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Customers' Awareness and Knowledge of Using Irradiation Technology Processed Foods in Egyptian Restaurants: An Exploratory Study

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وعي العملاء ومعرفتهم بإستخدام الأغذية المعالجة بتكنولوجيا التشعيع في المطاعم المصرية: دراسة استكشافية

الملخص

تحتاج وتيرة التعامل مع التقنيات المبتكرة في صناعة الأغذية إلى إجراءات ذو جودة للحفاظ على سلامة الغذاء، وخاصة عند إستخدام المطاعم المنتجات الغذائية التي تمت معالجتها بإحدى التقنيات المبتكرة في صناعة الغذاء، فإنها ستواجه ردود فعل وأسئلة مختلفة من العملاء حول هذه التكنولوجيا المبتكرة. يهدف البحث إلى معرفة مدى وعي ومعرفة العملاء بالمطاعم المصرية واستعدادهم لتناول الأغذية المعالجة بتقنية التشعيع. لتحقيق هدف البحث، تم تصميم إستبيان إلكتروني وتوزيعه بشكل عشوائي على عينة من العملاء في المطاعم المصرية، وتم إستلام **500** ردًا صالحًا للتحليل الإحصائي بواسطة **SPSS V.28**. أشارت النتائج إلى أن العملاء في المطاعم المصرية ليس لديهم معلومات كافية عن الأغذية المعالجة بتقنية التشعيع لقبول تجربة تناول الأغذية المعالجة بتقنية التشعيع في المستقبل. لذلك ربما يكون قبول العملاء وثقتهم في الأغذية المعالجة بإستخدام الإشعاع التكنولوجي

هو العقبة الرئيسية أمام عملية تسويق هذه التقنية المبتكرة للأغذية في المطاعم المصرية. بناءً على النتائج، تم اقتراح بعض التوصيات وتوجيهها إلى المتخصصين في علوم الأغذية، وأصحاب المصانع، وأصحاب المطاعم، والطهاة، والمؤسسات الغذائية، والحكومة. كانت إحدى التوصيات الرئيسية أنه يجب توعية العملاء المصريين للأغذية المعالجة بتكنولوجيا التشعيع من خلال وسائل الإعلام والدعاية المؤسسية لإستدامة وسلامة الأغذية والتغذية وصحة الأغذية المصنعة من خلال تكنولوجيا التشعيع من خلال نشر المعلومات الكافية حول الأغذية المعالجة بتكنولوجيا التشعيع من قبل المتخصصين في علوم الأغذية.

الكلمات الدالة: تكنولوجيا تشعيع الأغذية، تشعيع الميكروويف، وعى العملاء، سلامة الغذاء، المطاعم المصرية.

Abstract:

The pace of dealing with innovative technologies in the food industry requires be of quality procedures to maintain food safety, especially when restaurants use food products that have been processed with one of the modern technologies in food making, they will face different reactions and questions from customers about this innovative technology. The research aims to know the

extent of awareness and knowledge of Egyptian restaurants customers and their willingness to eat foods processed with irradiation technology. To achieve the research aim, an electronic questionnaire was designed and distributed randomly to a sample of customers in Egyptian restaurants, 500 valid responses were received for statistical analysis by SPSS V.28 . The results indicated that customers in Egyptian restaurants do not have enough information about food processed with technology irradiation to accept the experience of eating food processed with technology irradiation in the future. Therefore, customers' acceptance and confidence in food processed with technology irradiation is the major obstacle to the marketing process of this new technique in Egyptian restaurants. Based on the results, some recommendations were suggested and directed to food science professionals, factory owners, restaurant owners, chefs, food establishments, and government. One of the main recommendations was that Egyptian customers must be made aware of irradiation technology processed foods through the media and institutional publicity for the sustainability and safety of food, nutrition, and health of irradiation technology processed foods through the dissemination of sufficient information about irradiation technology processed foods by food science professionals.

Keywords: Food Irradiation Technology, Microwave Irradiation, Customers' Awareness, Food Safety, Egyptian Restaurants.

Introduction:

According to **Bisht *et al.* (2021),** modern food technologies are a powerful way to avoid the worldwide spread of foodborne diseases that have caused huge disruptions to community health, economic systems, and ecosystems. Therefore, the application of food irradiation technology is one of the methods of processing and preserving food of all kinds, which are used in food processing places (**Arapcheska *et al.*, 2020; Mshelia *et al.*, 2022)**. Food irradiation is defined as the process of preserving food safety in which food is exposed to appropriate doses of ionizing radiation to kill insects, mold and other microbes and allergens that may be harmful, as the process involves carefully exposing food to a measured amount of ionizing radiation in a special treatment room on a conveyor belt for a specified period, which can help reduce dangerous food-borne pathogens such as microorganisms and bacteria that cause food poisoning, accordingly irradiation technology helps to destroy bacteria and improve food safety and shelf life**(Agbaka and Ibrahim, 2020)**. Where food is irradiated by x-rays, gamma rays, or electronic rays to destroy bacteria without affecting the food product **(Ebrahim *et al.*, 2022)**. Superior food quality and safety can be ensured through the use of irradiation in conjunction with standard food safety procedures such as washing, packaging, chemical or thermal treatment, freezing, refrigeration or drying, and lyophilization **(Lima *et al.*, 2018)**. There is a great development in the production of radioactive food due to the great acceptance among modern customers as it is considered the main driver that promotes the growth of the global market for radioactive food (**Castell-Perez and**

Moreira, 2021). Also, increasing customer awareness of the prevention of foodborne diseases is another stimulus that is expected to boost market growth (**Rozekhi *et al.*, 2018; Sulaiman *et al.*, 2022**). Another major growth-promoting factor is the benefits offered by food irradiation technology including the elimination of pathogenic microorganisms, the increased shelf life of foods, minimal use of chemical disinfection, food decontamination, and safety of food processes. The level of acceptance of radioactive food varies according to the type of products allowed for radiation in different regions of the world **(Rusin *et al.*, 2018; Galati *et al.*, 2019)**. The most common food products around the world include spices, herbs dry spices vegetables, and fruits (**Khalili *et al.*, 2017; Gyimah *et al.*, 2020; Kim *et al.*, 2022**).

