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Validation of the Scale Knowledge and Perceptions about Edible Insects through Stuctural Equation Modeling

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Abstract: Edible insects have been suggested as a more sustainable source of protein, but their consumption varies according to geographical and sociocultural influences. Focusing on the different aspects that can influence people's attitudes towards edible insects (EI), this work aimed to carry out the statistical validation of an instrument aimed at assessing different dimensions of this field: the KPEI (knowledge and perceptions about EI) scale. The instrument consists of 64 questions distributed by the following dimensions: Culture and Tradition, Gastronomic Innovation and Gourmet Kitchen, Environment and Sustainability, Economic and Social Aspects, Commercialization and Marketing, Nutritional Characteristics, and Health Effects. The data were collected in 13 countries (Croatia, Greece, Latvia, Lebanon, Lithuania, Mexico, Poland, Portugal, Romania, Serbia, Slovenia, Spain, and Turkey). The validation of the KPEI scale was made through Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM). The results revealed two acceptable models, both retaining 37 of the 64 initial items, distrusted by the seven dimensions as: Culture and Tradition (5 items), Gastronomic Innovation and Gourmet Kitchen (5 items), Environment and Sustainability (8 items), Economic and Social Aspects (5 items), Commercialisation and Marketing (4 items), Nutritional Aspects (6 items), Health Effects (4 items). Both multifactorial models resulting from the CFA/SEM analyses showed approximately equal goodness of statistical fit indices with values of Root Mean Square Error of Approximation (RMSEA), Root Mean Square Residual (RMR), and Standardized Root Mean Square Residual (SRMR) partially zero and values of Goodness of Fit Index (GFI) and Comparative Fit Index (CFI) approximately one, i.e., very close to a perfect fit. For the first-order model, the ratio between chi-square and degrees of freedom is χ^2/df = 13.734, GFI = 0.932, CFI = 0.930, RMSEA = 0.043, RMR = 0.042, SRMR = 0.042; and for the second-order model χ^2/df = 14.697, GFI = 0.926, CFI = 0.923, RMSEA = 0.045, RMR = 0.047, SRMR = 0.046). The values of composite reliability (CR = 0.967) and mean extracted variance (MEV = 0.448) are indicative of a good fit. Finally, the reliability analysis indicated a very good internal consistency (Cronbach's α = 0.941). These results confirm the successful validation of the KPEI scale, making it a valuable instrument for future application at the international level.

Keywords: statistical validation; confirmatory factor analysis; structural equation modelling; scale

1. Introduction

Planet earth is facing a tremendous challenge linked with the urgent need to provide sustainable food systems that can ensure the feeding of the growing world population [1]. Some of the consequences of intensive food production include global warming, due to the effects of greenhouse gas (GHG) emissions, loss of natural habitats, deforestation, and animal overexploitation. These pressures are owing both to vegetable as well as animal production [2–5]. Still, animal production has been the focus because it is reported as being responsible for about 80% of the GHG emissions resulting from the entire food sector. These emissions include cattle breeding, as well as the growing of forage necessary for their feeding, plus transportation of the animals to the processing plants and of the meat product to the sales points [6].

In recent years, insects have been pointed out as a possible alternative to other more conventional sources of protein, with positive environmental impacts when compared with other animal productions. This results from the lower ecological footprint of insects, so it is possible to obtain protein requiring much less feed, water, or land, and with the advantage of producing lower amounts of GHG [7–12]. Although unusual in Western societies, edible insects have been consumed regularly as a principal dish or a food supplement by people in many societies around the world, particularly some communities in the southeast of Asia, around the Pacific Ocean, in sub-Saharan African countries, and Central and South American countries [13,14].

Besides their lower environmental impact, edible insects constitute a rich source of valuable nutrients and health-related compounds. They constitute a rich source of energy, particularly protein of good quality and essential amino acids; fat, including unsaturated fatty acids; minerals (such as calcium, iron, potassium, selenium, and magnesium); and vitamins (such as biotin, riboflavin, and pantothenic acid). Nevertheless, given the high diversity of species aimed at human consumption, their nutritional and therapeutic value is highly variable [15–17].

Edible insects have been used in traditional folk medicine by local healers to cure ailments and various health disorders. A review by Gahukar [13] discusses some pros and cons related to the utilisation of insects collected from the wild as therapeutic tools to increase wellness. Some of the health problems that have been deemed treatable with insects and their derived products include fever, cold, cough, back pain, swelling, or burns, among others. Also, more complex diseases have been referred to as treatable with insects, including diabetes, obesity, disorders of the urinary tract, gastric cancer, ulcers, varied tumours, haemorrhoids, rheumatism, asthma, Parkinson's disease, etc. [18,19].

Although possessing valuable nutritional and therapeutic characteristics and providing a sustainable source of food, it is undeniable that there is, among Western consumers, some reluctance and neophobic attitudes towards edible insects [15,20]. Some scientific studies have been developed to investigate the attitudes and acceptability of edible insects in various regions or countries [21–23]. They highlight the low degree of acceptability of entomophagy, i.e., the practice of eating insects [20,24]. Although EIs are consumed in many parts of the world, many obstacles are posed to entomophagy, predominantly in western countries, but also in some countries where eating insects is traditional but that today tend to imitate the western habits and tend to devalue their gastronomic traditions. Many people look at the consumption of insects with disgust and associate it with primitive behaviours. A high number of studies have shown that, for example, in European countries, there is a low propensity to consume EIs [3,10,11,14–16]. In countries where EIs are not part of the traditional diet, there is a reluctance to eat them because people associate them with unfamiliar foods and negative emotions [17,25–28]. Eating habits and food choices are dissimilar around the world. Nevertheless, globalisation has approximated many cultures and their particular gastronomic traditions [29]. The work by Guiné et al. [30] discusses the transition of EIs from ethnic food into novel foods, contributing to a better acceptance, many of the times with the insects included in the foods as ingredients and not as whole insects [29].

A vast diversity of EI species are available for human consumption. More than two thousand species of EIs are reported to be consumed by over 2 billion people in 130 countries, with special emphasis in sub-Saharan Africa, Central and South America, Southeast Asia, and the Pacific. Some of the most frequently consumed insects around the world include cricket, caterpillar, palm weevil, beetle, grasshopper, mealworm, termite, ant, bee, or wasp [31–33]. Since 2003, the FAO (Food and Agriculture Organization of the United Nations) recognises the challenges of supplying food to the increasing number of people while diminishing the pressure on the ecosystems and natural resources. For that reason, the FAO has been intervening towards the adoption of measures to incentive the production and consumption of insects at the global level. These have been complemented with access to information to increase knowledge, which can be a tool to help consumers make more sustainable food choices. Although in the generality of the countries where insects are consumed, there is a lack of proper regulations to guarantee the quality and safety of EIs; in the European Union Market, the Novel Food Regulation establishes the legal frame for the introduction of innovative foods into the EU while guaranteeing food safety to protect consumers. Under this legal frame, some insects have been approved as novel foods, including the most recent recently approved cricket [34,35].

Keeping in mind the importance of understanding the different aspects that influence people's attitudes towards edible insects based on their knowledge and perceptions, to support policies, actions, and/or programs that promote the necessary food transition, this work focuses on the statistical validation at an international level of an instrument aimed at evaluating the different dimensions of this problem, more precisely: Culture and Tradition, Gastronomic Innovation and Gourmet Kitchen, Environment and Sustainability, Economic and Social Aspects, Commercialization and Marketing, Nutritional Aspects and, finally, Health Effects. Hence, the present study was undertaken to validate the new scale KPEI (Knowledge and Perceptions About Edible Insects) in the ambit of the international project EISuFood (https://raquelguine.wixsite.com/eisufood, accessed on 27 January 2023) based on data collected in 13 countries. The purpose of the work was to give a contribution to the scope of validated instruments available to evaluate consumer behaviour and, specifically, peoples' knowledge and perceptions about edible insects as a way to understand peoples' food choices. Given that EIs are foods with highly variable degrees of acceptability according to societal influences and geographical location, the inclusion of participants from different countries helps to have a wider overview of the problem.

2. Materials and Methods

2.1. Instrument

The questionnaire used for the present research was developed in the ambit of the EISuFood project and was prevalidated for a sample of Portuguese participants [36]. The instrument contained 64 items, measured based on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, and 5 = strongly agree) [37].

