BRAZILIAN JOURNAL OF FOOD TECHNOLOGY

ISSN 1981-6723
Online version

ORIGINAL ARTICLE

Vitamin D-enhanced pork meat consumers' purchase intention: an exploratory case study in Spain

Intenção de compra dos consumidores de carne de porco aprimorada com vitamina D: um estudo de caso exploratório na Espanha

Begoña Panea[1]*, Guillermo Ripoll[1]

[1] Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), Instituto Agroalimentario de Aragón (IA2), Zaragoza, Spain

***Corresponding author:** Begoña Panea, Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), Avda. Montañana, 930, 50059, Zaragoza - Spain, e-mail: bpanea@aragon.es

Cite as: Panea, B., & Ripoll, G. (2021). Vitamin D-enhanced pork meat consumers' purchase intention: an exploratory case study in Spain. *Brazilian Journal of Food Technology*, *24*, e2020105. https://doi.org/10.1590/1981-6723.10520

Abstract:

This paper investigated if Spanish consumers would be willing to consume vitamin D-enhanced pork meat from animals fed on mushrooms treated with ultraviolet (UV) light. The questionnaire briefly explained the context of the study (vitamin D deficiency) and asked the consumers to choose answers with which they were most in agreement (non-enriched meat, enriched meat with synthetic vitamin D or enriched meat with vitamin D from UV-irradiated mushrooms). A survey was conducted to 400 non-vegan nor vegetarian consumers in Aragón (Spain) by direct invitation. Sampling was carried out in a random and stratified manner, by province, gender and age group using the Aragón population data for 2017 (INE). Some sociodemographic, health and consumption habit data were requested. Most consumers preferred non-enriched meat. Treatment with UV-irradiated mushrooms was rejected by most consumers, and the consumers who presented any willingness to buy meat enriched with UV-irradiated mushrooms were in the youngest age group.

Keywords: Vitamin D deficiency; Diet; Consumer; Mushroom; Irradiation; Survey.

Resumo

Este trabalho pesquisou a disposição dos consumidores espanhóis para pagar mais por uma carne enriquecida com vitamina D, sendo esta proveniente de animais que foram alimentados com cogumelos irradiados com luz ultravioleta (UV). A pesquisa explicava brevemente o contexto do estudo – a deficiência em vitamina D – e solicitava aos consumidores que escolhessem a resposta com a qual eles concordavam: carne não enriquecida, enriquecida com vitamina D sintética ou enriquecida com vitamina D de cogumelos irradiados com luz UV. A pesquisa foi enviada a 400 consumidores não veganos e não vegetarianos de Aragón, comunidade autônoma do nordeste da Espanha, por convite direito. A amostra foi desenvolvida com estratificação por província, gênero e idade, utilizando os dados de 2017 do Instituto Nacional de Estatística. Nessa pesquisa foram também investigados alguns dados sociodemográficos,

de saúde e de consumo. A maioria dos consumidores preferiu a carne não enriquecida. O tratamento com cogumelos irradiados foi rejeitado pela maioria dos consumidores, sendo os mais jovens os únicos dispostos a pagar por esse produto.

Palavras-chave: Deficiência em vitamina D; Dieta; Consumidor; Cogumelo; Irradiação; Pesquisa.

1 Introduction

Vitamin D plays an important role in various metabolic processes in humans and animals, including calcium and phosphorus metabolism and neuromuscular homeostasis. In this sense, the Institute of Medicine (IOM) from Canada established as recommendations no more than 600 IU/day for people up to 70 years old and 800 IU/day for those over 70 years old. Although vitamin D3 is produced after exposure to sunlight, it is well documented that there is a vitamin D deficiency in the European population, especially in the elderly, even in countries with high numbers of sunny days, such as Spain (Taofiq et al., 2017). Vitamin D requirements also depend on calcium and phosphorous concentrations in the diet, physiological developmental state, age, gender, and skin colour. The following population groups have a higher risk of vitamin D deficiency as following: the elderly because their endogenous capacity to synthesize vitamin D decreases; people with dark skin; people who live in places where the incidence of sunlight is low; and adolescents during the period of increased bone growth because there is an addition of mineral needs related to bone mineralization. In addition, the sedentary habits of many people and climatological conditions can cause low exposure to sunlight, increasing the risk of vitamin D deficiency.