The research's problem lies is that although food irradiation technology is one of the modern technologies in food processing, at the same time, customers in restaurants may not be interested in food irradiation technology because of the lack of comprehensive knowledge of that technology and its benefits (**Agbaka and Ibrahim 2020; Indiarto *et al.*, 2020; Ebrahim *et al.*, 2022**). In addition to the scarcity of studies that measure customers' awareness of technology food irradiation (**Rusin *et al.*, 2018; Rozekhi *et al.*, 2018; Galati *et al.*, 2019;Castell-Perez and Moreira, 2021; Sulaiman *et al.*, 2022; Recuero-Virto and Valilla-Arróspide, 2022; Siddiqui *et al.*, 2022**), especially in the field of restaurants, because restaurants use large quantities of food that need to be preserved and processed (**Sokolovska *et al.*, 2022)**.

Aims of the Research:

The research aims to identify the extent to which customers in Egyptian restaurants are aware of food irradiation technology, the questions that the customer needs to know about this modern technology, and the extent to which customers in Egyptian restaurants accept food treated with irradiation technology. Therefore, this study focuses on increasing customers' awareness of food irradiation technology and their acceptance of irradiated foods after adding new information about this technology and its advantages to bridge the research gap by fully discussing customers' questions about that technology. The field study was completed in 6 months "from **20** July 2022 to **25** December 2022".

Research Hypotheses:

Based on the researcher's exploring on the issue of irradiation technology processed foods and the informational effects and the extent of its contribution to the awareness and acceptance of irradiation technology processed foods by customers, the research hypotheses could be suggested as follows:

Hypothesis1: There is a significant Impact of Using Irradiation Technology Processed Foods in Egyptian restaurants (about "H. 1.1" customers awareness of the advantages of foods processed with irradiation technology, "H. 1.2" acceptance of customers to eat foods Processed with Irradiation technology, "H. 1.3" challenges affecting customers' acceptance of foods processed with irradiation technology) on customers' acceptance in Egyptian restaurants.

Hypothesis 2: There are significant differences between the acceptance of customers of irradiation technology processed foods according to demographical data ("H 2.1" gender, "H 2.2" Age, and "H 2.3" Educational level).

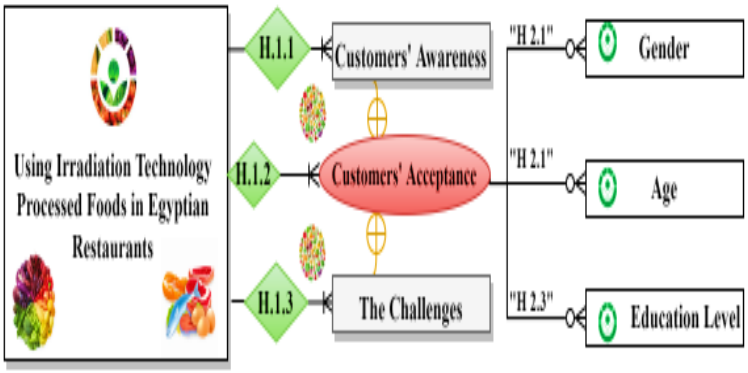

Figure 1: The Proposed Research Framework and Hypotheses

Literature review:

Use of Radiation Processed Foods in Restaurants:

Global Trends in Food Processing Irradiation Trading Market will reach USD 276.7 Million by 2026 (**Global Industry Analysts, 2022**). There are three types of ionizing radiation in commercial radiation for product processing such as foods, medical devices, etc., which are divided by the International Atomic Energy Agency "*IAEA*": (A) Radiation from high-energy gamma rays, (B) X-rays, (C) Accelerated electrons (**Kalyani, and Manjula, 2014; Khalili *et al.*, 2017; Gyimah *et al.*, 2020**). According to the *"CODEX*" General Standard for Irradiated Foods, these ionizing rays are only permitted for use in food irradiation applications (**Ebrahim *et al.*, 2022**). These types of

radiation are called "ionizing" because their energy is high enough to dislodge electrons from atoms and molecules and turn them into electrically charged particles called "ions". Ionizing radiation may originate from various sources as follows (**Dimov *et al.*, 2022)**:

(A) Gamma radiation "*Gamma rays*" The approved sources of gamma rays for food irradiation are the radionuclides cobalt-60 (60Co; the most common) and cesium -137 (137Cs). They contain energy levels of 1.17 and 1.33 MeV (60Co) and 0.662 MeV (137Cs).

(B) Machine sources of electron beams with energies up to 10 MeV.

(C) Machine sources of bremsstrahlung (X rays or decelerating rays) with electron energies up to exceed 5MeV.

According to **Wei *et al.* (2022),** food irradiation uses a controllable amount of ionizing radiation to ionize atoms or molecules in food. Where the atomic radiation penetrates the food to different degrees, discharging its energy and leading to the occurrence of ionization in the atoms and molecules. And what is meant by ionization is to free the electronics from their orbits around the nuclei of atoms and molecules, leading to their annihilation, that is, making them electrically non-neutral (**Ashfaq *et al.*, 2020**). This leads to an increase in the chemical activity of these atoms and molecules and the formation of free radicals. By free radicals, what is meant is atoms and molecules that have a non-double electron in their outer orbit, and therefore are highly chemically active, as they can combine with each other or with other atoms or molecules, accordingly, it is possible to change the molecular structure of cells, and prevent the division of living cells, such as bacterial cells

and Microbes and viruses. It can inhibit the full ripening of fruits and vegetables, through biochemical reactions (**Kalyani and Manjula, 2014**). Irradiation technology can extend the life span of chicken, turkey, and minced meat in restaurants, by keeping them for as long as possible as they are considered perishable foods, as they are processed using X-rays and gamma rays **(Handayani and Permawati, 2017; Panseri *et al.*, 2022; Yang *et al.*, 2022**). Irradiation is also used to process potatoes, onions, wheat, flour, spices, and fruits (**Darré *et al.*, 2022**). Irradiation technology and non-thermal food preservation techniques help sushi restaurants as it is one of the cold meals that is exposed to spoilage, causing many cases of food poisoning, so the irradiation technology inhibits microbiological growth to reduce or eliminate these risks (**Jadhav *et al.*, 2021; Kulawik and Dordević, 2022**).