The details of the items in each dimension are given below:

Items in dimension One—Culture and Tradition: 1. Entomophagy is a dietary practice that consists of the consumption of insects by humans; 2. insects are considered a traditional food in my country; 3. there are thousands of species of insects that are consumed by humans in the world; 4. consuming insects is characteristic of developing countries; 5. insects are present in events related to religious rituals; 6. insects are part of the gastronomic culture of most countries in the world; 7. in some countries, the tradition of eating insects is decreasing because of the "Westernization" of diets; 8. insect consumption is seasonal, so it varies according to the time of the year; 9. there are obstacles to consumers' acceptance of edible insects in Western countries; and 10. insects can be associated with traditional festivities and celebrations.

Items in dimension two—Gastronomic Innovation and Gourmet Kitchen: 1. Insects are considered exotic foods; 2. insects are traded as treats/delicacies; 3. insects are not suitable for human consumption; 4. insects are associated with taboos and food neophobia (not wanting to eat unfamiliar foods); 5. some gourmet restaurants use edible insects in their culinary preparations; 6. insects are present in culinary events and gastronomic shows; 7. insects are recommended by some recognised chefs; 8. chefs contribute to the popularisation of insects into gastronomy in Western countries; and 9. culinary education favours an overall liking for innovative insect-based products.

Items in dimension three—Environment and Sustainability: 1. Insects are a more sustainable alternative when compared with other sources of animal protein; 2. insect production for human consumption emits much fewer greenhouse gases than beef production; 3. insects efficiently convert organic matter into protein; 4. the production of insect protein uses considerably less feed than cow protein; 5. insects are a possibility for responding to the growing world demand for protein; 6. the production of chicken protein requires much less water than insect protein; 7. the ecological footprint (impact) of insects is smaller when compared with other animal proteins; 8. the production of insect protein requires much more area than pig protein; 9. insects are collected as a means of pest control for some cultivated crops; 10. the loss of biodiversity is lower with insect production compared with other animal food production; and 11. the energy input needed for the production of insect protein is lower than for the production of other proteins of animal origin.

Items in dimension four—Economic and Social Aspects: 1. Insect production can contribute to increasing the income of families in low-income areas; 2. insects provide protein foods at low prices; 3. the market for edible insects is expected to decline in the future; 4. presently, the Asia-Pacific and Latin America areas account for more than half of the edible insects market; 5. in some countries, insect farming is becoming a key factor in the fight against rural poverty; and 6. the income generated from insects can be affected by market fluctuations in price derived from availability.

Items in dimension five—Commercialisation and Marketing: 1. Edible insects are difficult to find on sale in street markets; 2. edible insects are easy to find on sale in supermarkets; 3. edible insects are on sale only in specialised shops; 4. the level of knowledge influences the willingness to purchase insect food; 5. price is among the motivations to consume insect foods; 6. the consumption of insects and derived foods depends on availability, 7. personalities/influencers can lead people to consume insects; and 8. insect consumption is independent of marketing campaigns.

Items in dimension six—Nutritional Aspects: 1. Insects have poor nutritional value; 2. insects are a good source of energy; 3. insects have high protein content; 4. insect proteins are of poorer quality compared with other animal species; 5. insects provide essential amino acids necessary for humans; 6. insects contain group B vitamins; 7. insects contain dietary fibre; 8. insects contain minerals of nutritional interest, such as calcium, iron and magnesium; 9. insects contain fat, including unsaturated fatty acids; and 10. insects contain anti-nutrients, such as oxalates and phytic acid.

Items in dimension seven—Health Effects: 1. There are appropriate regulations to guarantee the food safety of edible insects; 2. insects are used by some people in traditional medicine; 3. eating insects poses a substantial risk to human health; 4. industrially processed insect products are hygienic and safe; 5. insects and insect-based foods are often infected by pathogens and parasites; 6. insects collected from the wild may be contaminated with pesticide residues; 7. in certain countries, insects are approved officially for therapeutic treatment; 8. insects contain bioactive compounds beneficial to human health; 9. insects are potential sources of allergens; and 10. alfatoxins, which are carcinogens, can be present in insects.

2.2. Data Collection

This descriptive cross-sectional study was undertaken on a nonprobabilistic sample consisting of 6900 participants from 13 countries: Croatia, Greece, Latvia, Lebanon, Lithuania, Mexico, Poland, Portugal, Romania, Serbia, Slovenia, Spain, and Turkey. Ethical principles were strictly followed, and the questionnaire survey was approved by the Ethics Committee with reference 45/SUB/2021.

The data collection took place in the period between July and November 2021. As the survey was carried out during the COVID-19 pandemic and owing to some restrictions, the electronic platform Google Forms was used to deliver the questionnaires to the participants. Recruitment was done by email and social media and followed a snowball methodology in each of the participating countries. This methodology has proven more effective than multisite data collection [38]. Only adult citizens (aged 18 years old or over) were allowed to participate in the survey, and informed consent was obtained from those who answered the questionnaire.

2.3. Sample Characterisation

The sample was constituted of 6900 participants from different countries: Croatia (N = 686), Greece (N = 636), Latvia (N = 300), Lebanon (N = 357), Lithuania (N = 510), Mexico (N = 1139), Poland (N = 521), Portugal (N = 527), Romania (N = 492), Serbia (N = 344), Slovenia (N = 517), Spain (N = 575), and Turkey (N = 296).

The participants were aged between a minimum of 18 and a maximum of 88 years old with an average age of 35 ± 14 years. They were mostly female (63.0%), and the great majority resided in urban areas (68.6%) with lower percentages living in suburban (15.9%) or rural areas (15.5%). With respect to education level, most were undergraduate (36.5%), 32.4% completed a university degree, and 31.1% had completed postgraduate studies (MSc or PhD) (Table 1).

Table 1. Sociodemographic characterisation of the sample.

Variable	Group	N	%
Sex	Female	4347	63.0
	Male	2506	36.3
	No answer	47	0.7
Age	18–30 years	3321	48.2
	31–50 years	2489	36.1
	51 or more years	1080	27.7
Education	Postgraduate	2135	31.0
	University degree	2234	32.4
	Under-university	2519	36.6
Living environment	Rural	1067	15.5
	Urban	4726	68.5
	Suburban	1107	16.0

2.4. Statistical Analyses

The validation of the scale was obtained by means of reliability and validity tests following standardised statistical analyses. In this way, it is possible to expect that the results obtained from one sample can be generalised. The analyses were based on metric properties and took into account the distribution of the scale items, as well as assumptions of reliability and validity studies. These are essential for any data collection instrument to bear in order to ensure the quality of the information collected. Regarding the distribution of the items, the reference values for the asymmetry parameters considered were for skewness ≤ 3 and for kurtosis ≤ 7 [39].

The internal consistency of the items was evaluated by reliability studies. Pearson's linear correlation coefficient (r) was calculated for each paired item *versus* the overall score without that item. Cronbach's alpha was used to measure internal consistency [25], and McDonald's omega (ω) was also used to measure global consistency [40].

The confirmatory factor analysis (CFA) was made using the AMOS 24 software (Analysis of Moment Structures) and comprised the evaluation of the following parameters [41]:

(a) The factorial weights are represented by the unidirectional arrows that link the factors (also called latent variables) with the indicators (or manifest variables)—the weights are also symbolised by lambda (λ).
(b) The variances and covariances of the individual reliability of the indicators are represented by the unidirectional arrows linking the indicators to the errors—the variances are symbolised by delta (δ).
(c) The variances and covariances of the factors, which in turn are symbolised by phi (Φ).
(d) The error correlations, which are represented by delta (δ) and symbolised by bidirectional arrows, when covariance is included in the errors indicates that the covariance between the two indicators is due to reasons not explained by the factor (method effects). Bidirectional arrows are also used to symbolise covariance between factors.

The acceptance of the CFA model was grounded on the following observations: (i) the interpretability of the parameters, their weights, and statistical significance; (ii) the modification indexes that were proposed by the AMOS software; and (iii) the model adjustment indicators [41].

The interpretation of the different parameters was made based on the reference values indicated [39]:

- Correlation between the factors (Φ)—higher coefficients indicate better correlations.
- Regression coefficients (λ)—values greater than 0.50 are advisable.
- Individual reliability of indicators (δ)—the coefficients should be $\geq$0.25.
- Statistical significance—p-value < 0.05.

Taking into account that the modification indices are highly sensitive to the sample size, the orientation was given by the changing values proposed by the AMOS software, and the adjustment of the model was made with reference values higher than 11.

In what concerns the quality indicators for the adjustment of the model, the reference values adopted are shown in Table 2 [42,43].

