These include food neophobia, revulsion, cultural mismatch, the assumption that eating insects is antiquated, and a lack of information about entomophagy [9,13]. In addition, insects are frequently viewed as unsanitary pests rather than wholesome food sources and are linked to the transmission of illnesses [14]. According to Fernandez-Cassi et al. [15], the European Food Safety Authority [16] assessed that viruses provide a low-risk danger to people and vertebrate animals after conducting a risk assessment for insects meant for food and feed. Food items that contain insect powder can benefit from a high protein content [13] as well as vital micronutrients that boost immunological function, such as copper, iron, zinc, and vitamin B12 [3].

When it comes to food, neophobia is based on the belief that certain human actions are immoral or disgusting [17], such as the hatred of unfamiliar meals [18]. Surprisingly, neophobia is more common in older people than in younger people [19]. It is obvious that men and women react differently to neophobia [20]. Higher educational accomplishment has been demonstrated to lower it [19,20], implying that education level is also essential.

Research has indicated that heightened awareness and exposure to extra-indulgent foods (EI foods) enhance the probability of consuming them [5]. Even in situations when cultural contexts are largely comparable, different cognitive frameworks can influence eating decisions [5]. Piha et al. [5] investigated the willingness of residents of Northern and Central Europe to purchase insect-based foods. They found that experiences related to the product had a positive correlation with knowledge, which in turn affected general attitudes and ultimately affected purchasing intentions.

Since prevention is still possible, but reversing the effects becomes unlikely after certain thresholds are reached, addressing climate change becomes an imperative worldwide priority. Like the rest of the globe, Lebanon is confronted with impending difficulties such as high temperatures and decreased agricultural yields, which exacerbate food scarcity and impede the production of adequate household food. A growing number of countries throughout the world, especially in the MENA area, are experiencing food insecurity as a result of continuous conflicts, political unrest, financial crises, and climate change [21,22]. A notable example is Lebanon, which has seen decades of hardship due to issues such as structural corruption, the Syrian conflict, and the catastrophic explosion that occurred at the Beirut Port on August 4, 2020. The crisis in Lebanon is ranked as one of the "top 10 most severe crises globally since the 19th century" by the World Bank. The Lebanese pound (LBP) is constantly losing value in relation to the US dollar (USD), which makes it extremely difficult for the nation to obtain food on its own without outside assistance.

Since the ongoing war between Russia and Ukraine has disrupted Lebanon's primary supply of wheat, the country's food problems have become worse, requiring immediate action to ensure the availability of essential foods [23]. Adding to the difficulty, importing food requires USD, while national food costs and earnings are in LBP. Lebanon has untapped agricultural potential at home, but it is unable to leverage it for food sustainability. Lebanon faces a lack of effective marketing and communication tactics for essential and indigenous (EI) foods, as well as poor awareness [24]. It is thus critical to study the extent of information about EI foods and their influence on intake in this regard. Despite its small size, Lebanon offers a lot of potential for EI due to its different landscapes, climate, and cultural diversity [25]. Furthermore, despite its potential, Lebanon's (EI) acceptance faces a number of challenges, including limited farm access, poor commercial infrastructure, and complex export regulations [26,27]. The incapacity of public institutions to encourage agriculture [28] and a deficiency in stakeholder cooperation [29] continue to be major obstacles to the sector's expansion in Lebanon.

Consumer awareness and knowledge gaps concerning agriculture and food significantly reduce food demand and acceptability [30]. According to research, there is a clear association between customer purchasing behavior and level of knowledge [31,32]. According to Briz and Ward [33], customers' inclination to buy or consume food products is positively influenced by their level of food knowledge. Stobbelaar et al. [34] and De Magistris and Gracia [35] found that increased consumer awareness of food items leads to more positive feelings about them. Several studies have examined how information influences consumer knowledge. Park et al. [36] argue that product-related experiential memory is more significant for knowledge appraisal than product-class information memory.

According to Bigné [37], information from a variety of sources influences consumer awareness, including governmental administration, the media, environmental groups, and online commerce.

2 Research motivation and questions

The primary goal is to examine customers' attitudes and understanding of EI, as well as to present a thorough picture of the prospects and challenges associated with their implementation in developing countries. This study investigates the influence of sociodemographic factors and knowledge on insects and insect-based products consumption in Lebanon, a developing country. The study investigates how much people in Lebanon, a country with no historical tradition of consuming insects, understand the sustainability of EI. This is significant because consumers may play an essential role in promoting more sustainable diets that incorporate insect protein-rich foods. Furthermore, the study will look into potential sociodemographic disparities in acceptance and awareness among Lebanese people, such as living environment, gender, education level, and age groups.

