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Genetically modified foods: construction and validation of a questionnaire to ascertain the knowledge, opinion and training of physicians and nutritionists

Alimentos geneticamente modificados: construção e validação de um questionário para averiguar o conhecimento, a opinião e a formação de médicos e nutricionistas

Abstract

Introduction: Genetically modified foods (GMF) have recently entered the European market. This political decision generated social controversy due to debate over the actual health and environmental risks. Faced with this reality, health professionals, such as physicians and nutritionists, play a key role in decoding this new food technology. A diagnosis of the personal, professional reality and training needs of these specialists regarding GMF is therefore relevant. **Objectives:** To construct and validate a questionnaire to characterize the knowledge, opinion and training needs of nutritionists and physicians regarding genetically modified foods. **Methods:** The questionnaire was implemented online in 2016, with 526 respondents. Validation strategies through semantic analysis, internal consistency analysis and exploratory factor analysis were applied. **Results:** The questionnaire was validated, presenting a reliability based on Cronbach's alpha coefficient of 0.76. Seventeen factors were extracted, being organized in four themes: opinion, training, knowledge and personal / professional reality. This article highlights the importance of statistical procedures in the validation of questionnaires. **Conclusion:** The questionnaire could be implemented as a diagnostic tool to ascertain the reality of health professionals (namely physicians and nutritionists, in particular) dealing with challenges of introducing transgenic foods into human food diet.

Keywords: Questionnaire. Genetically Modified Foods. Physicians. Nutritionists.

Resumo

Introdução: Alimentos geneticamente modificados (AGM) entraram recentemente no mercado europeu. Essa decisão política gerou polêmica social devido ao debate sobre os riscos reais à saúde e ao meio ambiente. Diante dessa realidade, profissionais da saúde, como médicos e nutricionistas, desempenham papel fundamental na decodificação dessa nova tecnologia de alimentos. Portanto, é relevante um diagnóstico da realidade pessoal, profissional e das necessidades de treinamento desses especialistas em relação ao AGM. **Objetivos:** Construir e validar um questionário para caracterizar as necessidades de conhecimento, opinião e treinamento de nutricionistas e médicos sobre alimentos geneticamente modificados. **Método:** o questionário foi implementado on-line em 2016, com um total de 526 respondentes. Foram aplicadas estratégias de validação por meio de análise semântica, análise de consistência interna e análise fatorial exploratória. **Resultados:** O questionário foi

validado, apresentando confiabilidade baseada no coeficiente alfa de Cronbach de 0,76. Foram extraídos 17 fatores, organizados em quatro temas: opinião, formação, conhecimento e realidade pessoal / profissional. Este artigo destaca a importância dos procedimentos estatísticos na validação de questionários. **Conclusão:** O questionário pode ser implementado como uma ferramenta de diagnóstico para verificar a realidade dos profissionais de saúde (médicos e nutricionistas, em particular) que lidam com os desafios da introdução de alimentos transgênicos na dieta alimentar humana.

Palavras-chave: Questionário. Alimentos Geneticamente Modificados. Médicos. Nutricionistas.

INTRODUCTION

Genetically modified foods (GMF) have been taking on a permanent place on supermarket shelves, in the European Union in general and Portugal in particular. Their short-term and long-term effects on health and the environment are the subject of scientific discussion, which does not seem to end soon. Faced with such a reality, health professionals are important “actors” concerning this issue, since they are sources of information regarded as independent and credible, to whom patients can rely for clarification of doubts about risks or benefits associated with GMF. As such, a multidimensional survey on the personal and professional reality on the training needs of these professionals concerning the subject is justified. A tool that allows for the diagnosis of this reality is the application of questionnaires, with subsequent adequate analysis of the output data. Questionnaire-based studies allow evaluation of attitudes,^{1,2} perceptions,³ knowledge,^{4,5} satisfaction⁶ and behaviors⁷ of individuals within different contexts. These questionnaires should include questions (items) that, in content and quantity, allow to evaluate the object this study.⁸ And of course, all questionnaires should be reliable (give reproducible results) and valid (measure precisely what is intended to be measured).⁹