Finally, some additional measures were used to verify the quality of the model as follows:

- The composite reliability (CR): indicates if the items constitute manifestations of the factor. Reference values higher than 0.70 are suggested, although lower values may be acceptable for research with an exploratory nature [43].
- The mean extracted variance (MEV): it evaluates the convergent validity that occurs when the indicators, which are a reflection of a factor, saturate strongly in this factor. Values $\geq$ 0.50 are indicative of adequate validity, but this limit can be adjusted to 0.40 in exploratory analyses [43].
- The discriminant validity (Φ): it allows the evaluation of the discriminant validity of the factors, and their values (r^2) must not be higher than the MEV of each of the factors.

Table 2. Reference values of the quality indicators for the adjustment of the model, addapted from [42,43].

Evaluations	Indicators	Reference Values

Absolute fit	Ratio of chi-square and degrees of freedom (χ^2/df)	If (χ^2/df) is equal to 1 the fit is perfect.
		If (χ^2/df) is >1 and $\leq$2 the fit is good.
		If (χ^2/df) is >2 and $\leq$5 the fit is acceptable.
		If (χ^2/df) is >5 the fit is unacceptable.

	Root mean square residual (RMR)	The lower the value of RMR the better is the fit. RMR = 0 indicates a perfect fit.
	Standardised root mean square residual (SRMR)	Values lower than 0.08 are generally considered a good fit. SRMR = 0 indicates a perfect fit.
	Goodness of fit index (GFI)	Values $\geq$ 0.95 are recommended. Values > 0.90 are considered a good fit. GFI = 1 is a perfect fit.
Relative fit	Comparative fit index (CFI) [1]	Values < 0.90 indicate a poor fit. Values $\geq$ 0.90 and $\leq$0.95 indicate a good adjustment. Values > 0.95 indicate a very good adjustment. CFI = 1 corresponds to a perfect fit.
Population discrepancy index	Root mean square error of approximation (RMSEA)	Values for RMSEA [2] between 0.05 and 0.08 mean the adjustment is good. Values of RMSEA < 0.05 are considered very good.

[1] It is an additional comparative index of the adjustment to the model. This index is independent of the sample size. [2] With a 90% confidence interval.

3. Results

In this work, a confirmatory factorial analysis (CFA) was used to evaluate how the items considered in the seven dimensions could fit into a multidimensional variable. Table 3 shows the statistics for the global set of items used to obtain the KPEI scale, aimed at evaluating knowledge and perceptions about edible insects. Regarding the mean values and the corresponding standard deviations, we observed that the lowest mean value was observed for item C2 “Insects are considered a traditional food in my country” (M = 1.74, SD = 1.22), and the highest was observed for item N3 “Insects have high protein content” (M = 1.74, SD = 1.22). Nevertheless, it is observed that the great majority of the items are well centred, i.e., with values around the centre of the scale (which varied from a minimum of 1 to a maximum of 5). With respect to the correlation coefficients, some variables have very low values, close to zero, such as items S6 “The production of chicken protein requires much less water than insect protein” (r = −0.03), M2 “Edible insects are easy to find on sale in supermarkets” (r = −0.002), M8 “Insect consumption is independent of marketing campaigns” (r = 0.001), and H10 “Aflatoxins, which are carcinogens, can be present in insects” (r = 0.002). As opposed to these, items with higher correlation item totals are S5 “Insects are a possibility for responding to the growing world demand for protein” and N3 “Insects have high protein content” (both with r = 0.685, corresponding to about 60% of variance explained). By analysing the values of alpha in Table 3, in all cases, they are higher than 0.93 indicating a very good internal consistency and recommended for applied research [41,44].

The first model obtained with CFA was produced based on all 64 items in the seven dimensions. Table 4 shows the results of the estimates, critical ratios, and saturation of the items, and the corresponding model is presented in Figure 1. The values of the critical ratio in Table 4 are significant for practically all the items, just with the exception of M2 “Edible insects are easy to find on sale in supermarkets” (p = 0.896), S6 “The production of chicken protein requires much less water than insect protein” (p = 0.275), and M8 “Insect consumption is independent of marketing campaigns” (p = 0.072). Hence, these items are not recommended to remain in the model.

Table 3. Statistical results: correlation item-total and values of Cronbach's alpha if the item is eliminated.

Variables	Statistics [1]				
	M	SD	r	r^2	α
Dimension One—Culture and Tradition (C)					
C1	3.56	1.10	0.447	0.240	0.932
C2	1.74	1.22	0.258	0.344	0.933
C3	3.63	1.04	0.481	0.291	0.932
C4	2.75	1.11	0.306	0.196	0.933
C5	2.79	1.04	0.282	0.275	0.933
C6	2.93	1.17	0.352	0.307	0.933
C7	3.30	1.03	0.432	0.317	0.932
C8	3.02	1.01	0.329	0.273	0.933
C9	3.60	1.13	0.380	0.264	0.932
C10	3.04	1.11	0.409	0.347	0.932
Dimension Two—Gastronomic Innovation and Gourmet Kitchen (G)					
G1	3.81	1.13	0.468	0.332	0.932
G2	3.33	1.10	0.412	0.293	0.932
G3	3.60	1.25	0.323	0.318	0.933
G4	3.78	1.10	0.317	0.218	0.933
G5	3.63	0.98	0.562	0.495	0.931
G6	3.44	1.04	0.540	0.534	0.931
G7	3.32	0.98	0.566	0.585	0.931
G8	3.36	1.01	0.543	0.534	0.931
G9	3.40	1.08	0.601	0.489	0.931
Dimension Three—Environment and Sustainability (S)					
S1	3.44	1.16	0.660	0.568	0.930
S2	3.65	1.06	0.643	0.595	0.931
S3	3.54	0.97	0.644	0.555	0.931
S4	3.67	1.02	0.629	0.600	0.931
S5	3.62	1.08	0.685	0.621	0.930
S6	3.22	0.99	-0.030	0.268	0.935
S7	3.53	1.03	0.595	0.507	0.931
S8	3.35	1.06	0.021	0.289	0.935
S9	3.45	0.99	0.390	0.279	0.932
S10	3.36	0.96	0.512	0.407	0.932
S11	3.55	0.99	0.594	0.523	0.931
Dimension Four—Economic and Social Aspects (E)					
E1	3.45	1.04	0.631	0.499	0.931
E2	3.43	1.05	0.603	0.486	0.931
E3	3.53	0.98	0.190	0.248	0.933
E4	3.54	0.90	0.478	0.343	0.932
E5	3.39	0.89	0.547	0.438	0.931
E6	3.38	0.90	0.488	0.345	0.932
Dimension Five—Commercialisation and Marketing (M)					
M1	3.65	1.16	0.157	0.286	0.934
M2	2.16	1.11	-0.002	0.154	0.935
M3	3.57	1.03	0.262	0.262	0.933
M4	3.73	1.07	0.482	0.339	0.932
M5	3.10	1.13	0.364	0.309	0.932
M6	3.38	1.08	0.447	0.351	0.932
M7	3.72	1.10	0.525	0.360	0.931
M8	2.59	1.15	0.001	0.137	0.935

Table 3. *Cont.*

Variables	Statistics [1]				
	M	SD	r	r^2	α
Dimension Six—Nutritional Aspects (N)					
N1	3.73	1.04	0.342	0.368	0.933
N2	3.54	1.04	0.593	0.504	0.931
N3	3.87	0.97	0.685	0.602	0.931
N4	3.41	1.02	0.267	0.375	0.933
N5	3.38	0.91	0.635	0.551	0.931
N6	3.22	0.81	0.539	0.513	0.932
N7	3.28	0.95	0.494	0.416	0.932
N8	3.39	0.88	0.613	0.581	0.931
N9	3.11	0.90	0.380	0.362	0.932
N10	3.00	0.82	0.205	0.256	0.933
Dimension Seven—Health Effects (H)					
H1	3.15	1.03	0.283	0.232	0.933
H2	3.67	0.93	0.506	0.359	0.932
H3	3.40	1.05	0.269	0.418	0.933
H4	3.41	0.98	0.554	0.385	0.931
H5	3.20	0.99	0.124	0.416	0.934
H6	3.58	0.95	0.280	0.266	0.933
H7	3.36	0.83	0.439	0.373	0.932
H8	3.36	0.86	0.603	0.474	0.931
H9	3.20	0.90	0.145	0.309	0.934
H10	2.99	0.83	0.002	0.275	0.934

[1] M = mean value; SD = standard deviation; r = correlation coefficient (item-total); r^2 = proportion of the variance explained; α = Cronbach's alpha if item is deleted.

