ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

Vol. 38 (Nº 32) Año 2017. Pág. 4

Market acceptance of irradiated food in the city of Piracicaba /SP-Brasil

Aceitabilidade de mercado para alimentos irradiados na cidade de Piracicaba/SP-Brasil

Vanessa de Cillos SILVA 1; Fabrício José PIACENTE 2; Sônia Maria De Stefano PIEDADE 3; Valter ARTHUR 4

Recibido: 01/021/2017 • Aprobado: 12/03/2017

Content

ABSTRACT:
The increasing concern in relation to safety and hygiene of food consumption makes it so that food conservation is studied. Food radiation is a technique used for conservation, but many consumers associate this technique with dangers such as environmental contamination and development of diseases. This research had the objective of evaluating the acceptance of irradiated products by the consumer market in the city of Piracicaba/SP-Brasil. The methodology adopted was the application of a questionnaire in the city's supermarkets. After the application, the data was tabulated and analyzed. It was observed that the majority of interviewees wouldn't eat irradiated food. The unfamiliarity and questions about the safety of irradiated food were the main causes of rejection of irradiated food.
Keywords: Radiation, Questionnaire, Storage, Market acceptance.

RESUMO:
A preocupação crescente em relação à segurança e higiene dos alimentos consumidos faz com que técnicas de conservação de alimentos sejam estudadas. A irradiação de alimentos é uma técnica utilizada para a conservação, porém muitos consumidores associam essa técnica a perigos, tais como, contaminação ambiental e desenvolvimento de doenças. O presente trabalho teve como objetivo avaliar a aceitabilidade de produtos irradiados junto ao mercado consumidor da cidade de Piracicaba/SP-Brasil. A metodologia adotada foi a aplicação de questionário em supermercados da cidade. Após a aplicação, os dados foram tabulados e analisados. Observou-se que a maioria dos entrevistados não consumiria alimentos irradiados. O desconhecimento e dúvidas quanto a segurança dos alimentos irradiados foram os principais motivos para a rejeição apresentada para alimentos irradiados.
Palavras-chave: Irradiação, Questionário, Armazenamento, Aceitabilidade de mercado.

1. Introduction

The increasing worry of consumers, in relation to safety and hygiene, of the food consumed, makes it so that different techniques of food storage are studied.

The irradiation, which consists of a form of non-thermal microbiological control, has been gaining more and more space and is being widely studied. It appears to be efficient in relation to pathogen control of minimally processed food and the increased shelf life of these products. This technique is complementary to the other conservation procedures such a pasteurization and can be performed after the product has been packaged, thus reducing the possibility of recontamination.

However, this irradiation technique isn't widely disseminated, it is unfamiliar among consumers in addition to facing bias. Therefore, it is necessary to verify the acceptance of irradiated products, and in the future advertise this technique and clear up any of the consumer's questions or concerns.

Thus, the objective of this research is to verify the acceptance of irradiated products by the consumer market in the city of Piracicaba/SP.

---

2. Literature Review

2.1 Food Irradiation

Food irradiation is "a physical process which consists of submitting the food, already in bulk packaging, to controlled doses of ionizing radiation for sanitary, phytosanitary and technological purposes" (BRASIL, 2001). It is considered a cold technique since it does not cause a significant raise in temperature during the process (MERRITT JUNIOR; VAJDI; ANGELINI, 1985).

The first studies of irradiation use on food in Brazil were carried out by the Center for Nuclear Use in Agriculture (CENA) in the 1960s. Brazilian legislation for the use of this technology is currently described in Resolution RDC #21 – January 26, 2001 which follows the international norms proposed in Codex Alimentarius by the Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA) (MODANEZ, 2012).

Resolution RDC # 21, regulated by the National Agency of Sanitary Surveillance, established the general requirements for irradiation use in food with sanitary quality checks on the final product. It emphasizes that the food irradiation process should be carried out by installations licensed by the proper state, municipal or Federal District via issuance of a sanitary license, which is done after authorization by the National Commission of Nuclear Energy and registration with the proper organ at the Ministry of Health (BRASIL, 2001).

In Brazil, there are five companies and institutions that possess the legal requirements to irradiated products on a commercial scale: CBE (one branch in Cotia/SP and one in Jarinu/SP), Acelétron Irradiação Comercial (Rio de Janeiro/RJ), Instituto de Pesquisas Energéticas e Nucleres – IPEN-CNEN/SP (São Paulo/SP), Centro de Energia Nuclear na Agricultura – CENA/USP (Piracicaba/SP) and Centro Tecnológico do Exército – CTEx (Rio de Janeiro/RJ). Food irradiation on a commercial scale is used in approximately 50 countries and at about 200 installations distributed throughout the world (CATTARUZZI, 2012).

Resolution RDC # 21 even establishes that any food can be irradiated and that the dosage should obey the minimum and maximum values, being that the minimum values are those that guarantee the proposed objective and that the maximum values being those that are less than the doses that affect the proper functioning and/or sensorial characteristics of the food (BRASIL, 2001).