The biologically active form of vitamin D, called 1,25$(OH)_2$-vitamin D3, is a steroid hormone that has been historically classified as a vitamin because of the way in which its association with rickets was discovered. The chemical structure of vitamin D was determined in 1930 in the laboratory of Professor Adolf Otto Reinhold Windaus of the University of Göttingen (Germany). Vitamin D2, which can be produced by the ultraviolet irradiation of ergosterol, was chemically characterized in 1932. Vitamin D3 was not chemically characterized until 1936, when it became clear that vitamin D is a steroid and, more specifically, a secosteroid. For decades, it has been recognized that vitamins D2 and D3 have the same biological activity in humans, but in 2011, Heaney et al. (2011) showed that D3 is approximately 87% more potent in raising and maintaining serum 25(OH)D concentrations and produces 2- to 3-fold greater storage of vitamin D than equimolar D2.

Foods of animal origin are the main sources of vitamin D3, especially cod liver oil (2100 µg/kg) and some fish, such as herring (400 µg/kg) or tuna (250 µg/kg) (www.bedca.net), whereas vegetables in general and seeds in particular are especially poor in vitamin D. One way to alleviate vitamin D deficiency in a population is through food enrichment. An enriched food is one in which one or more essential nutrients have been added. It is an inexpensive procedure that has been used not only to solve nutritional deficiencies in certain sectors of the population but also to improve the quantity and quality of the nutrients of the food to which they are added. (Taofiq et al., 2017). If this addition has a demonstrable positive effect on health, the product is termed a functional food. During recent decades, enormous progress has been made in the development of functional foods because they offer interesting growth opportunities to the food industry (van Kleef et al., 2005).

The foods that are most frequently enriched in vitamin D are milk and its derivatives, but there are many people who do not consume dairy products, whether due to lactose intolerance or to other reasons; therefore, it is necessary to look for other sources of vitamin D.

In Spain, a possibility regarding this source of vitamin D could be to enrich pork as it is one of the most consumed meats. The consumption of fresh meat in Spain amounts to 34.9 kg/person/year, with 10.23 kg corresponding to pork (Spain, 2019). Nevertheless, the muscle of slaughtered animals has small amounts of vitamin D. According to the official databases of food composition in some countries (Canada, Sweden, Spain and Denmark), vitamin D3 content varies between 0.65 µg/kg and 3.40 µg/kg, whereas the content of 25-OH-D3

ranges from 0.60 µg/kg to 1.40 µg/kg. To increase the vitamin D content in pork meat there are basically two strategies: exposure of the animals to the sun or addition of vitamin to animal feed. The exposition of the animals to sunlight have been scarcely studied. Some studies demonstrated that sunlight exposition increases serum vitamin content although only some of them reported a vitamin deposition in the muscle (Barnkob et al., 2019; Larson-Meyer et al., 2017). On the other hand, in the European Union (EU) the addition of vitamin D3 or 25 (OH) D3 is allowed in pig feed, but the maximum allowed level is 50 µg/kg of feed (European Union, 2017). The added vitamin can be synthetic, but it can also come from a natural source. This natural source could be mushrooms. In recent years, there has been great interest in them because their vitamin D content can be increased by exposing them to ultraviolet (UV) light (Nölle et al., 2017; Taofiq et al., 2017); however, the conversion rate depends on the dose and temperature of that exposure (Kamweru & Tindibale, 2016; Simon et al., 2011). In humans, it has been observed that consuming mushrooms exposed to UV light is just as effective as taking vitamin D supplements (Keegan et al., 2013), with an intake of 2000 IU of vitamin D from mushrooms equivalent to 2000 IU from synthetic vitamin D2 or vitamin D3.