Table 4. Regression weights for the first-order initial model.

Trajectories			Statistics [1]			
			E	SE	CR	*p*
C1	←	CC1	1.000			
C2	←	CC1	0.953	0.041	23.511	***
C5	←	CC1	1.008	0.038	26.807	***
C6	←	CC1	1.273	0.044	28.635	***
C7	←	CC1	1.233	0.041	30.013	***
C8	←	CC1	1.059	0.038	28.121	***
C9	←	CC1	1.027	0.040	25.833	***
C10	←	CC1	1.389	0.045	30.623	***
G1	←	GG2	1.000			
G2	←	GG2	1.001	0.034	29.292	***
G3	←	GG2	0.685	0.034	20.285	***
G4	←	GG2	0.612	0.030	20.431	***
G5	←	GG2	1.350	0.037	36.244	***
G6	←	GG2	1.481	0.040	36.774	***
G7	←	GG2	1.464	0.039	37.444	***
G8	←	GG2	1.427	0.039	36.605	***
G9	←	GG2	1.453	0.040	35.912	***
S1	←	SS3	1.000			
S2	←	SS3	0.960	0.014	66.515	***
S3	←	SS3	0.842	0.013	62.955	***
S4	←	SS3	0.926	0.014	66.424	***
S5	←	SS3	0.990	0.015	67.304	***
S6	←	SS3	0.016	0.014	1.091	0.275

Table 4. *Cont.*

Trajectories			Statistics [1]			
			E	**SE**	**CR**	***p***
E1	←	EE4	1.000			
E2	←	EE4	0.978	0.018	55.788	***
E3	←	EE4	0.205	0.017	12.411	***
E4	←	EE4	0.644	0.015	42.906	***
E5	←	EE4	0.777	0.015	52.504	***
E6	←	EE4	0.657	0.015	44.022	***
N1	←	NN6	1.000			
N2	←	NN6	1.779	0.059	30.002	***
N3	←	NN6	1.797	0.059	30.677	***
N4	←	NN6	0.711	0.038	18.781	***
M1	←	MM5	1.000			
M2	←	MM5	−0.006	0.048	−0.130	0.896
M3	←	MM5	1.249	0.073	17.143	***
M4	←	MM5	2.140	0.109	19.562	***
M5	←	MM5	1.870	0.099	18.808	***
M6	←	MM5	2.094	0.108	19.446	***
M7	←	MM5	2.272	0.116	19.664	***
H4	←	HH7	1.000			
H3	←	HH7	0.368	0.023	16.233	***
H2	←	HH7	0.907	0.022	40.643	***
H1	←	HH7	0.657	0.023	28.469	***
S7	←	SS3	0.859	0.014	60.642	***
S8	←	SS3	0.087	0.015	5.675	***
S9	←	SS3	0.501	0.014	35.458	***
S10	←	SS3	0.664	0.013	49.289	***
S11	←	SS3	0.808	0.014	59.414	***
M8	←	MM5	0.089	0.049	1.798	0.072
N5	←	NN6	1.747	0.056	30.988	***
N6	←	NN6	1.419	0.047	30.171	***
N7	←	NN6	1.480	0.051	29.063	***
N8	←	NN6	1.690	0.055	30.995	***
N9	←	NN6	1.158	0.043	26.911	***
N10	←	NN6	0.589	0.031	19.276	***
H5	←	HH7	0.131	0.021	6.138	***
H6	←	HH7	0.522	0.021	24.666	***
H7	←	HH7	0.793	0.020	40.225	***
H8	←	HH7	1.026	0.022	47.203	***
H9	←	HH7	0.337	0.020	17.206	***
H10	←	HH7	0.087	0.018	4.910	***
C3	←	CC1	1.218	0.041	29.639	***
C4	←	CC1	0.940	0.038	24.753	***

[1] E = estimate; SE = standard error; CR = critical ratio; p = significance (*** means $p < 0.05$).

The model represented in Figure 1 is the initial solution, and the statistical indicators for the model are shown in Table 5. The value of $\chi^2/\mathrm{df} = 22.171$ is still too high; GFI = 0.751 is not acceptable because it is lower than 0.9; CFI = 0.749 indicates a poor fit, with desired values over 0.9; RMSEA = 0.055, which is still higher than 0.5; RMR = 0.072 is considered adequate, for being close to zero; SRMR = 0.056 is good for being below 0.08.

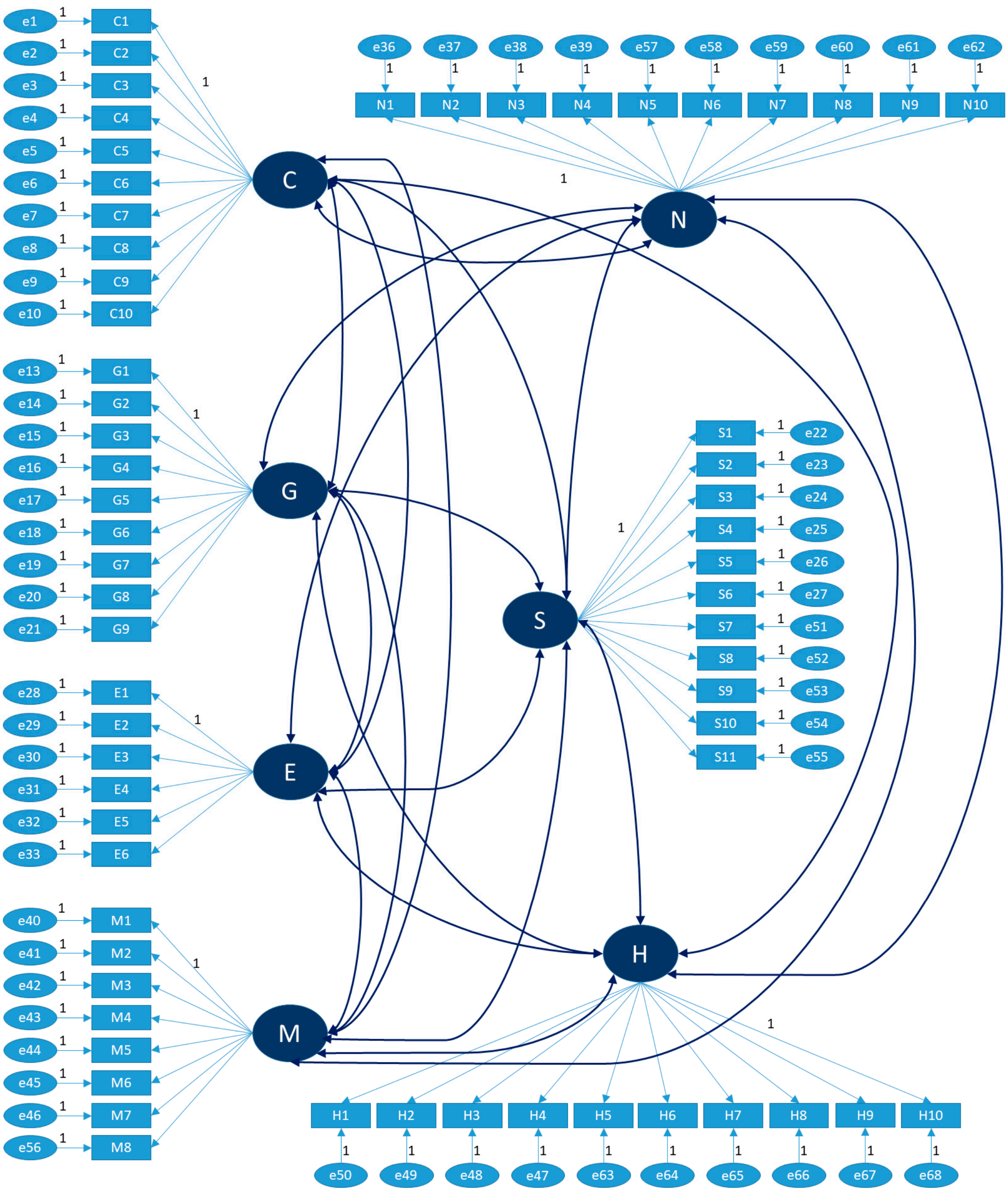

Figure 1. First-order initial multidimensional model for the KPEI scale.

Table 5. Goodness of fit indices of the CFA for the KPEI scale first-order models.