Another point to highlighted and present in national legislation is that all food that undergoes the irradiation process should contain the phrase "THIS FOOD TREATED WITH IRRADIATION" on its label (BRASIL, 2001). International legislations from the Food and Drug Administration (FDA) require the labels of irradiated foods to show they symbol called Radura (Figure 1) surrounded by the phrase "treated with radiation" (GROCERY MANUFACTURES ASSOCIATION -

GMA, 2009).

Figure 1. International symbol used for the identification of irradiated products (Radura)

Source: GMA, 2009

The sources of radiation authorized by the National Commission of Nuclear Energy to be used in food are: cobalt-60 gamma radiation, cesio-137, X-rays (generated by machines operating with energy up to 5 MeV); and electrons (generated by machines operating with energy up to 10 MeV).

Cobalt-60 and accelerated electrons are the most commonly used sources in food processing. Gamma rays are electromagnetic radiations that don't have mass or charge, therefore bringing about great penetrative power (BELLINTANI et al., 2002). 60Co gamma radiations show high penetrative power in tissues, good dosage uniformity, low environmental risk and a half-life of 5.3 years (HERNANDES; VITAL; SABBA-SRUR, 2003; ICGFI, 1999). 60Co isotope gamma rays penetrate the food causing alterations which can also occur in the act of processing, freezing sterilizing or even cooking (CRAWFORD; RUFF, 1996).

Food irradiation is a physical treatment to which packaged or bulk foods are exposed. The time of exposure depends on the type of food and desired objective, in other words the prevention of growths, delay in maturation, reduction of microbial load, elimination of pathogenic microorganisms, sterilization, disinfection of grains, cereals, fruits and spices (COUTO; SANTIAGO, 2010).

The use of the irradiation technique has been widely studied and has been showing satisfactory results in relation to food conservation in the majority of analyzed experiments. In the studies carried out over the past few years, no substances exclusively produced in irradiated food were found (RELA, 2000). The irradiation does not turn the food radioactive when exposed to this process regardless of dosage and time of exposure. It passes through food without leaving residues. The irradiated products can be stored, transported or consumed right after treatment. It's worth mentioning that international health officials approved irradiation dosage up to 10 kGy as a food safety measure (ICGFI, 1999).

The Grocery Manufacturers Association - GMA (2009) confirmed that the irradiation does not cause significant alterations in the food macronutrients such as proteins, lipids and carbohydrates. It was even commented that the micronutrients, especially the vitamins, can show reduction when food undergoes the irradiation process, but the reductions also happen in other food processing methods such as cooking and freezing.

The costs of irradiation treatment vary according to the dosage used, ranging from US$10 to US$15 per ton for applying low dosages and in the case of aiming for longer fruit and vegetable shelf-life, and from US$100 a US$250 for high dosages, in radiation of spices for example (VIEITES et al., 2004). In general, when considering the product`s increased shelf life, the irradiation costs end up being compensated for by the decrease in product waste, thus turning

into a great potential to be used in minimally processed fruits and vegetables.

Several studies have been published in the area of food irradiation and emphasize the use of the irradiation technique using adequate doses for each type of product as an efficient method in microbial control, and at the same time, increasing the products' shelf-life, especially those that were minimally processed. Siqueira (2001), who studied the effects of radiation on Tilapia; Giannoni (2004) in minimally processed formosa papayas; Basbayraktar et al. (2006), in minimally processed carrots; Oliveira (2007) who confirmed the effects of the thermal processing technique associated with radiation of sugar cane juice

As examples of research that used irradiation for microbiological control, Siqueira (2001), who studied the effects of irradiation on Tilapia can be cited; Giannoni (2004) on minimally processed papayas; Basbayraktar et al. (2006), on minimally processed carrots; Oliveira (2007).

2.2 Market Acceptance for Irradiated Food

In relation to irradiation technology, it can be pointed out that in Brazil this technique is not widespread. For this reason, the consumer uninformed about food safety refuses eating food that has undergone this type of treatment.

Ornellas et al. (2006) analyzed consumer behavior in relation to the consumption of food treated by alternative methods, emphasizing irradiation use. The result was that consumers are increasingly demanding in terms of the safety of food acquired and that they are likely to buy these products. However, they emphasized the lack of advertizing information on methods such as food irradiation. In this study, 218 individuals from Belo Horizonte (MG) were interviewed and it was found that 59.6% of the interviewees did not know that the irradiation process could be used as a food conservation technique. The lack of information about this technique was highlighted due to the fact that 62% of the participants do not know if food irradiation can harm health and the environment. After the explanation that the food irradiation technique increases food safety, 89% of those interviewed showed that they were apt to eat irradiated food.