Microwave radiation is one of the radiations that food is exposed to, there is an enormous difference between food irradiation and microwave heating are two completely different processes with distinct and separate goals (**Cravotto, and Binello, 2019**). However, both irradiation of food and microwave heating emit radioactive energies that produce effects when absorbed into the food (**Yuan *et al.*, 2022**). Both require special equipment to generate and focus this energy, as well as to prevent potentially harmful effects on humans (**Guzik *et al.*, 2021**). Irradiation and microwave heating are relatively innovative technologies when applied to foodstuffs (**Yuan *et al.*, 2022**). Food irradiation is primarily used as a method of food preservation, but it also has potential as a more general unit process to bring about specific changes in nutrients (**Potter,**

1986). On the other hand, microwave energy is specifically used to produce fast and unique heating effects, one of whose applications could be food preservation (**Potter, 1986; Popelá˘rová *et al.*, 2022**).

Benefits of Approval Food Irradiation in restaurants:

According to **Chua (2022)**, There are many advantages that encourage the use of food irradiation technology, as it helps foods processed with irradiation technology to reduce the risk of infection with some foodborne diseases and food poisoning and significantly reduce the number of infections by reducing the level of bacteria and viruses the harmful "such as those caused by salmonella and E. coli, Listeria, and Campylobacter" (**Roberts, 2016; Ravindran and Jaiswal, 2019; Ezzatpanah *et al.*, 2022**). Food irradiation also extends the shelf life of some products by destroying or inactivating spoiled organisms and the ability of the irradiation process to easily destroy bacteria, thus increasing the shelf life of foodstuffs (**Mostafavi *et al.*, 2012; Nascimento *et al.*, 2022).** Irradiation can provide protection for people with weakened immune systems from foodborne diseases for patients, the elderly and pregnant women due to its ability to sterilize and disinfect food from bacteria (**Indiarto *et al.*, 2022**). Food irradiation technology helps reduce food waste. In addition, eating radioactive foods does not health risks pose long-term, and does not cause genetic damage (**Telpner, 2022**).It also has the ability to control food quality and safety, maintain the nutritional value of proteins and amino acids, and preserve the organoleptic properties of most types of food, which include (flavor, color and texture), also eating irradiated foods does not affect the metabolism of humans(**Potter,**

1986; Lima *et al.*, 2018; Panseri *et al.*,2022). Radiation processing facilities for food are environmentally friendly and safe and do not leave traces of radioactive materials in foodstuffs (**El Gameel and Amin, 2021**).

Customers' Awareness and Knowledge Towards Food Irradiation:

Customers' acceptance of irradiation-treated food in Egyptian restaurants will determine the extent of their awareness and knowledge of this modern technology because customers may be affected by food product information for fear of their health. It has been proven that reliable and adequate information affects customers' acceptance and satisfaction with foods produced using innovative technologies (**Agbaka and Ibrahim, 2020; Recuero-Virto and Valilla-Arróspide, 2022; Guzik *et al.*, 2022**). A study conducted in Malaysia on customers, where this study seeks to investigate customers awareness, attitude, trust and understanding towards food irradiation, 237 respondents participated in the study by surveying them, taking their opinions, and measuring their knowledge and awareness of food irradiation technology. The results revealed that the level of customer awareness towards food irradiation technology was high and optimal. On the other hand, there was acceptance and trust by customers towards eating irradiated food, the study indicated that the results could contribute to providing information regarding awareness, knowledge, attitude, and trust towards food irradiation among customers, in addition, they provide information and suggestions to the Malaysian government in managing and enforcing laws and regulations on

operators and producers of food and beverages in Malaysia (**Rozekhi *et al.*, 2018**).

According to **Gallo *et al* (2022),** there is a study conducted in Brazil on customers, on evaluating the extent of customers' knowledge and acceptance of radioactive food in a food bank called "*CEAGESP*". The study showed that 95% of customers have eaten food containing some radioactive ingredients, and 50% announced that they will eat Radioactive food, after applying all the questions, educational texts and videos about food irradiation technology, the results showed that 80% of customers will eat radioactive food, and in this way awareness information increased customers' acceptance of irradiated food by 30%, in addition, it was found that 80 % of "*CEAGESP*" food bank customers who have the necessary information on the benefits of irradiated foods accept and intend to eat irradiated foods in the near future.

Challenges of Using on Food Irradiation in Restaurants:

There are some obstacles that result from the application of food irradiation technology (**Akinloye *et al.*, 2015**). The use of food irradiation leads to changes in the sensory properties of some foods, as irradiation causes an unpleasant smell in some types of food and deteriorates the structural and anatomical properties of carbohydrates that contain fibers such as oats, lettuce, and broccoli. Food irradiation makes unsaturated fatty acids more susceptible to rancidity "*mephitis*" (**Silva *et al.*, 2011; Dimov *et al.*, 2022; Zheng *et al.*, 2022**). Food irradiation affects the loss of some vitamins from food, such as vitamin "A., B1., E., C" (**Lima *et al.*, 2018; Telpner *et al.*, 2022**). Microwave radiation also affects the formation of acrylamide, a

carcinogen and neurotoxic substance (**Michalak *et al.*, 2020**). It must be borne in mind that food irradiation technology cannot destroy pesticides and toxins already present in foodstuffs, and that food irradiation technology cannot make bad or spoiled food look good **(Pandiselvam *et al.*, 2022; Darré *et al.*, 2022).** One of the disadvantages facing irradiation technology is the lack of appropriate equipment used in the food irradiation process, in addition to the cost arising from food processing with irradiation technology (**Roberts *et al.*, 2016**).