However, consumers are reluctant to incorporate some technologies in food processing (Steur et al., 2016). Culture and social norms influence what people eat and the acceptance of technological innovations in food (Chen, 2018). Numerous studies have shown that consumers are willing to accept technologies as long as they result in a substantial improvement in the healthiness or intrinsic quality of food, thus being it nutritional or sensory, but they are not inclined to accept excessive product manipulation (Verbeke et al., 2010). Irradiation treatments are considered to be very unnatural and are perceived as a risk to the environment and health; therefore, they are widely rejected and are allowed in very few laws and in few products (Frewer et al., 2011; Frewer et al., 2016).

Therefore, this study aimed to investigate whether consumers in Aragón would be willing to consume vitamin D-enriched pork meat generated by adding UV-treated mushrooms to animal feed. The study was conducted in the context of an enterprise global pigs' feeding strategy, in order to answer a specific question.

2 Material & methods

An online survey was conducted of 400 consumers (only non-vegan, non-vegetarian) in Aragón by direct invitation (Netquest panel). For the design of the sample, population data from Aragón for 2017 were used, according to the National Institute of Statistics . Sampling was performed randomly and was stratified by province, gender and age group (≤18-25 years, 26-40 years, 41-55 years, 56-64 years). The fieldwork was conducted between November 8 and 15, 2018. The maximum admitted error level was 4.9% considering a confidence level at 95% ($p = q = 0.5$; $k = 2$), as shown in the technical sheet (Table 1).

Table 1. Technical survey data sheet.

Scope	**Aragón**
Universe	Non-vegan nor vegetarian consumers
Sample size	400
Sample error	4.90%
Sampling	Random stratification with proportional allocation by province, gender and age
Control	Coherence and stability
No. of surveys sent	932
Rate of participation	42.9%
Fieldwork	November 2018

The questionnaire briefly explained the context of the study (vitamin D deficiency, Figure 1) and asked the consumers to choose answers with which they were most in agreement (non-enriched meat, enriched meat with synthetic vitamin D or enriched meat with vitamin D from UV-irradiated mushrooms). In addition, they were asked to provide some

sociodemographic (gender, age and place of residence), health (allergy to mushrooms) and behavioral data (frequency of meat consumption). The time needed to complete the questionnaire and the type of device used (PC, tablet, or mobile phone) were recorded. The survey used is shown in Figure 1.