The study focuses on two important questions: *What is the level of knowledge of Lebanese people and their awareness about EI? Are there any sociodemographic differences in gender, age, living environment, and education level?*

3 Materials and methods

3.1 Instrument for data collection

This investigation used a survey instrument created as part of the EISuFood Project, which was a questionnaire. The primary goal of the project was to investigate different aspects of eating insects, such as habit analysis, traditional and cultural influences, innovative gastronomy, health effects, nutritional considerations, environmental and sustainable aspects, social and economic ramifications, and commercialization and marketing tactics. This article explores the extent to which Lebanese residents are aware of the sustainable effects of eating insects and the adoption of EI. On a central five-point Likert scale, with answer possibilities ranging from 1 = strongly disagree to 5 = strongly agree, participants were requested to indicate their level of agreement [38].

3.2 Data collection

A non-probabilistic sample of 357 participants from Lebanon was used for this descriptive cross-sectional research. The Declaration of Helsinki's ethical guidelines, in particular, were strictly followed during the creation of the questionnaire and the data-collecting procedures. Because of the COVID-19 pandemic's restrictions, data were collected via a computer/web-based technique from July to November of 2021. Google Forms was used as the electronic platform to conduct the survey instrument. A survey participation link was supplied to each participant, and access to the questionnaire was restricted to adult individuals (18 years of age or older) who had provided clear and informed permission in order to participate in the study.

3.3 Statistical analysis

The IBM, Inc. (Armonk, NY, USA) statistical analysis software SPSS Version 28 was used for this investigation. Basic descriptive statistics were utilized, along with statistical tests, to evaluate differences between variable groups. Because they were stronger and more effective than non-parametric tests, parametric tests were preferred. According to the Kolmogorov–Smirnov test, the large number of cases in this instance made it easier to collect data with a normal distribution. Consequently, parametric tests, notably the *t*-test for independent samples and analysis of variance (ANOVA), were done, augmented by a Tukey post hoc test to discover any discrepancies. Throughout all tests, a significance threshold of 5% was kept ($p < 0.05$).

4 Results

4.1 Sample characterization

The age range of participants varied from 19 to 72 years, with an average age of 33.6 ± 14.05 years. Participants were classified into certain age groups. The criterion used to establish the age classes was considering that in the present day, with increasing life expectancy, especially in European and neighboring countries, young adults no longer include only people up to 25 years, but a wider class of up to 30 years is adopted globally for the young adults. Also, because our sample, being a convenience sample, did not include many people over 65, and even because it is no longer widely accepted that people over 65 should be

named elderly, we opted for a different classification by including people under or over 50 years, as adults or senior adults, thus avoiding the need to establish a class for elderly. Based on these age classes, our sample consisted of 56% young people (18–30 years), 26.3% adults (31–50 years), and 17.7% senior adults (51 years or over).

The gender distribution of the participants showed that men made up the majority (54.3%), women made up a significantly lesser percentage (42.6%), and 3.1% of the participants did not identify their gender. The participants' living conditions were another characteristic looked at, and it was found that 56.9% of them lived in urban regions, compared to lesser percentages in suburban (21.8%) and rural (21.3%) locations. 3.6% reported having a much lower income, 15.4% had a lower income, 44.8% had an equal income, 29.1% had a higher income, and 7% had a substantially higher income in terms of income variety.

One relevant facet of the study was the participants' educational background; 4.8% of them had finished elementary, secondary, or undergraduate education. By comparison, a sizable majority (58.8%) had graduated from college, and a noteworthy fraction (36.4%) had pursued graduate-level education, such as master's or doctoral degrees (Table 1).

Table 1: Sociodemographic characteristics of the sample

Variables	Groups	*N*	%	Mean	Standard deviation
Age	Young adults	200	56	1.62	0.769
	Adults	94	26.3		
	Senior adults	63	17.6		
Gender	Female	152	42.6	1.61	0.549
	Male	194	54.3		
	Don't want to answer	11	3.1		
Education	Post-graduate education	130	36.4	1.68	0.559
	Completed a university degree	210	58.8		
	No university degree	17	4.8		
Living Environment	Rural	76	21.3	2.01	0.658
	Urban	203	56.9		
	Suburban	78	21.8		
Income	Much lower	13	3.6	3.2	0.912
	Lower	55	15.4		
	Equal to average	160	44.8		
	Higher	104	29.1		
	Much higher	25	7		
Total		**357**	**100**		

4.2 Lebanese validation of the instrument for collection of data on knowledge about EI

The population of Lebanon is covered by the validation of the questionnaire. The authors examined the reliability of the questions in the seven dimensions that account for the many features concerning EI cuisine for the replies of the Lebanese participants, even though the questionnaire had already been validated [39]. The seven dimensions were as follows: culture and tradition (C&T), gastronomic innovation and gourmet kitchen (GI), environment and sustainability (E&Su), economic and social aspects (E&So), commercialization and marketing (C&M), nutritional aspects (NA), and health effects (HE).

Table 2 displays the Cronbach alpha results. Most of the values are near 0.7 or above, indicating that each of the dimensions under examination has internal consistency. Furthermore, it was noted that the dietary components (α = 0.669) had the lowest internal consistency, while the health effect (α = 0.797) and environment and sustainability (α = 0.786) had the greatest alpha.