Research methodology:

To achieve the aim of the research, customers in restaurants were surveyed. The sample equation was applied to unlimited society **(Thompson, 2012)** as follows:

$$n = \frac{N \times P(1-P)}{\{N-1 \times (d^2 \div Z^2)\} + P(1-P)\}}$$

N:Sample size, P: Percentage of the purpose of this study 0.50 , d: Percentage of the error limit allowed 0.05 , Z:The standard degree used for giving general results is 95%. Thus, the standard degree = 1.96

$$\mathbf{N} = \frac{500000 \times 0.50(1-0.50)}{\{500000-1 \times (0.05^2 \div 1.96^2) + 0.05\,(1-0.50)\}}$$

$$= \frac{125.500}{325.63} \times 100 = 385.40 \simeq 385$$

The population of the study is unlimited due to the difficulty of determining a specific number of customers in Egyptian restaurants, so the random sample size is an ideal method to apply in this study. According to **Thompson, (2012)** the lower limit of respondents, that are suitable in this study is **385**. A number of **500** electronic

questionnaires were designed and distributed from 5 Mars **2022** to 1 September **2022**. The questionnaire consisted of five sections. The first section is intended to reveal the customers' demographic data. The second section intended to the customers Objective data in Egyptian restaurants. The third section included the extent of Customers awareness of the advantages of foods processed with irradiation technology in Egyptian restaurants (15 statements). The fourth section included the extent of Acceptance of customers to eat foods processed with irradiation technology in Egyptian restaurants (8 statements). The fifth section included Challenges affecting customers' acceptance of foods processed with irradiation technology in Egyptian restaurants (11 statements). The respondents were asked to answer these statements by using a five-point Likert-type scale (Strongly agree = 5, agree =4, neutral = 3, disagree = 2 and, strongly disagree = 1) to determine the levels of agreement with the statements investigated. The Statistical Package for the Social Sciences (SPSS) version **28.0** was used to analyze and compute the collected data. The range of each level of agreement was calculated as follow:

Table 1: Questions Answered Scale

Category	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Scale	1	2	3	4	5
Rang	1 – 1.80	1.81 – 2.60	2.61 – 3.40	3.41 – 4.20	4.21 - 5

Reliability Analysis

Table 2: Reliability Analysis

N	Dimensions	Number of Statements	Alpha
2	Customers Awareness of the Advantages of Foods Processed with irradiation technology in Egyptian Restaurants.	15	0.96
3	Acceptance of Customers to Eat Foods Processed with Irradiation Technology in Egyptian Restaurants.	8	0.94
4	Challenges Affecting Customers' Acceptance of Foods Processed with Irradiation Technology in Egyptian Restaurants.	11	0.93
Alpha Cronbach's test for all Dimensions.		**34**	**0.97**

Table No. **2** indicated that alpha coefficient of the questionnaires dimensions was **0.97** (higher than 0.70) **(Pallant, 2016)**. This result indicated to the reliability and validity of the questionnaires for using in the study.

Results and discussion

The results involved three main stages. Descriptive analysis was used to discover participants' responses, variance analysis for respondents' answers, correlation analysis, and regression were conducted to examine the relationship between independent variables and dependent variable. The results obtained were computed and analyzed in the following tables.

Table 3: Demographic Data of Customers.

Demographic Data	Attribute	Statistics		Rank
		Freq.	%	
Gender	Male	347	69.4	1
	Female	153	30.6	2
Total		500	100%	
Age	Less than 25 years	266	53.2	1
	From 25 – 40 years	140	28.0	2
	More than 40 years-Less than 60 years	85	17.0	3
	60 years and over	9	1.8	4
Total		500	100%	
Educational Level	Less than undergraduate	36	7.2	3
	University degree	359	71.8	1
	Postgraduate (Diploma- Master– PhD)	105	21.0	2
Total		500	100%	

As it can be observed from table 3 that, among the 500 respondents, a high proportion of the tested sample 69.4% were male and 30.6% of customers were female. The age variable represented as, 53.2% was of the respondents ranged in age Less than 25 years, followed by those from 25 – 40 years old with 27.0%, then more than 40 years and less than 60 by 28.0%, More than 40 years-Less than 60 years by 17.0% and finally, those whose ages ranged from 60 years and above by 1.8%. As for the educational level of

the respondents a high proportion of the tested sample 71.2% have a university educational degree and 21.0% were have postgraduates' degree (Diploma-Master–PhD) and 7.2% had average education "vocational or technical school".

Table 4: What do you think about the cost of food processed with irradiation technology in Egyptian restaurants?

Factor	Answers	Freq.	Percentage (%)	Rank	Mean
What do you think about the cost of food processed with irradiation technology in Egyptian restaurants?	Less than Natural	84	16.8	3	**2.37**
	Equal of Natural	145	29.0	2	
	More than Natural	271	54.2	1	
Total		**500**	**100%**	--	

The results of Table 4 revealed that the largest percentage of respondents 54.2 % said that irradiation technology processed foods is more expensive than natural foods, while 29.0% said that Irradiation technology Processed Foods is just as equal of natural foods in cost, and finally 16.8 % said that Irradiation technology processed foods is less expensive than natural foods.

Table 5: Do you think that eating foods processed with irradiation technology does not pose health problems for humans in the long term?

