



Awareness of Irradiated Food Consumption between Brazil and Argentina

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1. Introduction

Food irradiation is a process used for various purposes, the main function of which is food safety. Although food irradiation has been used to ensure food safety, most consumers are unaware of the basic concepts of irradiation, misinterpreting information and showing a negative attitude towards food treated with ionizing radiation [1, 2].

According to IAEA records from 2021, 68 countries authorize the sale of one or more types of irradiated food [3]. In 2017, there was a lack of validated instruments to assess awareness of the consumption of irradiated foods in Brazil. Thus a study [4] was carried out that resulted in the construction of a valid, robust instrument adapted to Brazilian culture, with the aim of assessing collective awareness of the consumption of irradiated foods, called the “Awareness Scale on Consumption of Irradiated Foods (ASCIF)”. As for the ASCIF [4], it was observed that this instrument showed good evidence of validity. Four factors were found safety of irradiated foods (S), concepts (C), labeling (L) and awareness (A), which represent the 31 items of the instrument.

In 2023, a new experiment was conducted to validate the ASCIF instrument for the Argentine population, which showed similarities and differences between the knowledge of consumers from the two Latin American cultures. The general objective of this study was to compare the responses of Argentinians and Brazilians to the Awareness Scale on Consumption of Irradiated Foods (ASCIF).

2. Methodology

2.1. Literature Review

The initial stage consisted of updating the bibliography using databases such as Scopus, Science Direct, Web of Science, Google Scholar and classic publications in the area under study. To refine the search, the following keywords were used in the search engines: "food irradiation" AND (knowledge OR attitude OR perception OR awareness) AND consumer AND (survey OR questionnaire OR interview) AND (Argentine OR Argentinean), from the last five years, in Portuguese, English and/or Spanish.

2.2. Sample

The group was made up of Argentinian men and women from different social classes and levels of education, from the province of Buenos Aires, identified on the lists of employees of the Comisión Nacional de Energía Atómica - CNEA (National Atomic Energy Commission), universities (professors and

students), companies in the food sector and the Argentine population in general, as the instrument aims to reach a lay audience on the subject of irradiated foods, so social variability in the sample is desirable. Participants accepted the terms of the Informed Consent Form before starting the survey by clicking next/continue in the collection system.

Respondents from all school levels (excluding the illiterate because the questionnaire requires their reading and comprehension) were considered for the research, with ages ranging from 18 to 70 years of age, of both sexes and of different social classes, with social variability being desirable in the sample. The instrument was applied online to these groups between October 25, 2023 and December 7, 2023, and the total number of respondents was 500.

2.3. Data Collect

The data were collected by electronic means, through the site <<https://pt.surveymonkey.com/>>. In order to evaluate the knowledge and behavior of consumers as well as about the knowledge and habits of consumers on irradiated foods, a questionnaire with a Likert scale of agreement was used. The scale offered five options of answer for each affirmative, ranging from strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4), and strongly agree (5). This instrument consisted of items that identified the socio demographic characteristics of the sample, behavior measures and measures of knowledge about the subject. To ensure that the collection was restricted to Argentina, the Internet Protocol (IP) range for access to the instrument's collection link was limited to residents of the Province of Buenos Aires.

2.4. Statistical Treatment

Statistical treatments guided the analysis of the data, providing the results for the research. The Paired Samples t Test was used to compare the scales applied in 2017 in Brazil [4] and in 2023 in Argentina. These statistical analyses were carried out using IBM SPSS (version 21).

2.5. Approval by Research Ethics Committees

This research project was approved in Brazil by the Research Ethics Committee of Universidade Brasil on October 20, 2023 (Certificate of Presentation for Ethical Appreciation 74513223.3.0000.5494). It was also approved in Argentina by the Comité de Ética Central del Ministerio de Salud de la Provincia de Buenos Aires, on September 22, 2023 (Ethical Evaluation Report No. ACTA-2023- 40111123-GDEBA-CECMSALGP).