Models for the KPEI Scale	Indicators [1]					
	χ^2/df	GFI	CFI	RMSEA	RMR	SRMR
First-order initial model (without modification indices)	22.171	0.751	0.749	0.055	0.072	0.056
First-order final model (with modification indices)	13.734	0.932	0.930	0.043	0.042	0.042
Second-order model	14.697	0.926	0.923	0.045	0.047	0.046

[1] χ^2/df = ratio of chi-square and degrees of freedom; GFI = goodness of fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; RMR = root mean square residual; SRMR = standardised root mean square residual.

As some high covariances were detected between some items belonging to the same factor, the model was respecified, based on the modification indices proposed by the software AMOS and also eliminating items with problems of colinearity. The solution with modification indices was obtained, as shown in Figure 2 and Table 6. This solution excluded some variables for not presenting statistical relevance for the model, resulting in a final scale with 37 items instead of the 64 included in the initial scale. All items have a significant *p*-value, and the values of λ are all acceptable, the lowest being 0.495 (M5″ Price is among the motivations to consume insect foods") and the highest being 0.810 (G7″ Insects are recommended by some recognised chefs").

Table 6. Regression weights for the first-order model with modification indices.

Trajectories			**Statistics** [1]				
			E	**SE**	**CR**	***p***	**λ**
C6	←	CC1	1.068	0.032	33.543	***	0.550
C7	←	CC1	0.967	0.029	33.533	***	0.566
C8	←	CC1	0.847	0.028	30.624	***	0.507
C10	←	CC1	1.095	0.032	34.294	***	0.594
G5	←	GG2	1.000				0.708
G6	←	GG2	1.128	0.019	58.493	***	0.755
G7	←	GG2	1.141	0.019	60.732	***	0.810
G8	←	GG2	1.104	0.020	56.390	***	0.758
G9	←	GG2	1.081	0.021	52.390	***	0.696
S1	←	SS3	1.000				0.753
S2	←	SS3	0.959	0.014	67.649	***	0.793
S3	←	SS3	0.836	0.013	63.318	***	0.751
S4	←	SS3	0.920	0.014	66.361	***	0.788
S5	←	SS3	0.987	0.014	68.824	***	0.801
E1	←	EE4	1.000				0.746
E2	←	EE4	0.975	0.017	57.302	***	0.722
E4	←	EE4	0.617	0.015	40.340	***	0.533
E5	←	EE4	0.768	0.015	52.137	***	0.673
E6	←	EE4	0.633	0.015	41.974	***	0.550
N2	←	NN6	1.000				0.628
N3	←	NN6	1.007	0.017	57.968	***	0.677
M4	←	MM5	1.000				0.610
M5	←	MM5	0.864	0.027	31.639	***	0.495
M6	←	MM5	0.975	0.027	36.055	***	0.587
M7	←	MM5	1.136	0.029	39.172	***	0.675
H4	←	HH7	1.089	0.029	38.075	***	0.608
H2	←	HH7	1.000				0.587
S7	←	SS3	0.848	0.014	60.328	***	0.721
S10	←	SS3	0.632	0.013	47.005	***	0.573
S11	←	SS3	0.781	0.014	57.570	***	0.693
N6	←	NN6	0.897	0.019	46.658	***	0.720
N7	←	NN6	0.966	0.022	44.512	***	0.662
N8	←	NN6	1.085	0.022	50.021	***	0.806
N9	←	NN6	0.754	0.020	37.648	***	0.543
H7	←	HH7	0.886	0.023	38.404	***	0.587
H8	←	HH7	1.174	0.027	43.088	***	0.747
C3	←	CC1	1.000				0.577

[1] E = estimate; SE = standard error; CR = critical ratio; *p* = significance (*** means $p < 0.05$); λ = weights.

The model represented in Figure 2 is the final first-order solution with the corresponding statistical indicators as presented in Table 5. The value of χ^2/df was decreased to 13.734, being now closer to the desired reference; GFI was increased to 0.932, now being considered a good fit; CFI = 0.930 indicates a good adjustment; RMSEA was decreased to 0.043, being now lower than 0.5; RMR was further decreased to 0.042, which is adequate for being even closer to zero; SRMR was also decreased to 0.042, being considered good.

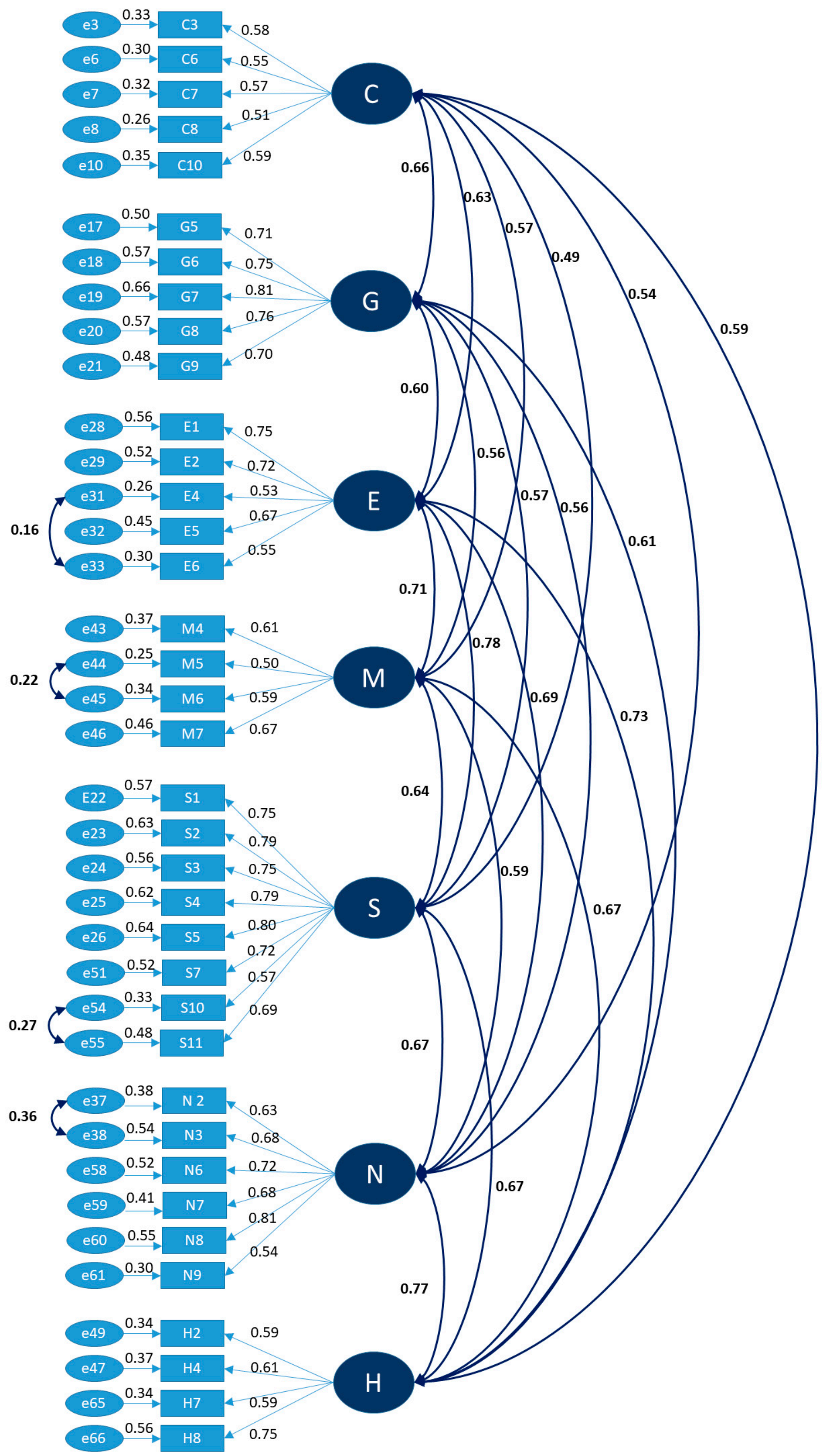

Figure 2. First-order final multidimensional model for the KPEI scale with modification indices and variables removed.

Given that the correlational values between factors were high, which suggest the possible existence of a second-order factor, this was further investigated by proposing a hierarchical structure with a second-order factor for the KPEI scale. This final second-order solution is presented in Figure 3. The goodness of fit indices for the global adjustment to the second-order model are also presented in Table 5, and they are very similar to the previous final first-order model (χ^2/df = 14.697, GFI = 0.926, CFI = 0.923, RMSEA = 0.045, RMR = 0.047, SRMR = 0.046).