Factor	Answers	Freq.	Percentage (%)	Rank	Mean
Do you think that eating foods processed with irradiation technology does not pose health problems for humans in the long term?	Yes	189	37.8	2	**1.85**
	To some extent	199	39.8	1	
	No	112	22.4	3	
Total		**500**	**100.0**	**--**	

According to table 5, The extent to which customers believe that eating foods treated with irradiation technology does not cause human health problems in the long term. Where 199 respondents 39.8% indicated neutrality of to that eating foods treated with irradiation technology does not cause human health problems in the long term. while 189 respondents 37.8% indicated approval of to that eating foods treated with irradiation technology does not cause human health problems in the long term. Finally, 36 respondents 8.8% indicated their disapproval of to that eating foods treated with irradiation technology does not cause human health problems in the long term.

Table 6: Do you accept to eat foods processed with irradiation technology in Egyptian restaurants?

Factor	Answers	Freq.	Percentage (%)	Rank	Mean
Do you accept to eat foods processed with irradiation technology in Egyptian restaurants?	Strongly Disaccept	53	10.6	5	**3.17**
	Disaccept	65	13.0	3	
	Neutral	187	37.4	1	
	Accept	136	27.2	2	
	Strongly Accept	59	11. 8	4	
Total		**500**	**100.0**	**--**	

The results of Table 6 revealed, the extent to which customers accept eating processed foods using irradiation technology in Egyptian restaurants. That the largest percentage 37.4% respondents expressed their acceptance of the eat foods processed with irradiation technology with neutrality. while 27.2% expressed their acceptance of the eat foods processed with irradiation technology with acceptance overeating it in Egyptian restaurants. Where 13.0% respondents expressed their not acceptance of the eat foods processed with irradiation technology. Where 11.8% respondents expressed their acceptance of the eat foods processed with irradiation technology with strong acceptance of eating it in Egyptian restaurants. Finally, 10.6% respondents not strongly accepting its consumption in Egyptian restaurants.

Table 7: Customers Awareness of the Advantages of Foods Processed with irradiation technology in Egyptian Restaurants.

Attributes	$\bar{x}$	SD	C.V	*Relative Weights*	T-test	*P-Value*	R
1. Food irradiation technology prevents foodborne illnesses.	3.59	1.077	30	23.93%	74.42	.000*	**5**
2. Food irradiation technology greatly helps prevent food-borne infections.	3.55	1.074	30.25	23.66%	73.80	.000*	**6**
3. Food atomic radiation helps to delay spoilage in some fresh perishable foods such as fish, crustaceans, poultry and meat, and to reduce the numbers of microorganisms in spices.	3.52	1.010	28.69	23.46%	77.85	.000*	**10**
4. Eating food processed	3.26	1.259	38.61	21.73%	57.94	.000*	**15**

with irradiation technology does not pose health problems for people in the long run.							
5. Food irradiation technology helps extend the shelf life of food items that are preserved.	3.63	0.995	27.41	24.2%	81.60	.000*	**2**
6. Food irradiation technology helps to sterilize and purify food from harmful bacteria and viruses, as the sterilization process is carried out by radiation from the center of the food to the outside to ensure food preservation, just as	3.51	1.073	30.56	23.4%	73.11	.000*	**11**

burgers and steaks are processed with irradiation.							
7. Food irradiation technology controls the preservation of food quality and safety.	3.54	1.145	32.34	23.6%	69.04	.000*	**8**
8. Food irradiation technology prevents food poisoning by reducing the level of microbes in the food.	3.64	1.021	28.04	24.26%	79.66	.000*	**1**
9. Food processed with irradiation technology is environmentally friendly and safe for human consumption.	3.32	1.153	34.72	22.13%	64.41	.000*	**14**
10. Food irradiation technology preserves	3.61	1.062	29.41	21.06%	76.05	.000*	**4**

the nutritional value, flavors, touch and texture of the food.							
11. Food irradiation technology helps to improve the physical properties by bringing about desirable physical changes such as greatly increasing the solubility of dried vegetables in water.	3.54	1.011	28.55	23.6%	78.33	.000*	**9**
12. Eating food processed with irradiation technology does not cause genetic damage.	3.40	1.145	33.67	22.66%	66.38	.000*	**13**

13. Food irradiation technology helps to easily eliminate bacteria (such as salmonella).	3.55	1.174	33.07	23.66%	67.61	.000*	**7**
14. Food irradiation technology helps reduce food waste.	3.62	1.065	29.41	24.13%	75.90	.000*	**3**
15. Food sterilized by irradiation technology can be preserved for many years without refrigeratio n, such as sterilized canned food, without spoiling.	3.41	1.077	31.58	22.73%	70.82	.000*	**12**
Average of Responses	**3.51**	**0.876**	**24.95**	**23.4%**	**----**	**----**	**--**

N= 500 **$\bar{x}$:** Mean **SD**: "Standard Deviation" **R**: Rank **CV**: Coefficient Variance $(SD \div \bar{x}\,\%)$ Relative Weights**:** Mean/scale × 100 Test value = (0.05) *sig. ≤ (. 05)

The results in Table 7 that the respondents do not have enough awareness about the irradiation technology processed foods of Egyptian restaurants, where the average was (mean= 3.51). Besides, the results show that there are significant differences among respondents towards the attributes of the table above which p-value ≤ (.01). The previous table shows that restaurants customers have knowledge of irradiation technology processed foods with an average range between (mean= 3.26- 3.64) in Egyptian restaurants.

With regard to the dimensions of the customers awareness of the advantages of foods processed with irradiation technology in Egyptian restaurants, the respondents showed a agree tendency towards most of the statements, and this means that they are sufficiently familiar with the foods processed with irradiation technology. Considering the responses of customers about their knowledge of that it is food irradiation technology prevents food poisoning by reducing the level of microbes in the food (mean=3.64, CV= 28.04), as well as the responses of customers about Food irradiation technology helps extend the shelf life of food items that are preserved (mean=3.63, CV=27.41), and while their responses were on that it is food irradiation technology helps reduce food waste (mean= 3.60, CV= 29.41), As for their awareness for is food irradiation technology preserves the nutritional value, flavors, touch and texture of the food (mean = 3.61, CV= 29.41), While the results showed the responses of customers about their

awareness of that it is food irradiation technology prevents foodborne illnesses (mean= 3.59, CV= 30).