The construction and validation of questionnaires involve a semantic analysis of included items and analyses based on statistical methodologies, such as exploratory factor analysis and internal consistency.^{10,11} Semantic analysis is the one that, in linguistics, aims at the correction of errors and ambiguities and the clarity of question content. The exploratory factor analysis aims at simplifying the structure of the questionnaire, grouping the items into more representative factors and explaining the data variability, and excluding those that do not have relevance in any of the factors.¹²⁻¹⁴ So it is possible to separate the important information of the redundant and random ones, and the obtainment of groups that can explain subconcepts. Internal consistency is a form of measurement based on the correlation between different items, guaranteeing that all items tested are measuring the right concept. A validated questionnaire with appropriate methodology leads to greater confidence in the research results.

This research aims at describing the steps in the process of creating a questionnaire examining the knowledge, opinion and training needs of physicians and nutritionists regarding GMF. The validation of the questionnaire was achieved through semantic analysis, internal consistency analysis and exploratory factor analysis.

METHODS

Identification of potential questions and initial questionnaire structure

The preliminary stage consisted of a bibliographical research on topics directly related to GMF (i.e., genetic engineering, biotechnology and food safety) and knowledge, opinion, perception and training regarding GMF.¹⁵⁻²⁶ This information was subsequently processed and adapted.

Based on the survey, a structured questionnaire was elaborated as follows: (i) introductory note with the research background and objectives, the institution involved, clarification of the main concepts and declaration of confidentiality and anonymity; (ii) nine questions for socio-demographic characterization of the respondents and (iii) 60 questions on four thematic axes: knowledge (GMF production, sale and labelling in Portugal), opinion (consumption, nutrition, health, risks / benefits), self-perception of training needs (type, content and form) and personal / professional reality as regards GMF. Of these, 57 were closed in qualitative dichotomous scales (yes / no; true / false), Likert type, with five levels (totally disagree, disagree, neither agree nor disagree, agree, totally agree) or multiple choice with a single option. Only three were open-ended questions.

Construction and validation of the questionnaire

Semantic validation

The questionnaire was sent to a sample of 13 physicians and 11 nutritionists, selected by convenience from several institutions, located in different geographic regions. These 24 individuals evaluated clarity, structure, presentation, relevance, efficacy and interactivity of the questionnaire.¹⁰ Additionally, the questionnaire was evaluated by two specialists who have experience in the elaboration of measurement instruments (questionnaires) and relevant scientific production related to GMF and nutrition.

Implementation

The questionnaire was implemented in the LimeSurvey online platform (version 1.91+) and released from March to July 2016. To increase visibility, partnerships were sought with national associations of Physicians and Nutritionists, scientific meetings and social and professional networks. The questionnaire was disseminated within a universe of 50.927 physicians and 2.300 nutritionists.

Statistical analysis

Respondent data was exported from LimeSurvey to Microsoft® Excel® (Microsoft Corporation, version 14.5.7) and later analyzed in the IBM SPSS Statistics 23 for Windows® program (SPSS Inc., Chicago, USA). Incomplete questionnaires that compromised the analysis were excluded.²⁷ Open and/or unanswered questions were also deleted. Subsequently, an internal consistency and factor exploratory analysis of the data was performed.

Reliability

The internal consistency of the questionnaire was evaluated based on Cronbach's alpha coefficient, which values range from 0 to 1, and the internal consistency of a questionnaire is greater as its value gets closer to 1. A coefficient value in the range of 0.6 to 0.8 was used as an indicator of acceptable moderate-to-moderate consistency.¹⁴

Exploratory factor analysis

The thematic axes of the questionnaire were validated by exploratory factor analysis, which allows for grouping of items into factors and structure simplification thereby reducing the total number of questions. These factors adequately synthesize the information involved.¹⁴