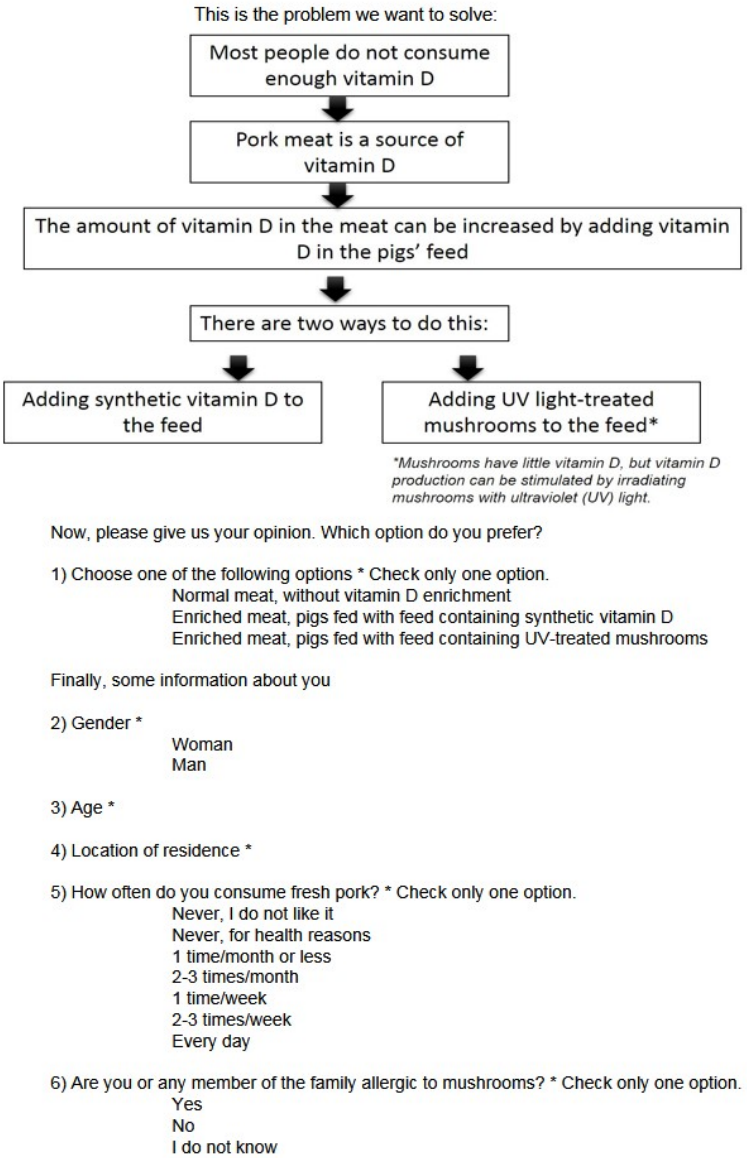

Figure 1. Survey design.

For the statistical analysis, R software was used. Frequencies were calculated for the sociodemographic, health and behavioral variables and for the response to the question posed. The effect of the sociodemographic, health and behavioral variables on the choice of the answer to the question was investigated by means of contingency tables and the calculation of X^2. Consumers who expressed that they did not eat pork it because they do not like it (1.7% of the total) or because health problems (0.3% of the total) was eliminated from the database, then the final number of valid answers was 392.

3 Results and discussion

Fifty percent of the respondents used their cell phones to complete the survey, 44.4% used a computer, and the rest used a tablet. The average time taken to answer the survey was 2 minutes and 42 seconds, with no differences among genders, ages or devices used ($p < 0.05$). The sample was balanced by gender (50% male) but not by age because those > 55 years old (17.1%) and ≤ 25 years old (10.7%) were less represented than those 26-40 years old (34.2%) and 41-55 years old (38.0%). For the provinces, 70.2% of the respondents were from Zaragoza, 18.6% were from Huesca, and 11.2% were from Teruel, which is consistent with the distribution of the population according to the Instituto Nacional de Estadística ((INE) – Spanish National Statistics Institute). Table 2 shows the distribution of consumers by province, gender and age.

Table 2. Sociodemographic characteristics of the sample.

Gender	Provinces	Age	Percentage (valid answers)
Men 50.0%	Huesca 17.3%	≤ 25	8.8
		26-40	32.4
		41-55	20.6
		> 55	38.2
	Teruel 11.2%	26-40	27.3
		41-55	27.3
		> 55	45.5
	Zaragoza 71.4%	≤ 25	3.6
		26-40	25.7
		41-55	51.4
		> 55	19.3
Women 50.0%	Huesca 19.9%	≤ 25	10.3
		26-40	41.0
		41-55	33.3
		> 55	15.4
	Teruel 11.2%	≤ 25	9.1
		26-40	63.6
		41-55	27.3
	Zaragoza 68.9%	≤ 25	20.7
		26-40	37.8
		41-55	33.3
		> 55	8.1

Number of the answers in function of sociodemographic variables are in Table 3. Regarding frequency of consumption, a 7.4% of consumers eats meat once/month or less, 23.2% of consumers eat meat 2-3 times/month, 37.5%, every week and 31.9%, more than once a week. Of the respondents, 93.9% did not have allergies to mushrooms, 1.0% did, and 5.1% said they did not know for sure. To the question "Which option do you prefer for enriching pork?", 81.4% responded that they preferred no enrichment, 6.4% preferred synthetic vitamin D enrichment, and the remaining 12.2% chose vitamin D enrichment from UV-irradiated mushrooms. None of the sociodemographic, health or behavioral variables investigated affected the option chosen ($X^2 < 0.05$), except for age ($p = 0.006$). Thus, those younger than 25 years had a higher frequency than expected for the options

"synthetic vitamin D" or "vitamin D from UV-irradiated mushrooms"; that is, they are the only ones willing to consider different options for food enrichment.

Table 3. Number (n) of the answers in function of sociodemographic characteristics of the sample.