The results also yielded of the customers awareness of the advantages of foods processed with irradiation technology in Egyptian restaurants, considering the responses of customers about their knowledge of that it is food irradiation technology greatly helps prevent food-borne infections (mean= 3.55, CV= 30.25). While the results showed the responses of customers about their awareness of that it is food irradiation technology helps to easily eliminate bacteria "such as salmonella" (mean= 3.55, CV= 33.07). As for their awareness for is food irradiation technology controls the preservation of food quality and safety (mean= 3.54, CV= 32.34). As well as the responses of customers about food irradiation technology helps to improve the physical properties by bringing about desirable physical changes such as greatly increasing the solubility of dried vegetables in water (mean= 3.54, CV= 28.55). as well as the responses of customers about food atomic radiation helps to delay spoilage in some fresh perishable foods such as fish, crustaceans, poultry and meat, and to reduce the numbers of microorganisms in spices (mean= 3.52, CV= 28.69).

Meanwhile, the customers awareness of the advantages of foods processed with irradiation technology in Egyptian restaurants, considering the responses of customers about their knowledge of that it is food irradiation technology helps to sterilize and purify food from harmful bacteria and viruses, as the sterilization process is carried out by radiation from the center of the food to the outside to ensure food preservation, just as burgers and steaks are processed with irradiation (mean= 3.51, CV= 30.56). While the results

showed the responses of customers about their awareness of that it is food sterilized by irradiation technology can be preserved for many years without refrigeration, such as sterilized canned food, without spoiling (mean= 3.41, CV= 31.58). As for their awareness for eating food processed with irradiation technology does not cause genetic damage (mean= 3.40, CV= 33.67). As well as the responses of customers about food processed with irradiation technology is environmentally friendly and safe for human consumption (mean= 3.32, CV= 34.72). as well as the responses of customers about eating food processed with irradiation technology does not pose health problems for people in the long run (mean= 3.26, CV= 38.61).

Table 8: Acceptance of Customers to Eat Foods Processed with Irradiation Technology in Egyptian Restaurants.

Attributes	$\bar{x}$	SD	C.V	*Relative Weights*	T-test	*P-Value*	R
1. You will be satisfied if Egyptian restaurants rely on irradiation-processed food to provide meals to customers.	3.56	1.284	36.06	44.5%	61.97	.000*	**2**
2. You have the passion to try the food processed with irradiation technology in the Egyptian restaurants.	3.45	1.120	32.46	43.12%	68.85	.000*	**7**

3. You are willing to eat irradiated foods despite their high prices.	3.33	1.159	34.80	41.62%	64.23	.000*	**8**
4. You have the acceptance to eat food processed with irradiation technology from a health point of view because it helps to significantly prevent food poisoning cases in restaurants.	3.50	1.187	33.91	43.75%	66.01	.000*	**4**
5. You have the acceptance to eat foods processed with irradiation technology because they preserve the nutritional value of proteins and amino acids.	3.47	1.058	30.48	43.37%	73.37	.000*	**6**
6. You have the acceptance to eat foods processed with irradiation technology because it	3.58	1.172	32.73	44.75%	68.23	.000*	**1**

maintains the quality and safety of foodstuffs.							
7. You are welcome to eat food processed with irradiation technology in Egyptian restaurants because it does not affect the human metabolism.	3.54	1.060	29.94	44.25%	74.70	.000*	**3**
8. You have the acceptance of eating foods processed with irradiation technology in Egyptian restaurants because of their ability to easily destroy bacteria such as salmonella and Shigella bacteria.	3.49	1.068	30.60	43.62%	73.12	.000*	**5**
Average of Responses	**3.49**	**0.961**	**27.53**	**43.62%**	**----**	**----**	**--**

N= 500 **$\bar{x}$:** Mean **SD**: "Standard Deviation" **R**: Rank **CV**: Coefficient Variance $(\mathbf{SD} \div \bar{\mathbf{x}}\,\%)$ Relative Weights**:** Mean/scale × 100 Test value = (0.05) *sig. ≤ (. 05)

According to the dimension acceptance of customers to eat foods processed with Irradiation technology in Egyptian

restaurants in Table 8, the respondents showed agree tendency towards acceptance of irradiation technology processed foods in Egyptian restaurants. which means that they have a willingness and conviction to experiment with irradiation technology processed foods. In detail, a large percentage of the sample agreed that have the acceptance to eat foods processed with irradiation technology because it maintains the quality and safety of foodstuffs (mean= 3.58, CV=32.73), and you will be satisfied if Egyptian restaurants rely on irradiation-processed food to provide meals to customers (mean=3.56, CV=36.06), they also agreed that are welcome to eat food processed with irradiation technology in Egyptian restaurants because it does not affect the human metabolism (mean = 3.54, CV= 29.94), and you have the acceptance to eat food processed with irradiation technology from a health point of view because it helps to significantly prevent food poisoning cases in restaurants (mean=3.50, CV=33.91), and they also agreed that have the acceptance of eating foods processed with irradiation technology in Egyptian restaurants because of their ability to easily destroy bacteria such as salmonella and Shigella bacteria (mean = 3.49, CV= 30.60), and they also agreed that have the acceptance to eat foods processed with irradiation technology because they preserve the nutritional value of proteins and amino acids (mean = 3.47, CV= 30.48), and that you have the passion to try the food processed with irradiation technology in the Egyptian restaurants (mean = 3.45, CV= 32.46), finally that you are willing to eat irradiated foods despite their high prices (mean = 3.33, CV= 34.80).

Table 9: Challenges Affecting Customers' Acceptance of Foods Processed with Irradiation Technology in Egyptian Restaurants.