The initial stage of exploratory factor analysis checked whether the data matrix was adequate for factorization, evaluating correlations between the items. The Kaiser-Meyer-Olkin (KMO) and Bartlett tests were used for this purpose. KMO values (or sample suitability index, calculated as the square of the total correlations divided by the square of the partial correlations of the items) can vary between 0 and 1: values under 0.5 are considered unacceptable, between 0.5 and 0.7 mediocre, between 0.7 and 0.8 good, between 0.8 and 0.9 optimum and above 0.9 excellent.¹⁴ The Bartlett test evaluates whether the covariance matrix is similar to an identity matrix (i.e., unit diagonal elements and remaining ones equal to zero). If the null hypothesis of matrix equality is rejected (significance level of 0.05), the correlations between the items are adequate and if the data

factor analysis can proceed (Pestana and Gageiro, 2014). Based on these two tests, and if the data matrix can be factorized, the questionnaire can be subjected to an exploratory factor analysis using the principal components method. The method of factors extraction was based on the Guttman-Kaiser criterion, retaining factors with eigenvalues greater than 1 and the percentage of variance explained by retained factors greater than 40%.^{28, 29}

The Varimax rotation criterion of the principal components' matrix was used. The retention of the items in each factor was based on absolute values of factor loading equal to or greater than 0.3¹⁴ and values of the calculated communalities (proportion of variance of each item explained jointly by retained factors, ranging from 0 to 1 greater than 0.5).^{13,14}

The study was approved by the Scientific Council of the College of Biotechnology, Portuguese Catholic University, Porto, Portugal.

RESULTS

Semantic Analysis

Factual errors, question ambiguities, item distribution, questionnaire length and overall content adequacy were corrected during the semantic validation procedure.

Expert recommendations and suggestions were incorporated, some items were reformulated, and others eliminated. The final questionnaire had 69 questions, of which nine were on socio-demographic characterization and the remaining 60 on GMF.

Statistical analysis

The final sample was composed of 526 respondents: 278 physicians and 248 nutritionists. This sample size exceeds the ideal value of 382 respondents, with a sampling error of 5% and a confidence level of 95%.²⁷

Of the 60 thematic questions (or items), three were excluded due to lack of answers (all were open-ended questions).

Reliability

The Cronbach's alpha coefficient obtained considering the 57 items was 0.76, revealing a substance-moderate consistency. This coefficient is a commonly used measure of reliability, that is, a measure to evaluate the internal consistency of questionnaires. The coefficient measures the coherence of the respondents' answers, its value indicating the extent to which the items and the scales that compose them measure the same concept.

Exploratory Factor Analysis

The questionnaire with the 57 items (chart 1) was submitted to an exploratory factor analysis using the principal components method. The obtained KMO index was 0.786 and the Bartlett sphericity test allowed to reject the null hypothesis to be rejected ($p < 0.05$), which shows a good correlation between the variables and corroborating the factor analysis.

The results of the method of factors extraction based on the Guttman-Kaiser criterion are shown in table 1. A total of 17 factors were obtained, which had their eigenvalues values greater than 1 and explain 63% of the total variance of the items.

Chart 1 presents the factor loading, communality and Cronbach alpha values of the items, grouped according to the results of the factor analysis after rotation of the principal components' matrix. The items included in the questionnaire were those that presented absolute loading values above 0.3 for all factors. This is considered the minimum value necessary for the factor loadings to be considered significant in exploratory analyses, being representative of the factors.³⁰ The higher the factor loading the better the item and, in this sense, many have relevant factor loadings. Two items of the questionnaire were excluded because they presented a factor loading close to zero.

As regards communality values, four items were below 0.5 (chart 1). However, these values were higher than 0.43, which explains at least 43% of the total variance. We chose to keep these items within the factors. Regarding Cronbach's alpha values, the values revealed a substantial internal consistency, ranging from 0.69 to 0.73.

Altogether 17 factors were retained and described the correlation structure between 55 items. Based on their composition (chart 1), the 17 factors were organized into four groups: opinion (factors 1, 2 and 3), training (factors 4 to 10), knowledge (factors 11 and 12) and personal/professional reality (factors 13 to 17) as pertains to GMF. These groups translate the objectives of the questionnaire.