						How option do you prefer?			How often do you consume fresh pork?			Are you or any member of the family allergic to mushrooms?		
			n	N	S	M	1/ month	2-3/ month	1/ week	2-3/ week	Every day	Yes	No	I do not know
Men (n=196)	Huesca (n=34)	≤ 25	3			3		1		1	1		3	
		26-40	11	10		1		3	4	4			11	
		41-55	7	7			1	4	2				5	2
		> 55	13	10	2	1	2	3	5	3			11	2
	Teruel (n=22)	≤ 25	0											
		26-40	6	4		2			5	1			6	
		41-55	6	6			1	1	4				4	2
		> 55	10	10				3	5	1	1		9	1
	Zaragoza (n=140)	≤ 25	5	2	2	1	1	1	2		1		5	
		26-40	36	26	3	36	3	9	10	13	1		35	1
		41-55	72	61	2	9	6	14	27	24	1		67	4
		> 55	27	24	1	2	2	6	11	8			26	1
Women (n=196)	Huesca (n=39)	≤ 25	4	2	1	1	1	1		2			4	
		26-40	16	12	1	3		5	6	5			16	
		41-55	13	10	1	2	1		10	2			12	
		> 55	6	6				1	1	4			6	
	Teruel (n=22)	≤ 25	2	1	1			1		1			1	
		26-40	14	12	2		1	5	3	4	1		14	
		41-55	6	3	1	2	1		2	3			6	
		> 55	0											
	Zaragoza (n=135)	≤ 25	28	20	2	6	2	11	8	7			27	1
		26-40	51	44	4	3	1	10	19	21			46	5
		41-55	45	39	2	4	6	9	16	14		1	43	1
		> 55	11	10		1		3	7	1			11	

N: Normal- Normal meat, without vitamin D enrichment; S: synthetic- Enriched meat, pigs fed with feed containing synthetic vitamin D; M: Enriched meat, pigs fed with feed containing UV-treated mushrooms; empty: square mean n=0.

Several studies (Font-i-Furnols & Guerrero, 2014; Font-i-Furnols et al., 2012; Ngapo et al., 2007) found that most Spanish consumers like pork and they consume eat pork mainly once a week, in agreement with current results. Although several authors stated that consumers' preferences depend on several factors, such as tradition, religion, age, education, gender, income, etc. (Ngapo et al., 2010; Verbeke et al., 2010), other authors (Bernués et al., 2012; Ripoll et al., 2015) shown that sociodemographic variables and life-style variables, such as frequency of consumption, were less significant than intrinsic cues in the consumer global appraisal, which could explain the lack of sociodemographic variables effect on our results. Nevertheless, we have found that younger people were more disposed to buy enriched meat. Some authors detailed that elderly people were predominantly skeptical about functional food in general (van der Zanden et al., 2014), maybe because young respondents tended to be more uninvolved about food whereas middle- and old-aged respondents have more frequently a conservative (traditional) profile (Bernués et al., 2012). In addition, risk perception is an important cue in consumer buy intention (Verbeke et al., 2007) because individual beliefs and background determines the propensity to value a certain product as natural (Ripoll et al., 2018; Ripoll & Panea, 2019). The perception of a food as healthy or natural leads to a greater willingness to pay for it (Gil et al., 2000). In addition, it has been specified that consumers require knowledge and practical experience to evaluate the quality of a product (Ripoll et al., 2018) which also could to explain found results. On the other hand, in consumer's studies, clustering is a common technique used to marketing strategies design (Bernués et al., 2012; Ripoll & Panea, 2019; Ripoll et al., 2018). Nevertheless, in current experiment and since preferable option was so poorly dependent on sociodemographic variables neither a clustering of consumers nor a decision tree can be developed.

5 Conclusions

Under the conditions of our study, we could conclude that most consumers prefer non-enriched meat. Treatment with UV-irradiated mushrooms was rejected by most consumers, and the only consumers who presented a willingness to buy meat enriched with UV- irradiated mushrooms were grouped into the youngest age.