Attributes	$\bar{x}$	SD	C.V	*Relative Weights*	T-test	*P-Value*	R
1. The cost arising from food processing with irradiation technology is very high.	3.63	0.971	26.74	33%	83.58	.000*	**3**
2. Food irradiation technology deteriorates the structural and anatomical properties of carbohydrates containing fiber (such as broccoli, lettuce, oats).	3.64	1.022	28.07	33.09%	79.57	.000*	**2**
3. Food irradiation makes trans fatty acids more susceptible to rancidity (the stink).	3.34	1.000	29.94	30.36%	74.76	.000*	**11**
4. Food irradiation technology cannot destroy pesticides and	3.54	0.915	25.84	32.18%	86.52	.000*	**7**

toxins already present in foods.							
5. Food irradiation technology affects the loss of some vitamins from foods.	3.75	0.995	26.53	34.09%	84.21	.000*	**1**
6. Microwave radiation affects the formation of acrylamide, which is a carcinogenic and neurotoxic substance.	3.62	0.892	24.64	32.90%	90.81	.000*	**4**
7. The use of food irradiation technology leads to changes in the sensory properties of some foods.	3.51	0.992	28.26	31.90%	79.22	.000*	**8**
8. Food irradiation technology cannot make bad or spoiled food look good.	3.55	0.895	25.21	32.27%	88.68	.000*	**6**
9. Lack of suitable equipment that is used in the	3.59	0.975	27.15	32.63%	82.34	.000*	**5**

food irradiation process.							
10. Food irradiation technology causes an unpleasant smell in some types of food.	3.45	1.123	32.55	31.36%	68.70	.000*	**10**
11. Customers confused irradiated food with radioactive food.	3.49	1.123	32.17	31.72%	69.43	.000*	**9**
Average of Responses	**3.55**	**0.772**	**21.74**	**32.27%**	**----**	**----**	**--**

N= 500 **$\bar{x}$:** Mean **SD**: "Standard Deviation" **R**: Rank **CV**: Coefficient Variance $(SD \div \bar{x}\,\%)$ Relative Weights**:** Mean/scale × 100 Test value = (0.05) *sig. ≤ (. 05)

According to the dimension, challenges affecting customers' acceptance of foods processed with irradiation technology in Egyptian restaurants in Table 9, the respondents showed agree tendency towards challenges affecting customers' acceptance of foods processed with irradiation technology in Egyptian restaurants, which means that customers' in restaurants face many challenges that make them hesitate to try irradiation technology processed foods in Egyptian restaurants. In detail, a large percentage of the sample agreed that food irradiation technology affects the loss of some vitamins from foods (mean=3.75,CV=26.53), and food irradiation technology deteriorates the structural and anatomical properties of carbohydrates containing fiber "such as broccoli, lettuce,

oats" (mean= 3.64, CV= 28.07), they also agreed that the cost arising from food processing with irradiation technology is very high (mean= 3.63, CV= 26.74), and microwave radiation affects the formation of acrylamide, which is a carcinogenic and neurotoxic substance (mean= 3.62, CV= 24.64), and they also agreed lack of suitable equipment that is used in the food irradiation process (mean= 3.59, CV= 27.15), and food irradiation technology cannot make bad or spoiled food look good (mean= 3.55, CV= 25.21), and food irradiation technology cannot destroy pesticides and toxins already present in foods(mean= 3.54, CV= 25.84), and the use of food irradiation technology leads to changes in the sensory properties of some foods (mean= 3.51, CV= 28.26), and customers confused irradiated food with radioactive food (mean= 3.49, CV= 32.17), and they also agreed food irradiation technology causes an unpleasant smell in some types of food (mean= 3.45, CV= 32.55). Finally, food irradiation makes trans fatty acids more susceptible to rancidity "*the stink*" (mean= 3.34, CV= 29.94).

Testing hypotheses

Hypothesis1: There is a significant Impact of Using Irradiation Technology Processed Foods in Egyptian restaurants (about "H. 1.1" customers awareness of the advantages of foods processed with irradiation technology, "H. 1.2" acceptance of customers to eat foods Processed with Irradiation technology, "H. 1.3" challenges affecting customers' acceptance of foods processed with irradiation technology) on customers' acceptance in Egyptian restaurants.

Table 10: Correlation coefficient between dependent and independent variables:

Variables Test		Customers Awareness	Customers' Acceptance
Customers awareness of the advantages of foods processed with irradiation technology.	Correlation Coefficient	1.00	**0.841****
	Sig. (2-tailed)	0	0.000
	N	500	500
Acceptance of customers to eat foods processed with irradiation technology.	Correlation Coefficient	**0.841****	1.00
	Sig. (2-tailed)	0.000	0
	N	500	500
Variables Test		**The Challenges**	**Customers' Acceptance**
Challenges affecting customers' acceptance of foods processed with irradiation technology.	Correlation Coefficient	1.00	**0.685****
	Sig. (2-tailed)	0	0.000
	N	500	500
Acceptance of customers to eat foods processed with irradiation technology.	Correlation Coefficient	**0.685****	1.00
	Sig. (2-tailed)	0.000	0
	N	500	500

Correlation is significant at the 0.01 level,** **H. S= High significant at the ≤ (. 01) level

With regard to Table 10, There are significant correlations between customers' acceptance of experience irradiation technology processed foods in Egyptian restaurants and customers' awareness of irradiation technology processed foods in Egyptian restaurants (Corr = 0.841**), and here are significant correlations between customers' acceptance of experience irradiation technology processed foods in Egyptian restaurants and challenges affecting customers' acceptance of foods processed with irradiation technology in Egyptian restaurants (Corr = 0.685**). Accordingly, it is necessary to provide adequate information about irradiation technology processed foods as it contributes to a large percentage of customers' persuasiveness to accept foods processed with irradiation technology. Thus, the first hypothesis **H.corr.1 was be accepted.**

Table 11: The Simple Regression

Factors affecting on Guests Acceptance	Parameters of Regression	T-test	p-value	R
Customers awareness of the advantages of foods processed with irradiation technology.	0.807	20.87	0.000*	1
Challenges affecting customers' acceptance of foods processed with irradiation technology.	0.178	4.057	0.000*	2

* = Highly significant at P≤ 0.05

With regard to Table 11, It could be seen that; the values of the Parameters of Regression are less than 0.05. There is a significant effect at the 0.05 level of significance on the dependent variable. customers' awareness of irradiation technology processed foods in Egyptian restaurants ranked as the first factor which affects customers' perceptions toward acceptance of irradiation technology processed foods, then challenges affecting customers' acceptance of foods processed with irradiation technology in Egyptian restaurants was ranked as the second factor that affects the perceptions of customers', to transforming their acceptance to experience of irradiation technology processed foods in the Egyptian restaurants.