Silva et al. (2010) studied knowledge and attitudes about irradiated food of nutritionists who are faculty at institutions of higher education at institutions of higher education in Belo Horizonte/MG. This research consisted of 66 professors of which 13.6% did not know the definition of irradiated food; 12.1% of professors stated that irradiated food becomes radioactive; 71.2% are not familiar with the food irradiation process. The study confirmed that the main reason for the non-acceptance by the consumer is the lack of knowledge on the subject. In spite of the unfamiliarity, 80.3% of professors that participated in the research confirmed that they would have consumed this food even if they knew the product was irradiated, in other words, if this information had been written on the label and if they knew about the subject. It was found that 31.8% of interviewees thought that the radiation process makes the food less nutritious and 97% of the professors that participated in the research don't talk about this subject in their classes which means that future nutritionists, health professionals who were trained to advise consumers about food consumption, did not have the minimum training necessary in their education about irradiation use in the process of food conservation.

Modanez (2012) analyzed acceptance of irradiated food. The research was carried out at Centro Universitário Fundação Santo André (Santo André/SP) with 664 undergraduate students. Of those interviewed, 66% had a bad impression when they hear someone talk about nuclear energy; 80% said they did not have any information about applications of nuclear energy during their schooling; 74% do not know that one of the applications of nuclear energy is food irradiation; 70% believe that irradiated food becomes radioactive and 69% said they would not eat irradiated food. After clarification on the subject, a new questionnaire was applied where 94% said they had a good impression about nuclear energy applied to food and 81% stated they would eat irradiated food. The study shows the importance of spreading information for

greater acceptance by consumers in relation to the food irradiation process.

The acceptance of food irradiation by consumers is also the subject of study in other countries as seen below.

A study by the Gallup Organization (1993) in the United States to measure consumer attitudes about irradiation as a technique connected to food safety showed that the majority of consumers are aware about the food irradiation technique and 73% of people interviewed had already heard about irradiation. It was also found that after explanations about the technique 54% of the participants were willing to eat irradiated or non-irradiated meat.

Misra, Fletcher and Huang (1995) analyzed the attitudes of consumers in Georgia (United States) about irradiated food and checked their knowledge on the subject. The research sent 500 e-mail messages with answer to 47% of the questionnaires. In order know the concern related to food safety: pesticide residue, residue from medicine of animal origin, growth hormones, conservatives, bacterias, irradiation, naturally occurring toxins. Among the seven options mentioned, the order of concern was: 1st pesticide residue; 2nd growth hormones 3rd residue from medicine of animal origin; 4th bacteria; 5th conservatives; 6th irradiation and 7th naturally occurring toxins. In spite of the fact that radiation appears sixth on the list of concerns, of those interviewed who pointed out irradiation as the most worrisome, 40% considered it as a serious problem. When questioned about the concern dealing with specific subjects related to food irradiation, the following results were obtained for the classification of extremely worried: 60.2% worry about the possibility of the food becoming radioactive, 53.3% about the possibility of nutritional loss, 65.1% are concerned with the possible environmental risks and 63.8% with the occupational risk. When questioned if they had already hear about radiation use as a technique for food conservation, 54.5% said yes, however 47% of these said they did not know anything about the subject. And even when questioned about willingness to buy irradiated food, 56% were indecisive and 31% were willing to buy it.

Resurreccion et al. (1995) carried out a study in Georgia (United States) to see customer attitudes about irradiation. It was found that 72% of consumers said they knew about irradiation but about 88% of these said they did not know much about the process and 33% believe that irradiated food becomes radioactive.

He, Flether and Rimal (2004) studied the factors that affect the negative perception by consumers in relation to irradiated meat. Among some of the factors, lack of knowledge is cited which ends up causing misunderstanding and fear of the irradiation technique. These authors carried out research using 740 consumers from the United State, applied by the University of Georgia Research Center between December 1999 and January 2000 via telephone interviews whose sample was chosen randomly. The research had the main objective of assessing consumer attitude in relation to irradiated meat consumption. Some data: more than 40% of those interviewed believe that the mean turns radioactive when it undergoes the irradiation process, more than 44% think that radiation can reduce the meat's nutritional characteristics, 25% believe the consumption of radiated meat can increase the chance of developing some type of cancer, more than 45% are worried about environmental pollution that this technique could cause. Five empirical models were developed to explore the negative consumer perceptions related to irirradiated meat (increased risk of cancer, increased radiation level, nutritional loss, risk to employees and environmental pollution), and considering the age, gender, level ethnicity education, family income, knowledge about food radiation and perception of food safety standards. In the five models age was inversely proportional to negative perceptions of irradiated meat. People with higher levels of education and knowledge on the subject had fewer negative perceptions related to irradiated meat.