3. Results and Discussion

In the literature review, no recent psychometric instruments were found that assessed Argentine consumers' awareness of irradiated foods. In this sense, the ASCIF psychometric instrument, which has been validated for Brazil [4], was also used for the present adaptation study for Argentina. The ASCIF is considered a complex instrument, both because of its subject matter, which is unknown to a large part of the population, and because of its structure, consisting of four factors (Safety of irradiated foods (S); Concepts (C); Labeling (L); Awareness (A)) distributed in 31 items (S = 15; C = 8; L = 5; A = 3).

A total of 500 Argentine consumers (51% women, 49% men) were involved in the study to validate the scale. 28.4% were aged between 30 and 39, 47.8% said they had a university degree and an average family income of 2 to 5 minimum wages, equivalent to 900 to 2,250 dollars a month (24%).

The statistical assumptions of normality, linearity and singularity were analyzed. It was observed that the histograms, skewness and kurtosis values and significance tests (Shapiro-Wilk) indicated a normal distribution. According to [5], deviations from multivariate normality are innocuous when all the variables meet this condition. The model was assumed to meet the linearity hypothesis. This was achieved by

analyzing the residuals and observing that the points were randomly distributed around zero. At the same time, the uniqueness assumption was analyzed by the variables meeting the VIF criterion of less than 5 and tolerance greater than 0.1, as recommended by [5].

Table I shows the detailed scores of the items and their errors ordered by the four factors, as well as a brief comparison between the Argentine and Brazilian responses to the 31 items in the instrument. It can be seen that for both the Argentine and Brazilian populations, the highest score was obtained on question 16 (Q16. I consider it necessary to carry out educational campaigns to inform the population about the irradiation of food), with values of 3.88 (0.04) and 4.59 (0.03) respectively, indicating values between agree and strongly agree on the likert scale.

The lowest score was obtained in question 8 (Q8. I consciously consume irradiated food) for the Argentine sample, with a value of 2.40 (0.04), while for the Brazilian sample the lowest score was observed in question 10 (Q10. I would be willing to pay more for irradiated food) with a score of 2.38 (0.04) indicating values closer to disagree on the likert scale.

Table I. ASCIF items with means for Argentina and Brazil.

Items	Means (s.e) (Argentina)	Means (s.e) (Brazil)
Q29. I consider that irradiated foods are not harmful to health in the long term. ^a <i>(Q29. Yo considero que los alimentos irradiados no hacen mal a la salud a largo plazo.)</i>	3.09 (0.05)	3.01 (0.04)
Q11. I would encourage consumption of irradiated foods. ^a <i>(Q11. Yo incentivaría el consumo de alimentos irradiados.)</i>	3.02 (0.05)	2.84 (0.04)
Q28. I consider that irradiated foods are not harmful to health in the medium term. ^a <i>(Q28. Yo considero que los alimentos irradiados no hacen mal a la salud a medio plazo.)</i>	3.15 (0.05)	3.12 (0.04)
Q30. I consider that irradiated foods are not harmful to the health of future generations. ^a <i>(Q30. Yo considero que los alimentos irradiados no hacen mal a la salud de las próximas generaciones.)</i>	3.12 (0.05)	3.03 (0.05)
Q13. I would consume irradiated food because I know that these are safe for consumption. ^a <i>(Q13. Yo consumiría alimentos irradiados, porque sé que estos son seguros para el consumo.)</i>	3.21 (0.05)	3.11 (0.05)
Q12. I would consume irradiated foods, as I know they do not cause health damage. ^a <i>(Q12. Yo consumiría alimentos irradiados, porque sé que estos no causan daños a la salud.)</i>	3.18 (0.05)	3.10 (0.05)
Q27. I consider that irradiated foods are not harmful to health in the short term. ^a <i>(Q27. Yo considero que los alimentos irradiados no hacen mal a la salud a corto plazo.)</i>	3.20 (0.05)	3.24 (0.04)
Q15. I approve the consumption of irradiated foods. ^a <i>(Q15. Yo apruebo el consumo de alimentos irradiados.)</i>	3.19 (0.05)	3.16 (0.05)
Q26. I feel safe about the consumption of irradiated foods. ^a <i>(Q26. Yo me siento seguro cuanto al consumo de alimentos irradiados.)</i>	3.09 (0.05)	3.01 (0.05)
Q10. I would be willing to pay more for irradiated food. ^a <i>(Q10. Yo estaría dispuesto a pagar más por alimentos irradiados.)</i>	2.41 (0.05)	2.38 (0.04)
Q9. I would consume irradiated food. ^a <i>(Q9. Yo consumiría alimentos irradiados.)</i>	3.04 (0.05)	3.35 (0.05)
Q21. I have confidence in buying a food when I read on the label the following information " Food Treated with Ionizing Energy". ^a <i>(Q21. Yo tengo seguridad al comprar un alimento cuando leo en la etiqueta la siguiente información: "Alimento Tratado con Energía Ionizante".)</i>	3.14 (0.05)	3.07 (0.05)
Q23. I would buy irradiated food because I know this process does not make the food radioactive. ^a <i>(Q23. Yo compraría alimentos irradiados, porque sé que este proceso no convierte el alimento en radioactivo.)</i>	3.32 (0.05)	3.48 (0.05)
Q25. Irradiated foods are nutritional safe. ^a	3.16 (0.05)	3.30 (0.04)