References

Barnkob, L. L., Petersen, P. M., Nielsen, J. P., & Jakobsen, J. (2019). Vitamin D enhanced pork from pigs exposed to artificial UVB light in indoor facilities. *European Food Research and Technology*, *245*(2), 411-418. http://dx.doi.org/10.1007/s00217-018-3173-6

Bernués, A., Ripoll, G., & Panea, B. (2012). Consumer segmentation based on convenience orientation and attitudes towards quality attributes of lamb meat. *Food Quality and Preference*, *26*(2), 211-220. http://dx.doi.org/10.1016/j.foodqual.2012.04.008

Chen, M.-F. (2018). Social representations of genetically modified foods and public willingness to consume such foods in Taiwan. *Journal of the Science of Food and Agriculture*, *98*(14), 5428-5434. PMid:29675854. http://dx.doi.org/10.1002/jsfa.9086

European Union. (2017). Reglamento de Ejecución (UE) 2017/1492 de la Comisión, de 21 de agosto de 2017, relativo a la autorización del colecalciferol como aditivo en piensos para todas las especies animales. *Diario Oficial de la Unión Europea*, Brussels.

Font-i-Furnols, M., & Guerrero, L. (2014). Consumer preference, behavior and perception about meat and meat products: an overview. *Meat Science*, *98*(3), 361-371. PMid:25017317. http://dx.doi.org/10.1016/j.meatsci.2014.06.025

Font-i-Furnols, M., Tous, N., Esteve-Garcia, E., & Gispert, M. (2012). Do all the consumers accept marbling in the same way? The relationship between eating and visual acceptability of pork with different intramuscular fat content. *Meat Science*, *91*(4), 448-453. PMid:22429803. http://dx.doi.org/10.1016/j.meatsci.2012.02.030

Frewer, L. J., Bergmann, K., Brennan, M., Lion, R., Meertens, R., Rowe, G., Siegrist, M., & Vereijken, C. (2011). Consumer response to novel agri-food technologies: implications for predicting consumer acceptance of emerging food technologies. *Trends in Food Science & Technology*, *22*(8), 442-456. http://dx.doi.org/10.1016/j.tifs.2011.05.005

Frewer, L. J., Fischer, A. R. H., & Kaptan, G. (2016). Consumer perceptions of risks from food. In H. Lelieveld, J. Holah & D. Gabrić (Eds.), *Handbook of hygiene control in the food industry* (pp. 15-23). Amsterdam: Elsevier/Woodhead Publishing.

Gil, J. M., Gracia, A., & Sanchez, M. (2000). Market segmentation and willingness to pay for organic products in Spain. *The International Food and Agribusiness Management Review*, *3*(2), 207-226. http://dx.doi.org/10.1016/S1096-7508(01)00040-4

Heaney, R. P., Recker, R. R., Grote, J., Horst, R. L., & Armas, L. A. (2011). Vitamin D3 is more potent than vitamin D2 in humans. *The Journal of Clinical Endocrinology and Metabolism*, *96*(3), E447-E452. PMid:21177785. http://dx.doi.org/10.1210/jc.2010-2230

Kamweru, P. K., & Tindibale, E. L. (2016). Vitamin D and vitamin D from ultraviolet-irradiated mushrooms. *International Journal of Medicinal Mushrooms*, *18*(3), 205-214. PMid:27481154. http://dx.doi.org/10.1615/IntJMedMushrooms.v18.i3.30

Keegan, R. J., Lu, Z., Bogusz, J. M., Williams, J. E., & Holick, M. F. (2013). Photobiology of vitamin D in mushrooms and its bioavailability in humans. *Dermato-Endocrinology*, *5*(1), 165-176. PMid:24494050. http://dx.doi.org/10.4161/derm.23321

Larson-Meyer, D. E., Ingold, B. C., Fensterseifer, S. R., Austin, K. J., Wechsler, P. J., Hollis, B. W., Makowski, A. J., & Alexander, B. M. (2017). Sun exposure in pigs increases the vitamin D nutritional quality of pork. *PLoS One*, *12*(11), e0187877. PMid:29136033. http://dx.doi.org/10.1371/journal.pone.0187877