4.3 Influence of sociodemographic variables on the EI dimensions

Table 3 presents the results of ANOVA tests to evaluate differences between groups for the seven dimensions of knowledge about EI. According to Table 3, practically all sociodemographic variables, except gender, influence the EI dimensions (significance of the test: $p < 0.05$. ANOVA with post hoc test of Tukey). Significant age differences are shown in Table 3, with statistically significant differences ($p < 0.05$) found in almost every case except for dimension NA. People between the ages of 31 and 50 had mean values, in general, higher than those of younger and older adults, suggesting that the former had a better comprehension of the knowledge component of EIs. For gender, no significant differences were found for any of the seven dimensions analyzed. The mean values for gender groups show that there are no disparities between men and women in any of the dimensions of knowledge about EI, and participants showed a somewhat precise comprehension of the characteristics of EI. Notably, both groups (men and women) had high averages and scores that were closely linked, indicating a positive assessment of knowledge. Significant variations were found for most of the dimensions when it came to the education categories $p < 0.05$. University graduates often showed higher mean values, while post-graduate

Table 2: Reliability analysis of the variable's dimensions of EI food

Dimensions	Cronbach's alpha	Cronbach's alpha based on standardized items	Number of items
Culture and tradition	0.744	0.735	10
Gastronomic innovation and Gourmet kitchen	0.711	0.74	9
Environment and sustainability	0.786	0.78	11
Economic and social aspects	0.679	0.68	6
Commercialization and marketing	0.72	0.711	8
Nutritional aspects	0.669	0.682	10
Health effects	0.797	0.803	10

students or those without a degree in the Lebanese population showed lower mean values. For most EI knowledge dimensions, no statistically significant differences were found between participants living in various environments (at a 5% level of significance). Some significant differences were found for dimensions C&T as well as for H&E. The participants from suburban regions had, in general, the highest mean scores, followed by those from urban and rural areas; however, there were modest variances in the mean scores. The findings show that there are no appreciable variations in the participants' EI knowledge based on where they live. With respect to income, only two of the seven dimensions studied were found to have significant differences ($p < 0.05$), NA and HE, both related to nutrition and health. For most dimensions, no significance based on income and living environment was observed for EI food in Lebanon, in contrast to more industrialized nations where a pattern of social differences in diet is established, leading to lower socioeconomic groups typically adopting lower-quality diets with inferior nutritional value [40,41].

The Pearson correlation statistical test findings are displayed in Table 4 with respect to EI knowledge. From the results, it can be observed that all dimensions showed positive correlations with each other. The health effect variable had the strongest link with EI's dietary components as well as with culture and tradition, according to the values of the correlation ($r = 0.671$ and 0.646, respectively). A noteworthy finding is that most of the variables have a strong positive association with culture and tradition, with values higher than 0.5 ($r = 0.603$ for GI, $r = 0.550$ for E&So, $r = 0.594$ for NA and $r = 0.646$ for HE), but also values very close to 0.5 in the remaining cases ($r = 0.459$ for E&Su, $r = 0.497$ for C&M). This suggests that civilization and culture have a significant impact on how people cook, how they feel about the environment, how they do business, how they communicate, what they eat, and how their health turns out. The association that exists between culinary innovation and culture and tradition ($r = 0.603$) highlights the significance of this type of innovation in the culinary field regarding sustainability, economic dynamics, good communication, dietary concerns, and health effects. Further evidence that health concerns are ingrained in many aspects of culture, cuisine, sustainability, economy, communication, and nutrition comes from the high positive association that exists between HE and other dimensions (correlation higher than 0.5 in all cases except for E&Su, with a value also very close to 0.5, $r = 0.495$). This emphasizes how food decisions and health outcomes are linked, as is becoming increasingly clear.

5 Discussion

According to data forecasts from the UN Department of Economic and Social Affairs, by the year 2100, there will be about 11 billion people on the planet [42]. Meeting this dilemma is critical, as the demand to feed more people grows increasingly urgent. However, improving economic conditions also means higher per capita food demand, which is another important consideration. Given that economic predictions indicate a one-third rise in global food consumption by 2050, some experts even suggest that this may be a more major driver of food demand than population growth.