<i>(Q25. Los alimentos irradiados son seguros bajo el aspecto nutricional.)</i>		
Q31. The World Health Organization (WHO) and the United Nations (FAO) recommend the irradiation of food. ^a	3.04 (0.06)	3.11 (0.03)
<i>(Q31. La Organización Mundial de la Salud (OMS) y la Organización de las Naciones Unidas (FAO/ONU) recomiendan la irradiación de alimentos.)</i>		
Q2. Food irradiation can be used to reduce microbial load on food. ^b	3.30 (0.05)	4.07 (0.04)
<i>(Q2. La irradiación de alimentos se puede utilizar para reducir la carga microbiana en los alimentos.)</i>		
Q7. Food irradiation can be used to increase shelf life. ^b	3.34 (0.05)	3.98 (0.04)
<i>(Q7. La irradiación de alimentos se puede utilizar para aumentar el plazo de vida útil de los alimentos.)</i>		
Q3. The irradiation of food can be used to inhibit the budding of bulbs, roots and tubers. ^b	3.26 (0.05)	3.58 (0.04)
<i>(Q3. La irradiación de alimentos se puede utilizar para inhibir el brote de bulbos, raíces y tubérculos.)</i>		
Q5. The minimum absorbed dose by the irradiated food must be sufficient to achieve the intended purpose. ^b	3.39 (0.05)	3.77 (0.04)
<i>(Q5. La dosis mínima absorbida por el alimento irradiado debe ser suficiente para alcanzar la finalidad pretendida.)</i>		
Q6. Argentina authorizes the use of food irradiation. ^b	3.07 (0.05)	3.63 (0.03)
<i>(Q6. Argentina autoriza el uso de la irradiación de alimentos.)</i>		
Q24. Irradiated food is microbiologically safe. ^b	3.28 (0.05)	3.50 (0.04)
<i>(Q24. Los alimentos irradiados son seguros bajo el aspecto microbiológico.)</i>		
Q4. Food irradiation can be used to delay the ripening of fruits. ^b	3.24 (0.04)	3.57 (0.04)
<i>(Q4. La irradiación de alimentos se puede utilizar para atrasar, retardar la maduración de las frutas.)</i>		
Q1. Irradiated food is different from radioactive food. ^b	3.30 (0.05)	3.99 (0.05)
<i>(Q1. El alimento irradiado es diferente del alimento radioactivo.)</i>		
Q18. All foods that undergo irradiation should have this information highlighted on the product label. ^c	3.51 (0.05)	4.53 (0.03)
<i>(Q18. Todos los alimentos que pasan por proceso de irradiación deberían tener esa información destacada en la etiqueta del producto.)</i>		
Q20. I consider the symbol of Radura important in the labels of irradiated foods. ^c	3.42 (0.05)	4.45 (0.03)
<i>(Q20. Yo considero importante el símbolo de la Radura en las etiquetas de los alimentos irradiados.)</i>		
Q22. The food label should highlight the information of irradiated food. ^c	3.38 (0.05)	4.40 (0.03)
<i>(Q22. La etiqueta de los alimentos debería destacar la información de alimento irradiado.)</i>		
Q19. I consider that the additional information contained in the labels of irradiated foods is important. ^c	3.71 (0.04)	4.45 (0.03)
<i>(Q19. Yo considero que las informaciones adicionales contenidas en las etiquetas de los alimentos irradiados son importantes.)</i>		
Q16. I consider it necessary to carry out educational campaigns to inform the population about the irradiation of food. ^c	3.88 (0.04)	4.59 (0.03)
<i>(Q16. Yo considero que es necesario hacer campañas educativas para informar a la población sobre la irradiación de alimentos.)</i>		
Q14. I know some irradiated food. ^d	3.21 (0.05)	2.58 (0.06)
<i>(Q14. Yo conozco algún alimento irradiado.)</i>		
Q17. I know Radura, the symbol used to represent irradiated food. ^d	3.25 (0.05)	2.45 (0.06)
<i>(Q17. Yo conozco la Radura: es el símbolo internacional utilizado para representar un alimento irradiado.)</i>		
Q8. I consciously consume irradiated food. ^d	2.40 (0.05)	2.40 (0.05)
<i>(Q8. Yo consumo conscientemente alimentos irradiados.)</i>		