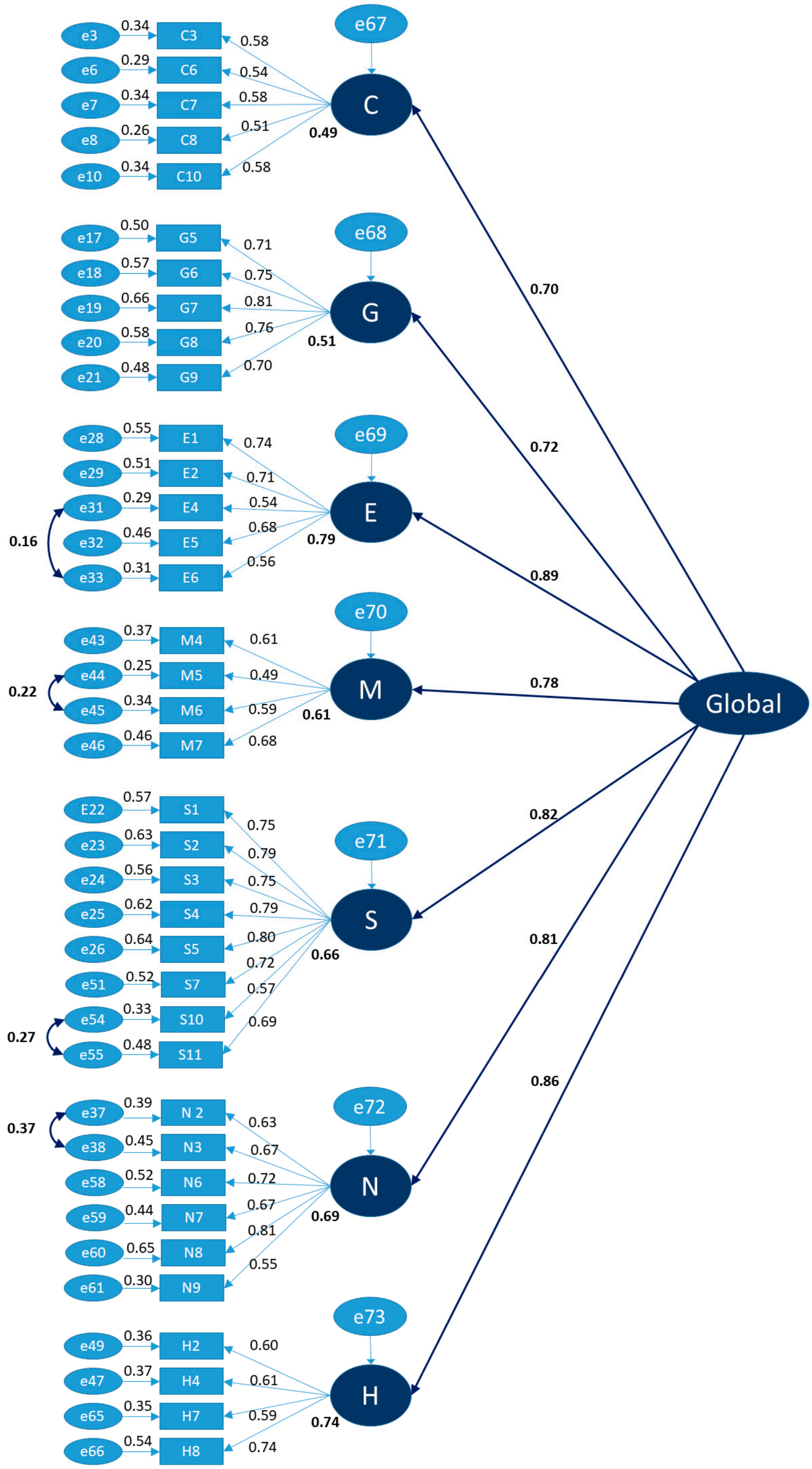

Figure 3. Second-order model for the KPEI scale.

The study was completed by analysing the results of composite reliability (CR) and convergent validity (MEV). By observing the values in Table 7 it was concluded that, with the exception of Factor 1 (Culture and Tradition), which presents reasonable internal consistency, all the others have good internal consistency indices since they have values of CR higher than 0.70. On the other hand, the values of MEV do not allow a decisive conclusion on the convergent validity in the studied sample since some values are lower than the threshold considered of 0.40, specifically Factor 1 (Culture and Tradition) and Factor 4 (Commercialisation and Marketing), which have values of 0.313 and 0.354, respectively. Still, the model is good based on the overall results, and the KPEI scale can be validated. The stratified composite reliability is good (0.967), being that the convergent validity is acceptable (0.448) [43].

Table 7. Parameters for internal consistency evaluation.

Factors/Dimensions	Composite Reliability CR	Mean Extracted Variance MEV
Factor 1/Culture and Tradition	0.694	0.313
Factor 2/Gastronomic Innovation and Gourmet Kitchen	0.862	0.555
Factor 3/Economic and Social Aspects	0.782	0.423
Factor 4/Commercialisation and Marketing	0.684	0.354
Factor 5/Environment and Sustainability	0.904	0.544
Factor 6/Nutritional Aspects	0.833	0.459
Factor 7/Health Effects	0.728	0.404
Stratified	0.967	0.448

The final model has 37 items, as previously mentioned, and the corresponding factorial structure is shown in Table 8 analysing the reliability separately by factors. The consistency of the seven factors is variable from good ($\alpha = 0.695$ for Factor One) to very good ($\alpha = 0.905$ for Factor Five). Additionally, all items included in each of the seven factors are confirmed as belonging to the scale since the value of alpha does not increase with the removal of any of them (Table 8).

In addition, the reliability analysis was undertaken considering the whole scale with all 37 items altogether. The results in Table 9 show that the global alpha is 0.941, which is very good, and again the removal of any of the items would not increase the value of alpha. The results of r^2 show that the item with the lowest percentage of explained variance is C8 "Insect consumption is seasonal, so it varies according to the time of the year" (with only 22.9% of variance explained), and the item with the highest percentage of explained variance is S5 "Insects are a possibility for responding to the growing world demand for protein" (%VE = 61.0%).

The confirmatory factor analysis with structuring equation modelling carried out in the present work to validate the KPEI scale revealed that from the initial 64 items distributed by seven dimensions, only 37 were retained in the final validated scale. This indicates that 27 items (42%) were not found appropriate to be included in the final model.

Based on the findings, on the validation of the KPEI scale and considering the role of a correct level of knowledge and positive perception towards their consumption, a conceptual model was built to highlight the knowledge and perceptions about EI and their implications (Figure 4).

Table 8. Reliability analysis of the scale considering the individual factors.

Items	Statistics [1]		
	r	r^2	α
Factor One—Culture and Tradition			0.695
C3	0.424	0.186	0.656
C6	0.450	0.207	0.646
C7	0.467	0.224	0.638
C8	0.434	0.203	0.652
C10	0.476	0.229	0.634
Factor Two—Gastronomic Innovation and Gourmet Kitchen			0.860
G5	0.641	0.438	0.839
G6	0.691	0.506	0.827
G7	0.741	0.566	0.814
G8	0.696	0.517	0.825
G9	0.620	0.404	0.846
Factor Three—Economic and Social Aspects			0.787
E1	0.607	0.423	0.731
E2	0.586	0.396	0.739
E4	0.497	0.272	0.767
E5	0.625	0.395	0.728
E6	0.509	0.286	0.763
Factor Four—Commercialisation and Marketing			0.706
M4	0.471	0.228	0.655
M5	0.468	0.237	0.657
M6	0.539	0.296	0.613
M7	0.488	0.248	0.644
Factor Five—Environment and Sustainability			0.905
S1	0.696	0.522	0.893
S2	0.751	0.577	0.888
S3	0.697	0.510	0.893
S4	0.749	0.583	0.888
S5	0.747	0.575	0.888
S7	0.691	0.484	0.893
S10	0.565	0.365	0.903
S11	0.679	0.493	0.894
Factor Six—Nutritional Aspects			0.832
N2	0.598	0.447	0.807
N3	0.613	0.471	0.803
N6	0.636	0.445	0.800
N7	0.600	0.381	0.806
N8	0.713	0.538	0.783
N9	0.487	0.276	0.828
Factor Seven—Health Effects			0.723
H2	0.497	0.260	0.671
H4	0.450	0.221	0.703
H7	0.534	0.317	0.652
H8	0.581	0.349	0.623

[1] r = correlation coefficient (item-total); r^2 = proportion of the variance explained; α = Cronbach's alpha if item is deleted.

Table 9. Reliability analysis of the whole KPEI scale.