Chart 1. Factor loading, communalities and Cronbach's alpha of items grouped by factor. Portugal, 2016. (Continues.)

Theme Area	Factor	Questionnaire Item	Factor Loading	Communalities	Cronbach's Alpha
Opinion		The consumption of genetically modified foods may induce an adverse clinical or nutritional picture.	0.759	0.613	0.71
		The consumption of genetically modified food may lead to health problems.	0.742	0.66	0.711
		There is scientific evidence that genetically modified organisms have negative health impacts.	0.721	0.602	0.711
		It is likely that transgenic foods are associated with some kind of symptom or pathology, even if it is not yet scientifically established.	0.691	0.602	0.713
		Consuming transgenic foods is, in practice, equivalent to the consumption of non-transgenic foods.	0.68	0.653	0.695
		Current standards are sufficient to protect people from possible risks of genetically modified food.	0.515	0.559	0.692
		If you chose a food product to buy and then notice that it was genetically modified, would you buy it (assuming there are other equivalents at the same price and without genetic modification)?	0.496	0.563	0.696
		Genetically modified seeds result in a healthier diet.	0.743	0.666	0.691
		Genetically modified seeds allow for greener farming.	0.716	0.649	0.697
		Transgenic foods currently on the Portuguese market are more nutritious than their conventional or biological counterparts.	0.706	0.619	0.691
		Genetically modified organisms are an important tool in the fight against hunger in the world.	0.606	0.609	0.696
		Genetic engineering can be used to produce food that brings benefits to mankind.	0.548	0.578	0.695
		The population is adequately informed about the consumption of transgenic foods.	0.687	0.615	0.696

Chart 1. Factor loading, communalities and Cronbach's alpha of items grouped by factor. Portugal, 2016. (Continues.)

Theme Area	Factor	Questionnaire Item	Factor Loading	Communalities	Cronbach's Alpha
Training		How do you keep up with the genetically modified food theme? News on the internet.	0.817	0.737	0.694
		How do you keep up with the genetically modified food theme? Scientific journals.	0.737	0.67	0.69
		How do you keep up with the genetically modified food theme? Books and miscellaneous technical documentation.	0.67	0.536	0.693
		How do you keep up with the genetically modified food theme? Conferences, lectures, seminars.	0.667	0.601	0.693
		How do you keep up with the genetically modified food theme? Contact with specialists.	0.505	0.536	0.694
		Did you receive any kind of training on genetically modified organisms under the bachelor's degree?	0.769	0.651	0.698
		What kind of topics would you like to see covered in that training? Genetically modified organisms and legislation.	0.798	0.708	0.686
		What kind of topics would you like to see covered in that training? Genetically modified organisms and ethics.	0.796	0.664	0.685
		What kind of topics would you like to see covered in that training? Genetically modified organisms and labeling.	0.767	0.658	0.687
		What kind of topics would you like to see covered in that training? Genetically modified organisms and environment.	0.739	0.618	0.687
		What kind of topics would you like to see covered in that training? Genetically modified organisms and genetics.	0.653	0.563	0.688
		What kind of topics would you like to see covered in that training? Genetically modified organisms and nutrition.	0.555	0.649	0.691
		What kind of topics would you like to see covered in that training? Genetically modified organisms and health.	0.516	0.703	0.692
		Do you consider it useful for your professional life to be continued training for updating on genetically modified foods?	0.339	0.544	0.687
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A theoretical work.	0.842	0.797	0.691
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A practical work.	0.837	0.793	0.687

Chart 1. Factor loading, communalities and Cronbach's alpha of items grouped by factor. Portugal, 2016. (Continues.)