To achieve the UN Sustainable Development Goals (SDGs), which define the "good life," it is imperative that every person has access to food. This project is closely related to accomplishing other SDGs, such as ending poverty, encouraging responsible consumption and production, protecting the environment, combating climate change, and preserving life on land and underwater. The achievement of these objectives is predominantly contingent upon the establishment of more sustainable food systems, which encompass efficacious strategies to alleviate the consequences of food production, processing, transportation, and waste generation throughout the supply chain, encompassing packaging materials [43,44]. The SDGs and the goal of eradicating poverty through responsible food production and reduced use of natural resources align with this

Table 3: Reliability analysis of the variable's dimensions of EI food

Variables	Groups		Dimensions of knowledge about EI						
			C&T	GI	E&Su	E&So	C&M	NA	HE
Age	Young adults	Mean	3.4200	3.4550	3.3750	3.4900	3.4050	3.5700	3.5950
		Std.D	0.7323	0.6931	0.6832	0.7017	0.7096	0.5889	0.6188
	Adults	Mean	3.6596	3.7660	3.7128	3.8191	3.6277	3.7128	3.8404
		Std.D	0.4985	0.4257	0.4549	0.3870	0.5284	0.4549	0.3682
	Senior adults	Mean	3.6190	3.7778	3.5873	3.7619	3.7143	3.6667	3.8730
		Std.D	0.6332	0.4559	0.6126	0.5302	0.6072	0.5680	0.5533
	***p*-value (Sig.)**		0.0066	0.0000	0.0000	0.0000	0.0008	0.0967	0.0001
Gender	Female	Mean	3.4671	3.5921	3.5066	3.6447	3.5526	3.6250	3.7171
		Std.D	0.6993	0.6546	0.6611	0.5801	0.6885	0.5497	0.6026
	Male	Mean	3.5567	3.5773	3.4742	3.5979	3.4794	3.6134	3.7010
		Std.D	0.6513	0.5907	0.6124	0.6544	0.6455	0.5668	0.5418
	No answer	Mean	3.5455	3.9091	3.9091	3.8182	3.7273	3.8182	3.7273
		Std.D	0.5222	0.3015	0.5394	0.6030	0.4671	0.4045	0.4671
	***p*-value (Sig.)**		0.4621	0.2187	0.0856	0.4547	0.3358	0.4937	0.9604
Education	Post-graduate education	Mean	3.3462	3.4538	3.4000	3.5385	3.3692	3.4538	3.5385
		Std.D	0.7441	0.6945	0.6774	0.6837	0.7059	0.5855	0.6119
	With university degree	Mean	3.6857	3.7286	3.5810	3.7143	3.6524	3.7667	3.8476
		Std.D	0.5325	0.4965	0.5751	0.5571	0.6094	0.4771	0.4848
	No university degree	Mean	2.7647	3.0000	3.2941	3.1765	3.0000	3.1765	3.2941
		Std.D	0.7524	0.7071	0.8489	0.6359	0.3536	0.6359	0.5879
	***p*-value (Sig.)**		0.0000	0.0000	0.0143	0.0003	0.0000	0.0000	0.0000
Living environment	Rural	Mean	3.6316	3.6053	3.4737	3.6447	3.5658	3.6842	3.7763
		Std.D	0.6076	0.5675	0.5994	0.5343	0.5498	0.5218	0.6022
	Urban	Mean	3.4236	3.5567	3.4778	3.5813	3.4729	3.5714	3.6453
		Std.D	0.7091	0.6604	0.6845	0.6944	0.6987	0.5958	0.5822
	Suburban	Mean	3.6538	3.6795	3.5897	3.7179	3.5897	3.7051	3.8077
		Std.D	0.5772	0.5221	0.5206	0.4807	0.6534	0.4589	0.4575
	***p*-value (Sig.)**		0.0085	0.3190	0.3805	0.2445	0.3228	0.1118	0.0485
Income	Much lower	Mean	3.5385	3.4615	3.3846	3.3077	3.4615	3.4615	3.3077
		Std.D	0.5189	0.5189	0.5064	0.9473	0.8771	0.5189	0.6304
	Lower	Mean	3.6000	3.5091	3.3455	3.6182	3.4727	3.7091	3.8000
		Std.D	0.7097	0.7168	0.6446	0.6524	0.6900	0.6287	0.5900
	Equal to average	Mean	3.5688	3.6000	3.5313	3.6438	3.5625	3.6625	3.7438
		Std.D	0.6307	0.6163	0.6237	0.6178	0.6313	0.5247	0.5408
	Higher	Mean	3.3750	3.6154	3.5288	3.6154	3.4423	3.5000	3.6442
		Std.D	0.6853	0.5797	0.6379	0.5797	0.6802	0.5574	0.5382
	Much higher	Mean	3.6000	3.7200	3.6000	3.7200	3.6800	3.8000	3.7600
		Std.D	0.7638	0.5416	0.7071	0.5416	0.5568	0.5000	0.6633
	***p*-value (Sig.)**		0.1410	0.5848	0.2966	0.3883	0.4139	0.0271	0.0369

Abbreviations: culture and tradition (C&T), gastronomic innovation (GI), environment and sustainability (E&Su), economic and social (E&So), communication and marketing (C&M), nutritional aspects (NA), health effect (HE); standard deviation (Std.D).

interest, which is fuelled by factors such as high nutritional value, low environmental impact, and the potential to improve the sustainability of rural communities and low-income families [45].