Hwang, Roe and Teisl (2005) found the concerns of North American consumers for eight types of technologies used in food, and to correlate the level of concern for each of them. For this, an e-mail survey was conducted in 2002 with North American consumers resulting in a sample of 1,656 people who completely answered the survey. The eight technologies analyzed were: antibiotics, pesticides, artificial growth hormones, genetically modified ingredients, radiation,

dyes and artificial flavors, preservatives and pasteurization. Pesticides and artificial growth hormones showed the biggest concern among consumers. Pasteurization, dyes and artificial flavors and preservatives were the least worrisome variables. Antibiotics, genetically modified ingredients and radiation showed intermediate levels of concern. The radiation technique ranked fifth among the eight technologies. They showed that the groups of technologies obtained (lower levels of concern, intermediate and higher) have similar characteristics.

Gunes and Tekin (2006) conducted a study in Istanbul, Turkey on the acceptance of irradiated products by Turkish consumers with a focus on red meat and raw poultry. The issue of food safety for some food processing methods, including radiation, was analyzed. The most worrying issue was related to bacteria, followed by food additives, pesticides, hormones and toxins. Radiation was among the techniques with fewer concerns, along with freezing and pasteurization. Only 13% of the sample indicated radiation as a concern. They also verified that 80% of participants had questions when asked about the safety of irradiated foods. After explaining about the benefits of food radiation, acceptance increased from 29% to 62%, emphasizing the importance of promoting the advantages related to food radiation technique.

Spaulding, Wiegand and O'Rourke (2006) conducted a study with a sample of 119 people in Illinois (United States) in order to study the knowledge and consumer perception regarding irradiated foods, especially ground beef. They found that 68% of respondents had heard about irradiated foods and 71% said they would buy irradiated ground beef. The main reason for the purchase of irradiated ground beef (85% of responses) was the belief that the technique kills harmful bacteria. It was found that 26% of the participants do not feel comfortable with the term radiation, 34% don’t feel very comfortable and 40% feel comfortable. Despite the high acceptance, consumer concern was observed regarding the safety, taste and nutritional characteristics of irradiated foods and that they need to be reassured on the subject. When asked about the irradiated ground beef, 76% of participants said they need to know the taste of the product does not change with radiation in order to eat it, 7% believe that the taste of irradiated ground beef is better and 17% think the flavor is worse than the non-irradiated product.

Flynn (2012), in a study conducted on behalf of the Association of Canadian Consumers done with a random sample of 1006 Canadians over 18 years old showed that 57% of people had not heard of food radiation before the survey. After a brief explanation that the technique can eliminate harmful bacteria, 66% of respondents supported food radiation as an option for consumers and when asked about the possibility of incorporating irradiated food for family consumption 54% were in favor of it.

Eustice and Bruhn (2013) found through other studies that demand for irradiated foods depends on consumer acceptance and knowledge in relation to the radiation technique remains limited. Many people confuse and associate the term radiation with radioactivity. They found that the interest in the purchase of irradiated food due to safety is growing especially after people receive information about the risks and benefits of the technique in question.

---

3. Methodology

Market acceptance of irradiated products was checked by applying a questionnaire in six randomly chosen supermarkets in Piracicaba /Sao Paulo/Brazil: Coop – Cooperativa de Consumo; Supermercado Dia% - Downtown; Delta Supermercados - Vila Rezende branch; Empório do Vovô; Extra Hipermercado e Pão de Açúcar. The semi-structured questionnaire was composed of nine questions, six closed, two open and one mixed. The open questions were transformed into closed so that the descriptive analyses were performed.

The sample size was obtained using the simple random sampling technique (BOLFARINE; Bussab, 2005) for a population of 316,192 inhabitants, referring to the inhabitants of the city of Piracicaba /SP over 19 years old (IBGE, 2010).

After the calculations, there was an approximately value found for 400 questionnaires so that

the sample was representative. The application of these questionnaires happened in the six aforementioned supermarkets during the 2013.

The tabulation of the data was performed and subsequently a descriptive analysis was made in which the frequency of each response was calculated and tables and graphs were made to facilitate presentation and analysis.

4. Presentation, Analysis and Discussion of Results

Questions 1 to 5 refer to the socio-economic characterization and its descriptive analyses are described in Table1.

Table 1. Socio-economic characterization of the sample elements

Variables	**Answer possibilities**	**%**
Gender	Feminine	60
	Masculine	40
Marital Status	Single	35.88
	Married	51.40
	Divorced	7.12
	Widow(er)	3.56
	Other	2.04
Education	Didn`t study	0.51
	Finished Elementary School	8.35
	Didn’t Finish Elementary School	4.81
	Didn`t Finish High School	10.63
	High School Graduate	35.44
	Didn’t Finish College	14.94
	Finished College	17.47
	Didn`t Finish Post-Graduation	3.80
	Finished Post-Graduation	4.05
Household Income	Up to 2 minimum salaries	21.99
	Between 2 and 4 minimum salaries	28.90
	Between 4 and 10 minimum salaries	38.87
	Between 10 and 20 minimum salaries	7.42
	More than 20 minimum salaries	2.81

It can be observed that by the socio-economic characterization of the sample, women for the most part, with an average of 36 years old, married, high school graduates and a salary range from 4 to 10 minimum salaries.