Items	Statistics [1]		
	r	r^2	α
C3	0.477	0.275	0.940
C6	0.372	0.256	0.941
C7	0.420	0.273	0.941
C8	0.327	0.229	0.942
C10	0.409	0.283	0.941
G5	0.553	0.477	0.940
G6	0.544	0.522	0.940
G7	0.577	0.581	0.939
G8	0.554	0.528	0.940
G9	0.602	0.477	0.939
E1	0.638	0.490	0.939
E2	0.617	0.476	0.939
E4	0.481	0.321	0.940
E5	0.566	0.426	0.940
E6	0.500	0.330	0.940
M4	0.469	0.288	0.940
M5	0.386	0.273	0.941
M6	0.455	0.333	0.941
M7	0.523	0.341	0.940
S1	0.656	0.553	0.939
S2	0.642	0.587	0.939
S3	0.641	0.542	0.939
S4	0.629	0.593	0.939
S5	0.688	0.610	0.938
S7	0.597	0.496	0.939
S10	0.524	0.387	0.940
S11	0.600	0.511	0.939
N2	0.591	0.479	0.939
N3	0.666	0.571	0.939
N6	0.538	0.470	0.940
N7	0.510	0.400	0.940
N8	0.611	0.560	0.939
N9	0.396	0.298	0.941
H2	0.500	0.329	0.940
H4	0.535	0.338	0.940
H7	0.440	0.341	0.941
H8	0.602	0.462	0.939
	Global KPEI scale		**0.941**

[1] r = correlation coefficient (item-total); r^2 = proportion of the variance explained; α = Cronbach's alpha if item is deleted.

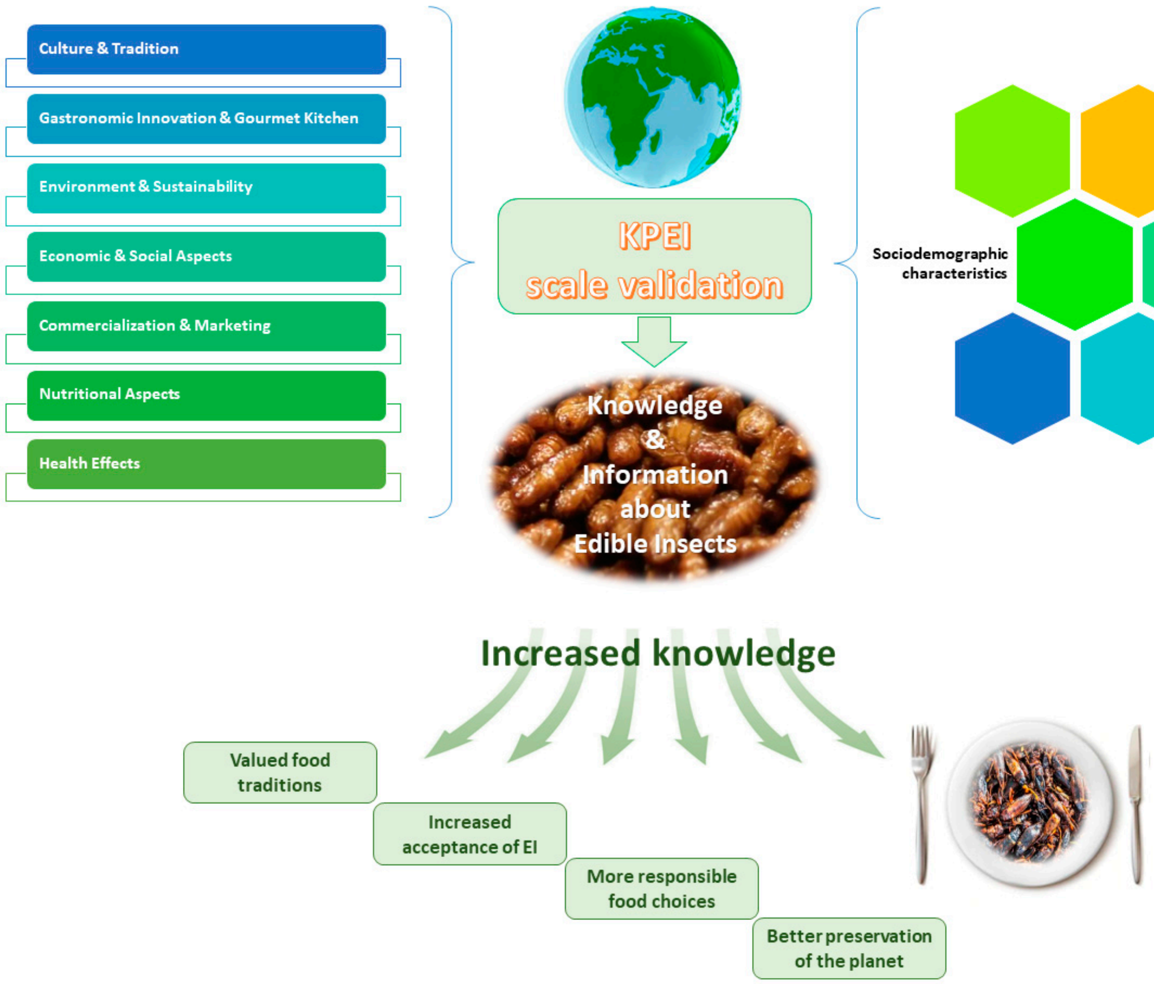

Figure 4. Resulting conceptual model for the knowledge and perceptions about EI and their implications.

4. Discussion

In what concerns the dimension Culture and Tradition, five items were validated in the scale: C3 "There are thousands of species of insects that are consumed by humans in the world", C6 "Insects are part of the gastronomic culture of most countries in the world", C7 "In some countries the tradition of eating insects is decreasing because of the Westernization of diets", C8 "Insect consumption is seasonal, so it varies according to the time of the year", and C10 "Insects can be associated with traditional festivities and celebrations". The review by Tan et al. [45] highlights some relevant determinants of acceptance of edible insects related to cultural as well as individual experiences. Neophobia keeps consumers aversive towards a class of food products that are not traditionally considered as foods in their cultural environment. However, in Western countries, feelings of disgust prevail [46,46–48]. When consumer perceptions are analysed among people whose cultural background considers insects as a delicacy, new insights come to light in terms of the psychological and cultural mechanisms that support consumer behaviour [45,49,50]. EIs are perceived as cultural resources indicating a rich biodiversity of food items [51]. In some remote or mountainous areas, EIs constitute an alternative basis of natural food resources. The cultural and traditional aspects related to EIs not only encompass their consumption but also technologies used for their collection and preparation methods, involving cooking or other ways to consume insects [49,52]. Florença et al. [29] present a recent review of the motivations for the consumption of EIs and focuses specifically on the comparison between insect-eating countries as opposed to Western countries. They refer that, although the acceptance of EIs is more difficult in countries which do not have a tradition of entomophagy, that can also be influenced by some positive motivators, related for example, to sustainability or curiosity.

Regarding the dimension Gastronomic Innovation and Gourmet Kitchen, the model retained five items: G5 "Some gourmet restaurants use edible insects in their culinary preparations", G6 "Insects are present in culinary events and gastronomic shows", G7 "Insects are recommended by some recognised chefs", G8 "Chefs contribute to the popularisation of insects into gastronomy in Western countries", and G9 "Culinary education favours overall liking for innovative insect-based products". The transition from traditional food items into appreciated gourmet dishes is on the rise due to the influence of some renowned chefs all over the world who explore the gastronomic potential of the EIs [32]. A positive perception of EIs have been gradually increasing in places where they were not part of the traditional gastronomy. Bee brood is one insect food with higher acceptability due to the more positive attitude of consumers towards bees, regardless of being in regions where entomophagy is a regular practice or even in regions where eating insects is still not usual [53]. EIs have been introduced into high-valued spots, such as gastronomic and cooking shows, culinary events and festivals, or chef's recommendations. The role of chefs has been recognised as pivotal for the successful introduction of EIs into gastronomy in western countries. These chefs use EIs to prepare delicate, trendy, and exquisite dishes, which are highly valued as gourmet preparations [54,55]. Chefs have the knowledge and skills to turn those food preparations into something unique, providing a set of pleasant sensations at several levels, including visual, taste, flavour, or texture, that please the consumer [56,57]. Traynor et al. [58] refer to culinary education as having a relevant impact on the attitudes and behaviours of consumers towards novel foods, with those who have a higher culinary education possessing a greater willingness to appreciate innovative food products.