Theme Area	Factor	Questionnaire Item	Factor Loading	Communalities	Cronbach's Alpha
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A short seminar.	0.808	0.703	0.693
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A class.	0.759	0.655	0.694
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? An optional subject.	0.446	0.43*	0.692
	0	What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A required subject.	0.631	0.624	0.696
		What kind of training do you consider most appropriate to receive during the bachelor's degree in relation to genetically modified foods? A module within a subject.	0.592	0.620	0.695
		Do you consider it useful to have some kind of training on genetically modified foods during the bachelor's degree?	0.327	0.47*	0.696
Knowledge	1	In Portugal the main transgenic crop is soybean.	0.817	0.753	0.691
		In Portugal the main transgenic in circulation is soybean.	0.781	0.739	0.69
		In Portugal organic food can also be transgenic.	0.658	0.599	0.69
		In Portugal several horticultural transgenic food is sold.	0.533	0.546	0.691
	2	In Portugal there is labeling of animal products produced using transgenic feeds.	0.786	0.742	0.689
		In Portugal there is labeling of transgenic foods.	0.765	0.733	0.689

Chart 1. Factor loading, communalities and Cronbach's alpha of items grouped by factor. Portugal, 2016. (Continues.)

Theme Area	Factor	Questionnaire Item	Factor Loading	Communalities	Cronbach's Alpha
Personal and professional reality	3	Do you feel it would be useful to take some kind of technical training on genetically modified organisms?	0.447	0.623	0.692
		Have you found difficulties or doubts (or do you feel you could find them) when talking about the subject of genetically modified foods with your patients / clients?	0.405	0.45*	0.689
	4	Have you performed any patient / client diagnoses involving the negative impact of genetically modified foods?	0.833	0.729	0.695
		In the last year, has any of the patients / clients raised any questions about genetically modified foods?	0.826	0.717	0.691
		On your own initiative (or would you indicate in any circumstance) do you tell your patient / client not to use genetically modified foods?	0.730	0.659	0.690
		If a patient / client asks if they can consume genetically modified food, what do you answer?	0.638	0.602	0.695
	5	How many times have you talked about the subject of genetically modified foods with your colleagues?	0.694	0.61	0.721
		How many times have friends or family ever asked you for your opinion on genetically modified foods?	0.664	0.561	0.721
		How many times have you had the initiative to talk about genetically modified foods with your patients / clients?	0.602	0.598	0.727
		When you shop, do you want to know if you are carrying any genetically modified food?	0.453	0.542	0.695
		Have you ever looked for any kind of information about genetically modified foods?	0.321	0.44*	0.690
	6	Have you ever bought any transgenic food?	0.886	0.887	0.690
		Have you ever eaten any transgenic food?	0.882	0.875	0.690
	7	Do you feel prepared to deal with transgenic issues that may arise, including some kind of symptom or pathology that may eventually be associated with them?	0.781	0.695	0.696
ejected Items		With regard to your job colleagues, do you feel more or less prepared to deal with issues related to genetically modified foods?	0.095	0.718	0.701
		How do you keep up with the issue of genetically modified foods? Social communication (press, radio, TV).	0.070	0.762	0.695

*Communalities value under 0.5

Table 1. Eigenvalues and total variance explained by factors extraction. Portugal, 2016.

Factor	Eigenvalue	% of variance	% of the cumulative variance
1	7.131	12.294	12.294
2	4.635	7.992	20.286
3	3.432	5.917	26.203
4	2.794	4.818	31.021
5	2.431	4.191	35.212
6	1.908	3.290	38.502
7	1.731	2.984	41.486
8	1.657	2.856	44.343
9	1.513	2.609	46.952
10	1.402	2.417	49.369
11	1.345	2.318	51.687
12	1.307	2.254	53.941
13	1.152	1.986	55.927
14	1.142	1.970	57.896
15	1.078	1.858	59.755
16	1.036	1.786	61.541
17	1.023	1.763	63.304

DISCUSSION

The validation of the developed questionnaire, based on the factor analysis procedures and reliability tests, allowed for a better organization of the contents aimed at an understanding of the current needs of health professionals regarding the issues around GMF. Results herein validate the questionnaire according to appropriate statistical procedures and led to a reorganization of the items in four theme areas. These areas have been classified and include the following core issues: (i) opinion - consumption, nutrition, health, risks and benefits of GMF; (ii) training - required contents, teaching-learning types and ways of updating; (iii) knowledge - issues related with the reality of GMF in Portugal, namely farming, circulation, sale and labelling; and (iv) personal / professional reality - issues, difficulties and doubts related to questions placed in a professional or personal context.