Ngapo, T. M., Fortin, J., Aalhus, J. L., & Martin, J. F. (2010). Consumer choices of pork chops: Results from two Canadian sites. *Food Research International*, *43*(6), 1559-1565. http://dx.doi.org/10.1016/j.foodres.2010.01.018

Ngapo, T. M., Martin, J. F., & Dransfield, E. (2007). International preferences for pork appearance: II. Factors influencing consumer choice. *Food Quality and Preference*, *18*(1), 139-151. http://dx.doi.org/10.1016/j.foodqual.2005.09.007

Nölle, N., Argyropoulos, D., Ambacher, S., Müller, J., & Biesalski, H. K.. (2017). Vitamin D-2 enrichment in mushrooms by natural or artificial UV-light during drying. *Lebensmittel-Wissenschaft + Technologie*, *85*, 400-404. http://dx.doi.org/10.1016/j.lwt.2016.11.072

Ripoll, G., & Panea, B. (2019). The effect of consumer involvement in light lamb meat on behavior, sensory perception, and health-related concerns. *Nutrients*, *11*(6), 1200. PMid:31141913. http://dx.doi.org/10.3390/nu11061200

Ripoll, G., Alberti, P., & Panea, B. (2015). Consumer segmentation based on food-related lifestyles and perception of chicken breast. *International Journal of Poultry Science*, *14*(5), 262-275. http://dx.doi.org/10.3923/ijps.2015.262.275

Ripoll, G., Joy, M., & Panea, B. (2018). Consumer perception of the quality of lamb and lamb confit. *Foods*, *7*(5), 80. PMid:29786652. http://dx.doi.org/10.3390/foods7050080

Simon, R. R., Phillips, K. M., Horst, R. L., & Munro, I. C. (2011). Vitamin D mushrooms: Comparison of the composition of button mushrooms (Agaricus bisporus) treated postharvest with UVB light or sunlight. *Journal of Agricultural and Food Chemistry*, *59*(16), 8724-8732. PMid:21736377. http://dx.doi.org/10.1021/jf201255b

Spain. Ministerio de Agricultura, Pesca y Alimentación. (2019). Informe del consumo alimentario en España 2018. Madrid: MAPA.

Steur, H., Odongo, W., & Gellynck, X. (2016). Applying the food technology neophobia scale in a developing country context. A case-study on processed matooke (cooking banana) flour in Central Uganda. *Appetite*, *96*, 391-398. PMid:26463016. http://dx.doi.org/10.1016/j.appet.2015.10.009

Taofiq, O., Fernandes, Â., Barros, L., Barreiro, M. F., & Ferreira, I. C. F. R. (2017). UV-irradiated mushrooms as a source of vitamin D2: A review. *Trends in Food Science & Technology*, *70*, 82-94.

van der Zanden, L. D., van Kleef, E., de Wijk, R. A., & van Trijp, H. C. (2014). Knowledge, perceptions and preferences of elderly regarding protein-enriched functional food. *Appetite*, *80*, 16-22. PMid:24798761. http://dx.doi.org/10.1016/j.appet.2014.04.025

van Kleef, E., van Trijp, H. C., & Luning, P. (2005). Functional foods: health claim-food product compatibility and the impact of health claim framing on consumer evaluation. *Appetite*, *44*(3), 299-308. PMid:15894404. http://dx.doi.org/10.1016/j.appet.2005.01.009

Verbeke, W., Frewer, L. J., Scholderer, J., & Brabander, H. F. (2007). Why consumers behave as they do with respect to food safety and risk information. *Analytica Chimica Acta*, *586*(1-2), 2-7. PMid:17386689. http://dx.doi.org/10.1016/j.aca.2006.07.065

Verbeke, W., Perez-Cueto, F. J., Barcellos, M. D., Krystallis, A., & Grunert, K. G. (2010). European citizen and consumer attitudes and preferences regarding beef and pork. *Meat Science*, *84*(2), 284-292. PMid:20374787. http://dx.doi.org/10.1016/j.meatsci.2009.05.001

Funding: Gobierno de Aragón (FITE 2018).

Received: Apr. 27, 2020; Accepted: June 17, 2021