Difficulties such as their unusual flavor, appearance, and limited public knowledge may prevent widespread adoption [46]. Many studies conducted in many countries have attempted to elucidate the complex relationship between consumers and the usage of insects as food. According to research conducted in Hungary, food neophobia is a barrier to eating insects, and gender is a crucial issue, with women being less inclined to eat insects than men. Orsi et al.'s [13] study on German consumers confirmed that neophobia and revulsion related to barriers to incorporating insects into their diet. Sogari et al. [47], on the other hand, determined that young Italians were willing to eat insects owing to their curiosity. Environmental concerns have been found to be a potent

Table 4: Correlation matrix between EI dimensions

Dimensions	C&T	GI	E&Su	E&So	C&M	NA	HE
C&T	1						
GI	0.603**	1					
E&Su	0.459**	0.532**	1				
E&So	0.550**	0.549**	0.521**	1			
C&M	0.497**	0.521**	0.538**	0.537**	1		
NA	0.594**	0.450**	0.400**	0.510**	0.471**	1	
HE	0.646**	0.589**	0.495**	0.583**	0.571**	0.671**	1

Abbreviations: culture and tradition (C&T), gastronomic innovation (GI), environment and sustainability (E&Su), economic and social (E&So), communication and marketing (C&M), nutritional aspects (NA), health effect (HE). **Correlation is significant at the 0.01 level (one-tailed).

motivator for sustainable food choices, emphasizing consumers' vital role in supporting good changes toward more sustainable diets [48]. However, the fundamental components of knowledge and information must be present for these behavioral changes to be effective [49].

Consistent with this viewpoint, the present study revealed certain gaps in the participants' understanding of sustainability matters pertaining to EI environmental effect. Redefining ways to achieve more sustainable food supply chains requires an understanding of management processes [50]. Notable disparities were found when the sociodemographic features of the participants were examined in relation to their knowledge levels about the sustainability of EIs. These differences showed a pattern of males and young adults having higher knowledge, which is consistent with earlier research that found gender and age to be factors influencing knowledge in a variety of domains [51,52], as well as factors influencing the adoption of environmental behaviors [53]. In addition to cultural background, Laureati et al.'s [54] study identified age and gender as the primary determinants of Italian consumers' readiness to eat EIs.

Knowledge of the sustainability of EIs was shown to be influenced by socioeconomic factors, such as income and education, with people with higher education levels demonstrating more knowledge. Seehawer and Breidlid [55] highlighted the importance of education in improving knowledge in a variety of fields and the role that high-quality education plays in helping students learn more effectively and become more knowledgeable about the aims of sustainable development. According to Estrada-Vidal and Tójar-Hurtado [56], university students' knowledge and attitudes are essential factors to consider when developing future interventions that aim to improve sustainability. Redman and Redman [57] pointed out that there is more to the indirect association between declarative knowledge and sustainable behavior than meets the eye. They proposed that social knowledge, as opposed to declarative information, is a more reliable indicator of sustainable behavior.

With respect to the sustainability of EIs, many studies in the literature have demonstrated that insects are comparatively more sustainable when compared with other animal protein sources, like cows, pigs, or even chicken [58]. However, consumption in some areas is not easy due to preconceptions, neophobia or even disgust towards insects that are not traditionally part of some people's diets [59]. The work by Zugravu et al. [60] identified knowledge as a factor in favor of increasing the acceptance of insects as food in a European Country, Romania. Another study focused on the consumption of EIs in the Netherlands, particularly in the context of circularity and urban farming [61]. The European context is particularly complex, and even after the European Food Safety Authority (EFSA) made public a positive risk assessment report regarding EI, it is true that few species can be legally farmed and processed in the European Market according to the Novel Foods regulation 2015/2283, as depicted in the review by Vale-Hagan [62].

The present study also looked at possible knowledge gaps depending on where people live, and it was found that two of the dimensions of knowledge about EI were significantly different according to the living environment. Our findings are in accordance with other studies where the choice to purchase EI meals was highly impacted by sociodemographic characteristics, including age, family size, income, and area, in China [63].

6 Conclusions

The purpose of this study was to evaluate Lebanon's general degree of awareness about the sustainability of EIs. The results showed a modest level of awareness. Significant

variations were found when the impact of sociodemographic variables on knowledge levels was examined, suggesting that adult individuals and with a university degree tend to have greater knowledge levels. Furthermore, significant differences in knowledge were found according to the individuals' residential settings, with urban dwellers often scoring lower. The investigation of socioeconomic factors, including income and education, revealed that individuals with higher income and education levels tend to possess more knowledge.

These results highlight how many demographic, social, economic, and geographic aspects affect understanding of the sustainability of EIs. This knowledge may be the basis for creating plans to improve the way that information is shared throughout communities, which may lead to more people being open to the idea of using insects as a sustainable source of protein substitute. It is advised that comparable studies be carried out in other nations, both those where entomophagy is a traditional practice and those where it is not, to further investigate the cross-cultural implications of this information, given the remarkable results.