Factors: ^a Safety of irradiated foods (S). ^b Concepts (C). ^c Labeling (L). ^d Awareness (A).

To compare the results obtained with the samples from Argentina and Brazil, a The Paired Samples t Test analysis was carried out. A t test is a type of statistical test that is used to compare the means of two groups. It is one of the most widely used statistical hypothesis tests in pain studies [6]. Null hypothesis stated that both means are statistically equal, whereas alternative hypothesis stated that both means are not statistically equal i.e., they are statistically different to each other [7]. According to [8], the paired samples t test, sometimes called the dependent samples t-test, is used to determine whether the change in means between

two paired observations is statistically significant. In this test, same subjects are measured at two time points or observed by two different methods.

Table II shows the results for the Paired Samples t Test. The 31 ASCIF questions were compared for the Argentine and Brazilian populations. At the same time, the four factors (S, C, L and A) of the Argentine and Brazilian ASCIF were analyzed.

Table II. Paired Samples Test.

		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	Q1(ARG) - BR	-0,598	1,712	0,077	-0,748	-0,448	-7,811	499	0,000
Pair 2	Q2(ARG) - BR	-0,626	1,392	0,062	-0,748	-0,504	-10,055	499	0,000
Pair 3	Q3(ARG) - BR	-0,150	1,438	0,064	-0,276	-0,024	-2,333	499	0,020
Pair 4	Q4(ARG) - BR	-0,172	1,415	0,063	-0,296	-0,048	-2,718	499	0,007
Pair 5	Q5(ARG) - BR	-0,292	1,511	0,068	-0,425	-0,159	-4,321	499	0,000
Pair 6	Q6(ARG) - BR	-0,428	1,484	0,066	-0,558	-0,298	-6,451	499	0,000
Pair 7	Q7(ARG) - BR	-0,506	1,379	0,062	-0,627	-0,385	-8,205	499	0,000
Pair 8	Q8(ARG) - BR	0,196	1,702	0,076	0,046	0,346	2,576	499	0,010
Pair 9	Q9(ARG) - BR	-0,104	1,674	0,075	-0,251	0,043	-1,389	499	0,165
Pair 10	Q10(ARG) - BR	0,086	1,615	0,072	-0,056	0,228	1,191	499	0,234
Pair 11	Q11(ARG) - BR	0,334	1,552	0,069	0,198	0,470	4,814	499	0,000
Pair 12	Q12(ARG) - BR	0,270	1,572	0,070	0,132	0,408	3,841	499	0,000
Pair 13	Q13(ARG) - BR	0,278	1,609	0,072	0,137	0,419	3,863	499	0,000
Pair 14	Q14(ARG) - BR	0,890	1,829	0,082	0,729	1,051	10,882	499	0,000
Pair 15	Q15(ARG) - BR	0,222	1,589	0,071	0,082	0,362	3,123	499	0,002
Pair 16	Q16(ARG) - BR	-0,704	1,252	0,056	-0,814	-0,594	-12,573	499	0,000
Pair 17	Q17(ARG) - BR	1,072	1,843	0,082	0,910	1,234	13,004	499	0,000
Pair 18	Q18(ARG) - BR	-1,032	1,343	0,060	-1,150	-0,914	-17,188	499	0,000