The remaining questions (from 6 to 9) are related to consumer knowledge in relation to related food. These results are shown in Table 2.

Table 2. Information about food radiation from the research participants

Questions	Possibilities	%
When you hear about Nuclear Energy, what is your impression?	Good	19.34
	Bad	63.87
	Other	16.79
What do you know about irradiated food?	Yes	40.76
	No	59.24
For those interviewees who answered the previous question the definition given was:	Correct	39.13
	Wrong	53.42
	Did not answer	7.45
Would you consume radioactive food?	Yes	22.08
	No	77.92

The question of interviewees' impressions in relation to nuclear energy showed that approximately 64% of the sample had a bad impression. This data corroborates the findings from other research, such as that of Pereira, Son and Neves (2009), Modanez (2012) and Cattaruzzi (2012) who found that 66% of respondents have negative a impression when asked about nuclear energy.

When asked what are irradiated foods, 59.2% of respondents said they did not know. This data is in agreement with Flynn (2012) who obtained that 57% of people interviewed had never heard of irradiated foods.

Of the respondents who knew the definition of irradiated foods, only 39.13% answered correctly. This shows that people erroneously think they know what means to the food radiation process is. The usual wrong answers relate to food radiation as a process that makes food radioactive, which can cause cancer, which makes food unfit for consumption and contaminated. Other studies show that some people confuse the term radiation with radioactivity or think that irradiated food becomes radioactive, interfering in the acceptance of these products (RESURRECION et al, 1995; Silva et al, 2010; MODANEZ 2012).

Regarding the question "Do you consume irradiated food?" The majority of respondents (approximately 78%) said they did not. Modanez (2012) and Cattaruzzi (2012) also found that the majority of people interviewed (69%) did not consume irradiated food when asked initially, that is, before any explanation about it.

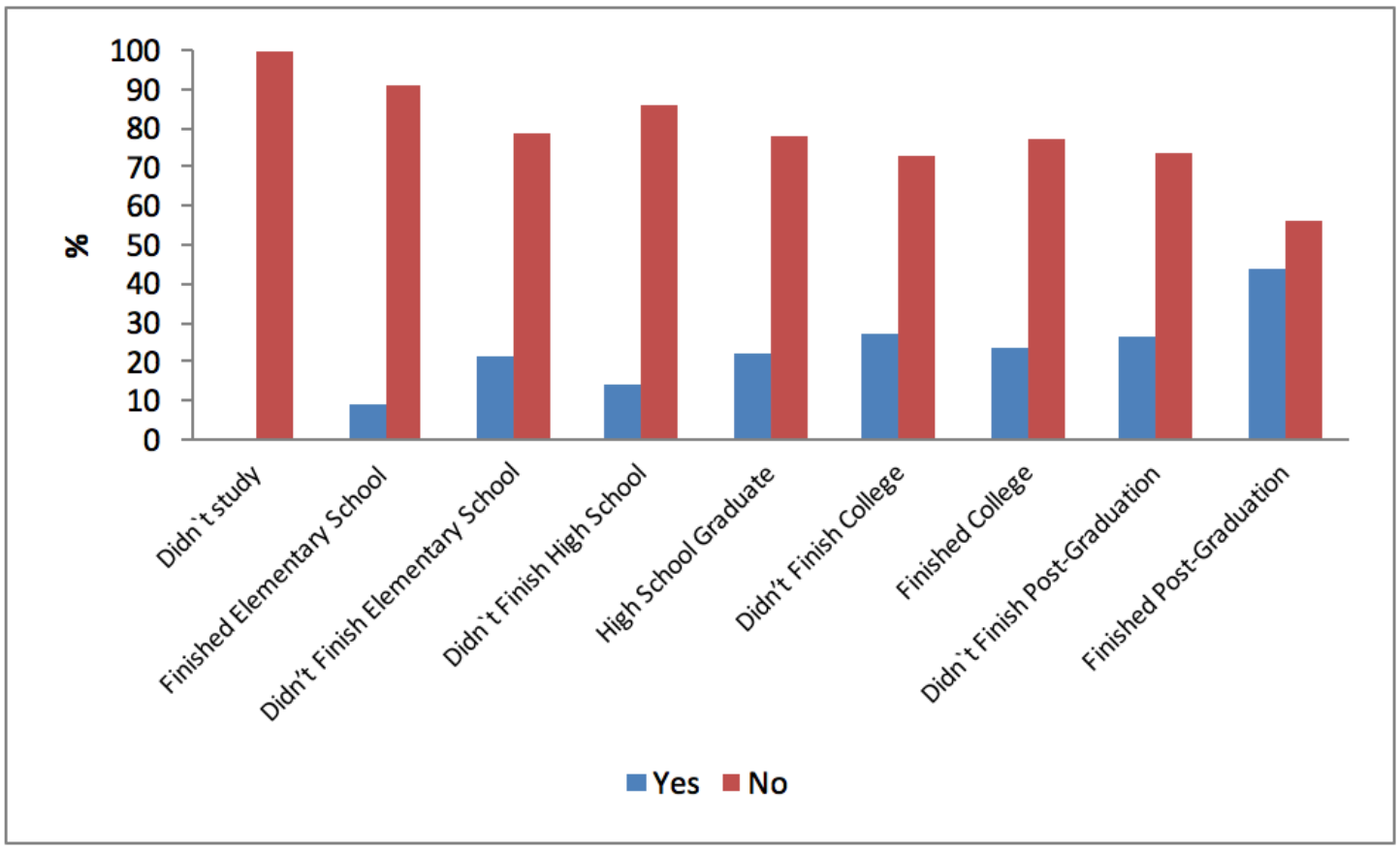
The main reasons for not consuming irradiated foods were: lack of knowledge on the subject and the thought that irradiated foods are harmful to health. Several studies cited above found that after information about the advantages of the radiation technique, the level of consumer acceptance increases, stressing that the lack of information is one of the main problems.