Acknowledgments: This work was supported by the FCT (Foundation for Science and Technology, I.P). Furthermore, we would like to thank the CERNAS (UIDB/00681/2020, doi: 10.54499/UIDP/00681/2020) Research Center and the Polytechnic University of Viseu for their support.

Funding information: We received funding from the FCT (Foundation for Science and Technology, Portugal) through project Ref. UIDB/00681/2020 (doi: 10.54499/UIDP/00681/2020). The APC was funded by FCT through project Ref. UIDB/00681/2020.

Author contributions: All authors accepted the responsibility for the content of the manuscript and consented to its submission, reviewed all the results, and approved the final version of the manuscript. NMB – conceptualization, investigation, data analysis, writing – draft; RPFG – project administration, data curation, writing – review and editing.

Conflict of interest: Authors state no conflict of interest.

Data availability statement: Data may be requested from the corresponding author upon reasonable request.

References

[1] Verkerk MC, Tramper J, van Trijp JC, Martens DE. Insect cells for human food. Biotechnol Adv. 2007;25:198–202.

[2] Harris M. Good to eat: Riddles of food and culture. New York: Waveland Press; 1998.

[3] Dossey AT, Morales-ramos JA, Rojas MG. Insects as sustainable food ingredients. Production, processing, and food applications. Cambridge, Massachusetts, USA: Academic Press; 2016. doi: 10.1016/c2014-0-03534-4.

[4] LaMotte S. The food that can feed and maybe save, the planet: Bugs [Internet]. Atlanta: CNN; 2019 [cited 2020 April 22]. https://edition.cnn.com/2019/10/25/health/insects-feed-save-planet-wellness/index.html.

[5] Piha S, Pohjanheimo T, Lähteenmäki-Uutela A, Křečková Z, Otterbring T. The effects of consumer knowledge on the willingness to buy insect food: an exploratory cross-regional study in Northern and Central Europe. Food Qual Prefer. 2018;70:1–10.

[6] Tabassum-Abbasi, Abbasi T, Abbasi SA. Reducing the global environmental impact of livestock production: The mini livestock option. J Clean Prod. 2016;112:1754–66.

[7] Bukkens S. The nutritional value of edible insects. Ecol Food Nutr. 1997;36:287–319.

[8] Mintel. Global new products database. Private data regarding new launched products in 86 markets across. London, United Kingdom; 2021. https://www.mintel.com/.

[9] Gere A, Székely G, Kovács S, Kókai Z, Sipos L. Readiness to adopt insects in Hungary: A case study. Food Qual Prefer. 2017;59:81–6. doi: 10.1016/j.foodqual.2017.02.005.

[10] (EU) 2017/2470. OJ L 194, 2.6.2021, p. 16–20.

[11] Smith MR, Stull VJ, Patz JA, Myers SS. Nutritional and environmental benefits of increasing insect consumption in Africa and Asia. Environ Res Lett. 2021;16:065001. doi: 10.1088/1748-9326/abf06c.

[12] Gómez-Luciano CA, Rondón Domínguez FR, Vriesekoop F, Urbano B. Consumer Acceptance of Insects as Food: Revision of Food Neophobia Scales. J Int Food Agribus Mark. 2021;34:305–19. doi: 10.1080/08974438.2021.1889733.

[13] Orsi L, Voege LL, Stranieri S. Eating edible insects as sustainable food? Exploring the determinants of consumer acceptance in Germany. Food Res Int. 2019;125:108573. doi: 10.1016/j.foodres.2019.108573; Kornher L, Schellhorn M, Vetter S. Disgusting or innovative-consumer willingness to pay for insect based burger patties in Germany. Sustainability 2019;11:1878. doi: 10.3390/su11071878.

[14] Patel S, Suleria HAR, Rauf A. Edible insects as innovative foods: Nutritional and functional assessments. Trends Food Sci Technol. 2019;86:352–9. doi: 10.1016/j.tifs.2019.02.033.

[15] Fernandez-Cassi X, Supeanu A, Jansson A, Boqvist S, Vagsholm I. Novel foods: A risk profile for the house cricket (Acheta domesticus). EFSA J. 2018;16(S1):e16082. doi: 10.2903/j.efsa.2018.e16082.

[16] EFSA Scientific Committee. Risk profile related to production and consumption of insects as food and feed. EFSA J. 2015;13(10):4257. doi: 10.2903/j.efsa.2015.4257.

[17] Schwartz GE, Weinberger DA, Singer JA. Cardiovascular differentiation of happiness, sadness, anger, and fear following imagery and exercise. Psychosom Med. 1981;43:343–64.

[18] Pliner P, Hobden K. Development of a scale to measure the trait of food neophobia in humans. Appetite. 1992;19:105–20.

[19] Meiselman HL, King SC, Gillette M. The demographics of neophobia in a large commercial US sample. Food Qual Prefer. 2010;21:893–7.