Concerning the dimension Environment and Sustainability, the final scale retained eight items: S1 "Insects are a more sustainable alternative when compared with other sources of animal protein", S2 "Insect production for human consumption emits much fewer greenhouse gases than beef production", S3 "Insects efficiently convert organic matter into protein", S4 "The production of insect protein uses considerably less feed than cow protein", S5 "Insects are a possibility for responding to the growing world demand for protein", S7 "The ecological footprint (impact) of insects is smaller when compared with other animal proteins", S10 "The loss of biodiversity is lower with insect production compared with other animal food production", and S11 "The energy input needed for production of insect protein is lower than for the production of other proteins from animal origin". These results indicate a great number of items validated in this group, which confirms the general perception about the higher sustainability of edible insects when compared, for example, with other sources of animal protein. The review by Ordoñez-Araque and Egas-Montenegro [59] highlights the problems associated with the livestock industry nowadays, namely the great need for productive areas, pollution generation, cause for global warming, or toxicity due to pathogens or drugs released into the soil. These negative environmental impacts are leading to the search for more environmentally friendly options, and edible insects have been pointed out by many as one part of the solution [60–62]. While insects are a good source of nutritional importance for people's diets, they also contribute to slowing down the deterioration of the environment. One of the advantages of rearing insects for food comes from their high feed conversion efficiency. In fact, they can convert plant feed into insect proteins much more efficiently when compared to mammals, such as cows or pigs, or birds, including chickens [63,64]. Another benefit of EIs is associated with their possible rearing on different types of biological waste, including manure, compost, and human waste [65]. The emission of gases with greenhouse effects was reported as being 100 times lower than that of cattle and beef, and also, the release of ammonia was found to be one-tenth of that of pigs [66,67]. Finally, EIs are advantageous also in terms of water use. Water is a resource that is becoming more and more scarce, and its utilisation is seen as a challenge for the future with the agricultural sector being particularly demanding in terms of water, consuming approximately 70% of the freshwater globally [68]. The water used to produce EIs is greatly smaller when compared with other animals [32]. On the other hand, the consumer is pretty well informed about these aspects related to the sustainability of EIs [1]. Nevertheless, some other aspects not yet evaluated with this questionnaire could be relevant, for example, evaluating the perceptions about the possible risks associated with insects, not only from the point of view of the human health [69] but also hazards to the environment, such as spreading diseases, although it is expected that the risks are similar to those of other animal productions [70].

With regards to the dimension Economic and Social Aspects, five items were considered valid: E1 "Insect production can contribute to increasing the income of families in low-income areas", E2 "Insects provide protein foods at low prices", E4 "Presently, the Asia–Pacific and Latin America areas account for more than half of the edible insect's market", E5 "In some countries insect farming is becoming a key factor in the fight against rural poverty", and E6 "The income generated from insects can be affected by market fluctuations in price derived from availability". The profitability of insect rearing has been established in new and traditional insect farms [71]. EIs constitute a way to add value to food items in local and poor communities in many parts of the globe, particularly in Africa or Asia [72,73]. Although the production of insects for food is a usual activity in traditional entomophagous communities, insect farming is still limited, although it is growing and expanding fast as a structured agribusiness [74–76]. In Europe, due to strict legislation and a higher degree of inertia in what concerns the adoption of new foods, the production, commercialisation, and consumption of EIs are less developed when compared with other regions of the globe [71].

In terms of the items for the dimension Commercialisation and Marketing, four items were considered adequate for the model: M4 "The level of knowledge influences the willingness to purchase insect food", M5 "Price is among the motivations to consume insect foods", M6 "The consumption of insects and derived foods depends on availability", and M7 "Personalities/influencers can lead people to consume insects". Over a period of five years, from 2018 to 2023, the market of EIs is expected to triplicate to nearly USD 1.2 billion, and by the year 2030 would be worth USD 8 billion [32]. These numbers are indicative of the commercial potential of the EI market, which is, however, still highly unequal across regions. Asia-Pacific and Latin America account for over 50% of the market, but it is envisaged a growth of the North American and European markets in the near future [32]. There is, however, some risk associated with these predictions owing to some possible decreasing trends related to the adoption of more westernised diets in countries where insects were traditional. Müller [26] reported a recent tendency to devalue insect-eating traditions in counties like Laos and Thailand, precisely due to the intent to adopt more westernised diets.

Regarding the dimension Nutritional Aspects, six items were retained by the model: N2 "Insects are a good source of energy", N3 "Insects have high protein content", N6 "Insects contain group B vitamins", N7 "Insects contain dietary fibre", N8 "Insects contain minerals of nutritional interest, such as calcium, iron and magnesium", and N9 "Insects contain fat, including unsaturated fatty acids". Edible insects have a high nutritional value and are rich sources of many macro and micronutrients. They are particularly rich in high-quality proteins, fatty acids, carbohydrates, vitamins, and minerals [17,27]. However, their nutritive value is different depending on the species or production variables [28]. EIs contain minerals, such as calcium, copper, iron, zinc, manganese, potassium, and sodium [77,78]. The vitamins present in EIs include mostly fat-soluble vitamins, such as A, D, E, and K, but also water-soluble vitamins C and those of the B complex are present in relevant amounts [78]. The protein contents in EIs are greatly variable, from 13% up to 77% (dry basis), according to the species or stage of development [30,78]. In EIs, polyunsaturated fatty acids can represent up to 70% of the total fatty acids present [78]. Nevertheless, EIs can also be a source of antinutrients, which can limit the absorption of nutrients in the intestine, but usually their concentrations are not considered problematic [77].

Finally, with regards to the dimension Health Effects, four items were validated: H2 "Insects are used by some people in traditional medicine", H4 "Industrially processed insect products are hygienic and safe", H7 "In certain countries, insects are approved officially for therapeutic treatment", and H8 "Insects contain bioactive compounds beneficial to human health". Insects have been utilised in traditional folk medicine. For example, they appear in pharmacopoeias of Korean traditional medicine used for treating arthritis or stroke [79]. According to Costa-Neto [80], insects constitute medicinal resources for humans in several cultures all over the world, and many biological activities have been scientifically established. EIs possess a diversity of bioactive compounds, for example, peptides [81,82], polysaccharides [83,84], and phenolic compounds [85,86], which have many health-enhancing or protective properties, namely antioxidant, antihypertensive, anti-inflammatory, antimicrobial, or immunomodulatory effects. The therapeutic potential of insects also includes analgesic, antibacterial, diuretic, anaesthetic, and antirheumatic properties [80]. In this way, EIs constitute not only a source of nutrients for the human body but also provide compounds with the potential to be transformed into ingredients for functional foods or nutraceutical formulations.

5. Conclusions

This study investigated the knowledge and perceptions about edible insects of a wide sample of participants from 13 different countries and allowed the validatation the KPEI scale using the statistical techniques of CFA couples with SEM. The validated scale included 27 items distributed within the different dimensions considered: Culture and Tradition, Gastronomic Innovation and Gourmet Kitchen, Environment and Sustainability, Economic and Social Aspects, Commercialization and Marketing, Nutritional Aspects, and Health Effects. Both multifactorial models resulting from the CFA/SEM analysis, first-order and second-order, included all the seven dimensions considered. Since the goodness of fit indices was practically equal for the first-order as well as the second-order models, both can be equally accepted to define the KPEI scale. The study enabled a solid validated KPEI scale considering the retained items due to the high number of participants (almost seven thousand) originating from different countries and from different population groups in terms of age, gender, professional area, or social and cultural influences. The validated KPEI scale allows a high degree of confidence in the data collected through its questions (37 items, precisely) either in this work or in future studies. Therefore, it may be used to better understand the perceptions and investigate the level of knowledge about edible insects in different geographical areas, cultural backgrounds, or population groups.

Some limitations could be highlighted. These results may have been influenced by the subjective perceptions and different levels of knowledge among the participants, much of it due to different sociocultural influences, bearing in mind that the participants were from 13 different countries. Therefore, it would be expected that there is some inconsistency between the answers of the participants, principally to those questions that referred to aspects that can in fact be highly variable among countries, especially considering that in some of them the practice of entomophagy can be considered traditional while in other it is not at all usual. Also, the use of different languages could be a drawback since it involved the translation from English to the different native languages, although in an attempt to minimise this difficulty, a double-sided translation process was adopted to avoid, as much as possible, any misinterpretations. Still, the Knowledge and Perceptions about EI (KPEI) scale developed and validated in this study can be interpreted as being of global coverage and applicability, constituting a very valuable tool for future studies about edible insects in each of the domains considered.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from the corresponding author upon request.

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