Fox (2002) studied the influence on the consumption of irradiated products and found that the main factor that interferes with the purchase irradiated products is information about the

radiation technique. Ornelas et al. (2006) found that lack of information is a limiting factor, and after receiving information that radiation increases food safety. 89% of the study participants stated that they consume irradiated food. Modanez (2012) found that after clarification of food radiation technique, 81% of the sample consume irradiated food.

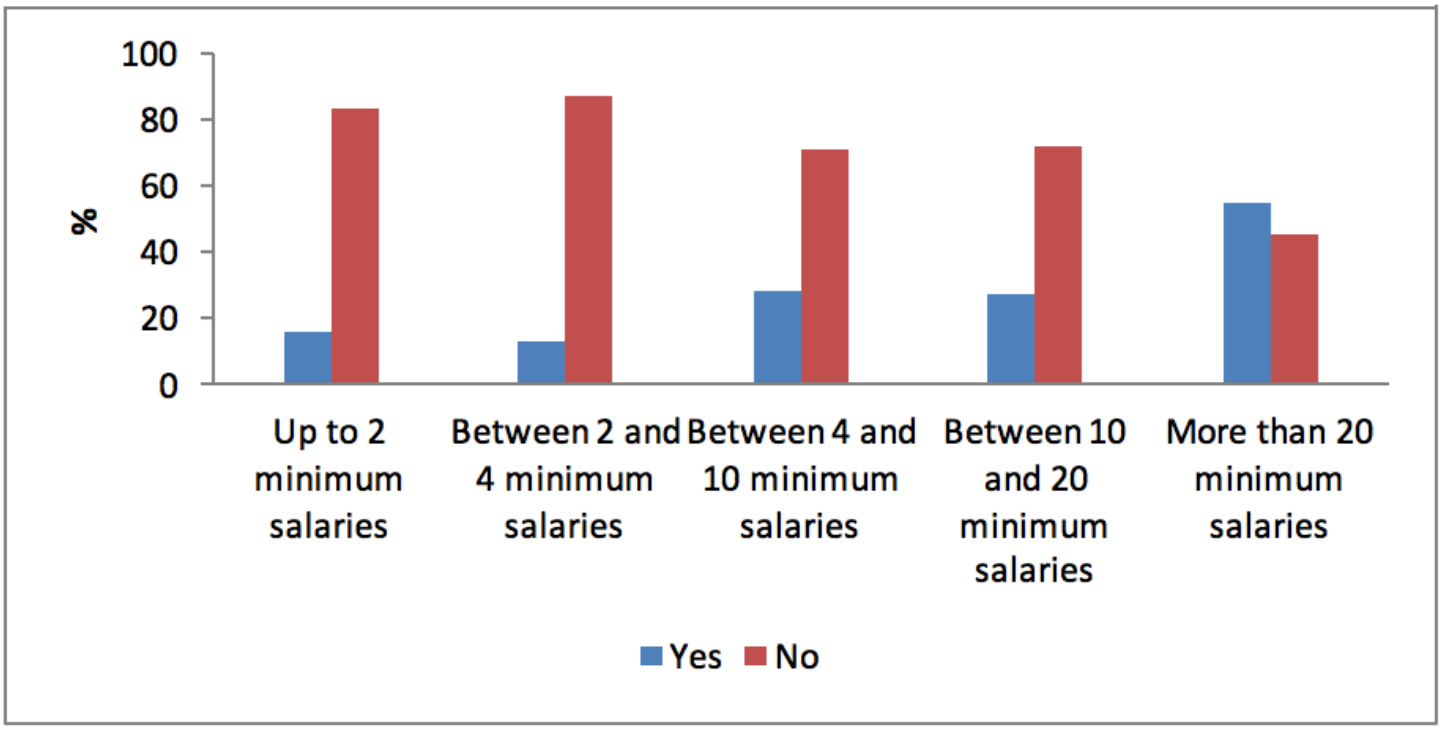
Relating the variable "would consume/would not consume irradiated food" with the variable of level of education, it is observed that the highest percentage of positive responses related to the consumption of irradiated food was from those who said they had completed post-graduate studies. Of these individuals, approximately 44% of the responses were favorable to the consumption of irradiated food. Similarly, the highest percentages of negative answers to the consumption of irradiated foods were obtained from respondents who did not (100% of responses) hadn't finished elementary school (approximately 91% of respondents who hadn't completed elementary school would not consume irradiated foods) (Figure 2).