[20] Tuorila H, Lahteenmaki L, Pohjalainen L, Lotti L. Food neophobia among the Finns and related responses to familiar and unfamiliar foods. Food Qual Prefer. 2001;12:29–37.

[21] WFP. At the Root of Exodus: Food Security, Conflict and International Migration.World Food Programme (WFP), Rome-Italy; 2017a.

[22] WFP. Lebanon Country Strategic Plan (2018–2020). World Food Programme (WFP), Beirut-Lebanon; 2017b.
[23] ESCWA, & FAO Arab Food Security: Vulnerabilities and Pathways.
[24] Boustani N, Cardoso A, Guiné R. Understanding the role of media and food labels to disseminate food related information in Lebanon. Open Agric. 2022;7(1):147–60. doi: 10.1515/opag-2022-0068.
[25] Kimbrell M. Organic movement slowly catching on in Lebanon. Lebanon: The Daily Star; 2007, November. http://www.dailystar.com.lb/News/Lebanon-News/2007/Nov-30/46733-organic-movement-slowly-catching-on-in-lebanon.ashx#axzz2q6gEdpw5.
[26] Halawi D. Organic farmers in Lebanon face export hurdles. Lebonan: The Daily Star; 2009. http://www.dailystar.com.lb/Business/Lebanon/Jun/01/Organic-farmers-in-Lebanon-face-export-hurdles.ashx#axzz2TwjRzUWP.
[27] Boustani N, Guiné R. Food determinants and motivation factors impact on consumer behavior in Lebanon. Open Agric. 2023;8(1):20220176. doi: 10.1515/opag-2022-0176.
[28] Bteich MR. *Towards a strategy for organic agriculture development in Lebanon*. abstract retrieved from the Mediterranean Agronomic Institute of Bari (Italy), CIHEAM-IAMB; 2002.
[29] Khoury R. Lebanon – country report. In: Al-Bitar L, (editor.). Report on Organic Agriculture in the Mediterranean Area. *Options Méditerranéennes*, Série B, No. 50. Bari: CIHEAM; 2004.
[30] Sangkumchaliang P, Huang W. Consumers' perceptions and attitudes of organic food products in Northern Thailand. Int Food Agribus Manag Rev. 2012;15(1):87–102. doi: 10.22004/ag.econ.120860.
[31] Tsakiridou E, Boutsouki C, Zotos Y, Mattas K. Attitudes and behavior towards organic products: An exploratory study. Int J Retail Distrib Manag. 2008;36(2):158–75. doi: 10.1108/09590550810853093.
[32] Boustasni NM, Ferreira M, Guiné RP. Food consumption knowledge and habits in a developing country: A case of Lebanon. Insights into Reg Dev. 2021;3(4):62–79.
[33] Briz T, Ward RW. Consumer awareness of organic products in Spain: an application of multinominal logit models. Food Policy. 2009;34(3):295–304. doi: 10.1016/j.foodpol.2008.11.004.
[34] Stobbelaar DJ, Casimir G, Borghuis J, Marks I, Meijer L, Zebeda S. Adolescents' attitudes towards organic food: A survey of 15-to 16-year old school children. Int J Consum Stud. 2007;31(4):349–56. doi: 10.1111/j.1470-6431.2006.00560.x.
[35] De Magistris T, Gracia A. The decision to buy organic food products in Southern Italy. Br Food J. 2008;110(9):929–47. doi: 10.1108/00070700810900620.
[36] Park CW, Mothersbaugh DL, Feick L. Consumer knowledge assessment. J Consum Res. 1994;21(1):71–82. doi: 10.1086/209383.
[37] Bigné, J. E. El consumidor verde: Bases de un modelo de comportamiento. Esic Mark. 1997;97:29–43.
[38] Likert R. A technique for the measurement of attitudes. Arch fur Psychol. 1932;22:5–55.
[39] Guiné RPF, Florença SG, Costa CA, Correia PMR, Ferreira M, Duarte J, et al. Development of a questionnaire to assess knowledge and perceptions about edible insects. Insects. 2022;13:47.
[40] Darmon N, Drewnowski A. Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. Nutr Rev. 2015;73:643–60. doi: 10.1093/nutrit/nuv027.
[41] Mullie P, Clarys P, Hulens M, Vansant G. Dietary patterns and socioeconomic position. Eur J Clin Nutr. 2010;64:231–8. doi: 10.1038/ejcn.2009.145.
[42] UN. World Population Prospects 2022. United Nations, Department of Economic and Social Affairs, Population Division; 2022. https://population.un.org/wpp/.
[43] Some S, Roy J, Chatterjee JS, Butt MH. Low demand mitigation options for achieving sustainable development goals: Role of reduced food waste and sustainable dietary choice. J Clean Prod. 2022;369:133432. doi: 10.1016/j.jclepro.2022.133432.
[44] Weber Macena M, Carvalho R, Cruz-Lopes LP, Guiné RPF. Plastic food packaging: Perceptions and attitudes of Portuguese consumers about environmental impact and recycling. Sustainability. 2021;13:9953. doi: 10.3390/su13179953.
[45] Gravel A, Doyen A. The use of edible insect proteins in food: Challenges and issues related to their functional properties. Innov Food Sci Emerg Technol. 2020;59:102272. doi: 10.1016/j.ifset.2019.102272.
[46] Vrenna M, Peruccio PP, Liu X, Zhong F, Sun Y. Microalgae as future superfoods: Fostering adoption through practice-based design research. Sustainability. 2021;13:2848. doi: 10.3390/su13052848.
[47] Sogari G, Menozzi D, Mora C. Exploring young foodies' knowledge and attitude regarding entomophagy: A qualitative study in Italy. Int J Gastronomy Food Sci. 2017;7:16–9.
[48] Guiné RPF, Bartkiene E, Florença SG, Djekić I, Bizjak MČ, Tarcea M, et al. Environmental issues as drivers for food choice: Study from a multinational framework. Sustainability. 2021;13:2869. doi: 10.3390/su13052869.
[49] Boustani N, Guiné R. Food choice motivations and perception of a healthy diet in a developing Mediterranean country. Open Agric. 2020;5(1):485–95. doi: 10.1515/opag-2020-0048.
[50] Kassaneh TC, Bolisani E, Cegarra-Navarro J-G. Knowledge management practices for sustainable supply chain management: A challenge for business education. Sustainability. 2021;13:2956. doi: 10.3390/su13052956.
[51] Ljubicic M, Saric MM, Rumbak I, Baric IC, Komes D, Satalic Z, et al. Knowledge about dietary fibre and its health benefits: A cross-sectional survey of 2536 residents from across Croatia. Med Hypotheses. 2017;105:25–31. doi: 10.1016/j.mehy.2017.06.019.
[52] Guiné RP, Florença SG, Anjos O, Boustani NM, Chuck-Hernández C, Sarić MM, et al. Are consumers aware of sustainability aspects related to edible insects? Results from a study involving 14 countries. Sustainability. 2022;14(21):14125.
[53] Ali Q, Parveen S, Yaacob H, Rani AN, Zaini Z. Environmental beliefs and the adoption of circular economy among bank managers: Do gender, age and knowledge act as the moderators? J Clean Prod. 2022;361:132276. doi: 10.1016/j.jclepro.2022.132276.
[54] Laureati M, Proserpio C, Jucker C, Savoldelli S. New sustainable protein sources: Consumers' willingness to adopt insects as feed and food. Ital J Food Sci. 2016;28:652–68. doi: 10.14674/1120-1770/ijfs.v476.
[55] Seehawer M, Breidlid A. Dialogue between epistemologies as quality education. Integrating Knowledges in Sub-Saharan African classrooms to foster sustainability learning and contextually relevant education. Soc Sci Humanit Open. 2021;4:100200. doi: 10.1016/j.ssaho.2021.100200.
[56] Estrada-Vidal LI, Tójar-Hurtado J-C. College student knowledge and attitudes related to sustainability education and environmental health. Procedia Soc Behav Sci. 2017;237:386–92. doi: 10.1016/j.sbspro.2017.02.030.
[57] Redman E, Redman A. Transforming sustainable food and waste behaviors by realigning domains of knowledge in our education system. J Clean Prod. 2014;64:147–57. doi: 10.1016/j.jclepro.2013.09.016.