The methodology used to construct and validate the questionnaire aimed at physicians and nutritionists and regarding GMF was used by different authors, both in similar themes and in different contexts. Ferreira et al.,³¹ for example applied a factorial analysis and reliability tests to adapt and validate a questionnaire to nursing students about their perception of the type of supervision that is provided in clinical practice. Despite being a different thematic area than the one present in our work, the methodology was similar and allowed the authors to find two factors that helped to clarify behaviors.

In Turkey, Erdogan et al.³² developed a questionnaire to assess the attitude of university students towards biotechnology, with items on genetic engineering, GMF consumption, medical application, consumer perception, ethics and environmental impact perception. This questionnaire was validated by tests of reliability and exploratory factor analysis. The development of this instrument aimed to contribute to the scientific education in this area, which still presents great knowledge gaps. These authors obtained a KMO index of

0.860, which was slightly higher than the one obtained in our work (0.786). However, both values are indicative of the strength of the correlation between the items in the questionnaire, allowing to continue with the factor analysis.

In Malaysia, Amin et al.³³ analyzed the attitude of distinct groups of individuals (agri-food producers, biotechnology industrialists, health professionals, members of governmental and religious organizations, students and the general public) for two types of GMF (soybean and palm oil) and a genetically modified drug (insulin). The dimensions incorporated in the questionnaires were familiarity, perception of benefits, perception of risks, acceptance of risks and, finally, incentives. Understanding the public attitude towards genetically modified food was the main objective. The instrument of research of Amin et al.³³ was multidisciplinary, self-built, and also validated with reliability tests and factor analysis. These authors used a 7-point Likert scales from the lowest level of agreement to the highest one, larger than the one used in our work. In terms of internal consistency assessed by Cronbach's alpha values results were similar and above 0.70.

Fonseca et al.¹¹ used an exploratory factor analysis to validate a questionnaire on the perception of Portuguese secondary school students on biotechnology. The main objective was to develop and validate statistical analysis procedures in questionnaires with multiple dimensions, using as pilot data the students' perceptions regarding the mentioned issues. The questionnaire included questions on genetic engineering, applications of biotechnology, consumption of GMF, labeling and purchase intent similar to our research, using component analysis with varimax rotation. The analysis excluded items that reduced internal consistency and exhibited acceptable communality (above 0.40).

Oliveira et al.³ constructed and validated a questionnaire to evaluate the perception of Portuguese adults on functional foods, also using an exploratory factor analysis. These foods are characterized by their potential to promote health and well-being and reduce the risk of certain diseases, a feature highly leveraged by marketing. The capacity of this questionnaire was validated, being a useful tool to evaluate the perception of consumers with the aim of promoting more informed and conscious choices. Cronbach's alpha ($\alpha=0.816$) and KMO index ($\alpha=0.855$) were higher than the ones obtained in our work, revealing good internal consistency of the questionnaire and a good correlation between the items as well.

The results obtained with our work allowed us to construct a valid and reliable questionnaire that could be implemented as an instrument to diagnose the reality of health professionals (physicians and nutritionists, in particular) in the face of the challenges of introducing transgenics into human food diet.

CONCLUSION

The final questionnaire obtained and validated is an innovative instrument that will allow to assess the opinion, knowledge, training and personal / professional reality of Portuguese physicians and nutritionists regarding GMF, contributing to the characterization and identification of gaps related to this subject. It is worth mentioning that, although this instrument has been validated by physicians and nutritionists, it can be applied to other health professionals who are involved in this subject.

The procedures used to validate the questionnaires, i.e., exploratory factor analysis and reliability, allow greater credibility to the research and consistency of the results attained from the research.

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