Figure 2. Percentages of answers to the question "Would you consume irradiated food?" according to educational level



When the association of the variable would consume/would not consume irradiated food " is made with the level of income, we note that the observed trend is that the higher the income, the higher the percentage of favorable responses to the consumption of irradiated food (Figure 3).

Figure 3. Percentages of answers to the question "Would you consume irradiated food?" According to the income level



5. Conclusions

In relation to market acceptance of irradiated products for the consumer market in the city of Piracicaba/SP-Brazil, 78% of everybody interviewed said they would not consume irradiated food. The reason for not consuming irradiated food was due to lack of familiarity and people's fear that this food would be harmful for health.

For the interviewees with higher levels of schooling and income, greater acceptance related to the consumption of irradiated food was found.

Therefore, it has been concluded that the dissemination of studies in the area of food radiation should be advertised among consumers, highlighting the advantages and disadvantages of the method of food conservation. This advertizing could generate an increase in the consumption of irradiated food, which according to how this thesis concludes, showed the efficiency in microbial control and greater acceptance of the sensorial characteristics observed for the different vegetables analyzed.

References

BASBAYRAKTAR, V.; HALKMAN, H.; YUCEL, P.; CETİNKAYA, N. Use of irradiation to improve the safety and quality of minimally processed fruits and vegetables. In: INTERNATIONAL ATOMIC ENERGY AGENCY – IAEA. Use of irradiation to ensure the hygienic quality of fresh, pre-cut fruits and vegetables and other minimally processed food of plant origin. Vienna, 2006.

BELLINTANI, S.A.; GILI, F.N. Noções básicas de proteção radiológica. São Paulo: IPEN, 2002. 53 p.

BOLFARINE, H.; BUSSAB, W.O. Elementos de amostragem. São Paulo: Editora Blucher, 2005.

BRASIL. Agência Nacional de Vigilância Sanitária 2001. Resolução - RDC Nº 21 DE 26 de janeiro de 2001. Aprova o Regulamento Técnico para irradiação de alimentos. Diário Oficial da União, Brasília, DF, n. 20-E, 29 jan. 2001. Seção 1, p. 35.

CATTARUZZI, E.B. Análise sobre a predisposição do consumidor em arcar com o custo do alimento processado por radiação ionizante. 2012. 109 p. Tese (Doutorado em Ciências) – Instituto de Pesquisas Energéticas e Nucleares - IPEN, 2012.

COUTO, R.R., SANTIAGO, A.J. Radioatividade e irradiação de alimentos. Revista Ciências Exatas e Naturais, Guarapuava, v. 12, n. 2, p. 193-215, 2010.

CRAWFORD, L.M.; RUFF, E.H. A review of the safety of cold pasteurization through irradiation. Food Control, Guildford, v. 7, n. 2, p. 87-97,1996.

EUSTICE, R.F.; BRUHN, C.M. Consumer acceptance and marketing of irradiated foods. In: FAN, X.; SOMMERS, C.H. (ED.). Food irradiation research and technology. 2. ed. London: Blackwell Publishing, 2013. p. 173-195.

FLYNN, D. Canadians support food irradiation once they know about it. Food Safety News, n. 4, April, 24, 2012.

FOX, J.A. Influences on purchase of irradiated foods. Food Technology, Chicago, v. 56, n. 11, 2002.

GALLUP ORGANIZATION. ABT Associates. Center of Food Safety and Quality Enhancement. University of Georgia. Consumer awareness, knowledge and acceptance of food irradiation. Arlington, Virginia: American Meat Institute Foundation, 1993.

GIANNONI, J.A. Irradiação gama e armazenamento do mamão "formosa" minimamente processado. 2004. 96 p. Tese (Doutorado) – Faculdade d eCiências Agronômicas, Universidade Estadual Paulista "Júlio de Mesquita Filho", Botucatu, 2004.

GROCERY MANUFACTURES ASSOCIATION - GMA. Food irradiation: a guide for consumers, policymakers and the media. Washington, DC, 2009. Disponível em: http://www.gmaonline.org/downloads/research-and-reports/SPP_Irradiation5.pdf. Acesso em: 05 fev. 2014.

GUNES, G.; TEKIN, M.D. Consumer awareness and acceptance of irradiated foods: results of a survey conducted on Turkish consumers. Swiss Society of Food Science and Technology, Amsterdam, v. 39, p. 443-447, 2006.