[58] Guiné RPF, Correia P, Coelaho C, Costa CA. The role of edible insects to mitigate challenges for sustainability. Open Agric. 2021;6(1):24–36. doi: 10.1515/opag-2020-0206.
[59] Florença SG, Guiné RPF, Gonçalves F, Barroca MJ, Ferreira M, Costa CA, et al. The motivations for consumption of edible insects: A systematic review. Foods. 2022;11(22):3643. https://www.mdpi.com/2304-8158/11/22/3643.
[60] Zugravu C, Tarcea M, Nedelesco M, Nuta D, Guiné RPF, Constantin C. Knowledge: A factor for acceptance of insects as food. Sustainability. 2023;15(6):4820. https://www.mdpi.com/2071-1050/15/6/4820.
[61] Mishyna M, Fisher ARH, Steenbekkers BLPA, Janssen AM, Bos-Brouwers HEJ. Consumption and production of edible insects in an urban circularity context: Opinions and intentions of urban residentes. Sustain Prod Consum. 2023;42:234–46. doi: 10.1016/j.spc.2023.10.001.
[62] Vale-Hagan W, Singhal S, Grigoletto I, Totaro-Fila C, Theodoridou K, Koidis A. Edible insects in mixed-sourced protein meals for animal feed and food: An EU focus. Food Humanity. 2023;1:1180–7.
[63] Liu A-J, Li J, Gómez MI. Factors influencing consumption of edible insects for Chinese consumers. Insects. 2020;11:E10. doi: 10.3390/insects11010010.