Pair 19	Q19(ARG) - BR	-0,738	1,300	0,058	-0,852	-0,624	-12,699	499	0,000
Pair 20	Q20(ARG) - BR	-1,024	1,427	0,064	-1,149	-0,899	-16,049	499	0,000
Pair 21	Q21(ARG) - BR	0,284	1,647	0,074	0,139	0,429	3,856	499	0,000
Pair 22	Q22(ARG) - BR	-1,034	1,420	0,064	-1,159	-0,909	-16,280	499	0,000
Pair 23	Q23(ARG) - BR	0,068	1,657	0,074	-0,078	0,214	0,918	499	0,359
Pair 24	Q24(ARG) - BR	-0,120	1,422	0,064	-0,245	0,005	-1,887	499	0,060
Pair 25	Q25(ARG) - BR	-0,022	1,468	0,066	-0,151	0,107	-0,335	499	0,738
Pair 26	Q26(ARG) - BR	0,286	1,693	0,076	0,137	0,435	3,778	499	0,000
Pair 27	Q27(ARG) - BR	0,088	1,530	0,068	-0,046	0,222	1,286	499	0,199
Pair 28	Q28(ARG) - BR	0,180	1,482	0,066	0,050	0,310	2,716	499	0,007

Pair 29	Q29(ARG) - BR	0,228	1,546	0,069	0,092	0,364	3,299	499	0,001
Pair 30	Q30(ARG) - BR	0,248	1,571	0,070	0,110	0,386	3,530	499	0,000
Pair 31	Q31(ARG) - BR	0,018	1,541	0,069	-0,117	0,153	0,261	499	0,794
Pair S	S - fator1	0,164	1,378	0,062	0,043	0,285	2,666	499	0,008
Pair C	C - fator2	-0,362	1,206	0,054	-0,467	-0,256	-6,701	499	0,000
Pair L	L - fator3	-0,906	1,175	0,053	-1,010	-0,803	-17,246	499	0,000
Pair A	A - fator4	0,719	1,475	0,066	0,590	0,849	10,903	499	0,000

Questions Q9 (I would consume irradiated food), Q10 (I would be willing to pay more for irradiated food), Q23 (I would buy irradiated food because I know this process does not make the food radioactive), Q24 (Irradiated food is microbiologically safe), Q25 (Irradiated foods are nutritional safe), Q27 (I consider that irradiated foods are not harmful to health in the short term) and Q31 (The World Health Organization (WHO) and the United Nations (FAO) recommend the irradiation of food) showed $p > 0.05$, so according to the null hypothesis, means are statistically equal.

The other questions showed $p < 0.05$, so according to the alternative hypothesis, both averages are not statistically equal, i.e. the Argentine and Brazilian responses are statistically different from each other.

When the factors S, C, L and A are tested, the p -value < 0.05 indicates that there is a statistically significant difference between the means of the Argentinian and Brazilian groups.

4. Conclusions

Analysis of the results revealed that the majority of Argentinian and Brazilian consumers are unaware of the benefits of irradiated foods. The comparison between the two cultures showed comparable results with similarities between the questions and factors analyzed.

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