HE, S.; FLETHER, S.; RIMAL, R. Factors affecting consumer negative perceptions about beef irradiation. In: SOUTHERN AGRICULTURAL ECONOMICS ASSOCIATION ANNUAL MEETING, 2004, Tulsa, Oklahoma. Disponível em: http://ageconsearch.umn.edu/bitstream/34672/1/sp04he02.pdf.

HWANG, Y. J.; ROE, B.; TEISL, M. F. An empirical analysis of United States consumers' concerns about eigth food production and processing technologies. AgBioForum, Columbia, v. 8, n. 1, p. 40-49, 2005.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. Censo Demográfico de 2010. Rio de Janeiro, 2010.

INTERNATIONAL CONSULTATIVE GROUP ON FOOD IRRADIATION - ICGFI. Facts about food irradiation. Vienna, 1999.

MERRITT JUNIOR, C.; VAJDI, M.; ANGELINI, P. A quantitative comparison of the yields of radiolytic products in various meats and their relationship to precursors. Journal of the American Oil Chemists' Society, Chicago, v. 62, p. 708-713, 1985.

MISRA, S.K.; FLETCHER, S.M.; HUANG, C.L. Irradiation and food safety: consumer attitudes and awareness. In: CASWELL, J.A. (Ed.). Valuing food safety and nutrition. Boulder: Westview Press, 1995. p. 435-455.

MODANEZ, L. Aceitação de alimentos irradiados: uma questão de aceitação. 2012. 104 p. Tese (Doutorado) –Instituto de Pesquisas Energéticas e Nucleares - IPEN, 2012.

OLIVEIRA, A.C.G. Efeitos do processamento térmico e da radiação gama na estabilidade físico-química, microbiológica e sensorial de caldo de cana puro e adicionado de suco de frutas, armazenado sob refrigeração. 2007. 105 p. Dissertação (Mestrado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, 2007.

ORNELLAS, C.B.D.; GONÇALVES, M.P.J.; SILVA, P.R.; MARTINS, R.T. Atitude dos consumidor frente à irradiação de alimentos. Ciência e Tecnologia de Alimentos, Campinas, v. 26, n. 1, p. 211-213, 2006.

PEREIRA, G.R.; FILHO, M.V.B.; NEVES, M.A. Um estudo sobre a inserção do tema "energia nuclear" no ensino médio de municípios da baixada fluminense – RJ. In: ENCONTRO NACIONAL

DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS - ENPEC, 8., 2009, Florianópolis. Florianópolis, 2009.

RELA, P.R. Cresce uso de irradiação para conservação de alimentos. Engenharia de Alimentos, São Paulo, v. 6, n. 29, p. 26-29, 2000.

RESURRECCION, A. V. A.; GALVEZ, F. C. F.; FLETCHER, S. M.; MISRA, S. K. Consumer attitudes toward irradiated food: results of a new study. Journal of Food Protection, Ames, v.58, n. 2, p. 193-196, 1995.

SILVA, K.D.; BRAGA, V.O.; QUINTAES, K.D.; HAJ-ISA, N.M.A.; NASCIMENTO, E.S. Conhecimento e atitudes sobre alimentos irradiados de nutricionistas que atuam na docência. Ciência e Tecnologia de Alimentos, Campinas, v. 30, n. 3, p. 645-651, 2010.

SIQUEIRA, A.A.Z.C. Efeitos da irradiação e refrigeração na qualidade e valor nutritivo da tilápia. 2001. 137 p. Dissertação (Mestrado em Ciências) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, 2001.

SPAULDING, A.D.; WIEGAND, B.R.; O'ROURKE, P.D. Consumer knowledge and perceptions of food irradiation: ground beef study. Journal of Food Distribution Research, Annapolis, v. 37, n. 1, p. 161-167, 2006.

VIEITES, R.L.; EVANGELISTA, R.M.; CAMPOS, A.J.; MOREIRA, G.C. Avaliação da contaminação microbiana do mamão minimamente processado e irradiado. Higiene Alimentar, São Paulo, v. 18, n. 118, p. 65-70, 2004.

---

1. Professor and coordinator in Business Management course of Piracicaba Technology College (FATEC Piracicaba), Piracicaba/SP, Brasil. Email: va.csilva@hotmail.com

2. Professor and researcher at the Master Program in Management and Technology in Production Systems, Centro Paula Souza (CEETPS) and professor at Centro Universitário Ancieta – UNIANCHIETA, São Paulo/SP, Brasil. Email: fjpiacente@bol.com.br

3. Professor at University of São Paulo (ESALQ/USP), Piracicaba/SP, Brasil. Email: soniamsp@usp.br

4. Professor at University of São Paulo (CENA/USP), Piracicaba/SP, Brasil. Email: varthur@cena.usp.br

---

Revista ESPACIOS. ISSN 0798 1015
Vol. 38 (Nº 32) Año 2017

[Índice]