Hypothesis 2: There are significant differences between the acceptance of customers of irradiation technology processed foods according to demographical data ("H 2.1" gender, "H 2.2" Age, and "H 2.3" Educational level).

Table 12: T-Test & One-Way ANOVA Test

DemographicData	Df	CI	T-Test	F	Sig.
Gender	498	0.95	0.458	-----	0.647*
Age	499	-----	-----	13.202	0.000**
Educational level	499	-----	-----	6.228	0.000**

N=410, $\bar{x}$**:** Mean, Test value= (0.05), "DF": degrees of freedom, CI: confidence interval **sig. ≤ (. 01) *sig. ≤ (. 05)

With regard to Table 12, the results of the t-test for two independent samples showed that there are no statistically significant differences between customers in Egyptian restaurants in the extent of their willingness to go through

the experience of eating irradiation technology processed foods in Egyptian restaurants again for the gender where the test t= (0.458) and P-value (0.647*), (more than 0.5). This result shows the difference between respondents by gender Referring to the results of the one-way ANOVA test showed that there are no statistically significant differences between customers in Egyptian restaurants in the extent of their ability to experience the experience of eating irradiation technology processed foods by age F value = (13.202), P-value = (0.000**), (more than 0.1). And at the same time, there are no statistically significant differences between customers in Egyptian restaurants in the extent of their ability to experience eating irradiation technology processed foods to the educational level where the F value = (6.228), P-value = (0.000**), (more than 0.1). Thus, the first hypothesis **H.corr.2 was be accepted.**

Conclusion

This study explores an investigation on an innovative food preservation technique, namely, Irradiation technology processed foods. It has been found that customers in Egyptian restaurants do not have awareness of irradiation technology processed foods, and this is due to the lack of sufficient information for the Egyptian client about irradiation technology processed foods and how it is processed , and that in the case of availability of information about the technology It will affect the ability of the Egyptian customer to respond to all his fears and doubts about this innovative technology. With regard to the

analysis of what customers towards Irradiation technology processed foods in Egyptian restaurants, it was found that the majority of customers are not aware of this new technology and expressed their desire to know information about Irradiation technology processed foods, Its role in food preservation, although it is a very cost-intensive process that requires radioactive metal processing, has been found to be a practical form of modern technology to ensure food safety in restaurants. The results revealed that not all foods are suitable for irradiation treatment for some nutrients, for example vitamins and saturated fats are affected to some extent by food irradiation. However, the irradiation of meats, vegetables and fruits has been widely studied and few cases of nutrient deficiencies have been reported as a result of processed with irradiation technology. The results also revealed that extending the shelf life by irradiating food is better than heat treatment and avoiding the need for artificial preservatives, thus preserving the nutritional value of food. Customers associate ionizing radiation with cancer and consider foods full of infrared radiation as dangerous as heat radiation. Studies have shown that microwave radiation leads to the formation of acrylamide, which is a carcinogenic and neurotoxic substance. This result is consistent with **Michalak *et al.* (2022)**. Finally, there is a significant impact of the dimensions of availability of sufficient information about Irradiation technology processed foods on the ability of customers to experience eating Irradiation technology processed foods in Egyptian restaurants in the near future .

Recommendations

According to the literature review and the results extracted from the field study, the following recommendations could be suggested:

1) Adopting the idea of food processed by irradiation technology efficiently according to the standards and specifications used for circulation and acceptance in the Egyptian market, especially the hospitality sector (hotels / restaurants ... etc.), and this is a simulation of its spread all over the world such as (American countries - European Union - East Asian countries), given Because it is within the desires of foreign customers soon in Egypt in hospitality establishments.
2) Permanent awareness by food science professionals for factory owners, restaurant owners, and chefs, and providing them with sufficient information irradiation technology processed foods.
3) Training workers and food handlers in Egyptian restaurants on how to deal with foods processed by irradiation technology so that they have the experience to deal professionally with these foods without any problems.
4) Egyptian customers must be made aware of irradiation technology processed foods through the media and institutional publicity for the sustainability and safety of food, nutrition, and health of irradiation technology processed foods through the dissemination of sufficient information about irradiation technology processed foods by food science professionals.

5) The Egyptian government must oblige all food irradiation facilities that use radioactive materials to be licensed, and regulations and standards for periodic inspection of food facilities must be drafted to ensure compliance with the operating license conditions, and severe penalties must be imposed on food facility owners in case of non-compliance with the standards set for processing food processed with technology irradiation.

Limitations and Future Research

The existing study yielded a strong relationship between the use of food Processed with irradiation technology and customer awareness and knowledge of this innovative technology in Egyptian restaurants, which is the focus of the research. It cannot be claimed that its results are generalizable and represent the entire restaurant industry within Egypt, which means that there are fruitful opportunities for future studies for researchers and owners of factories and restaurants, for example, to investigate the views of restaurant owners and managers who are interested in innovative technologies for the development of food science and the readiness of chefs in Egyptian restaurants. to deal with these food innovations. Moreover, because the information provided to the subjects of this study prior to giving their opinion was limited, some subjects were unable to express their support or objection to the issue of the intention to accept eating food Processed with irradiation technology in Egyptian restaurants. Accordingly, at this stage of theoretical development and empirical evidence, we can only partially predict the factors

affecting awareness and customer acceptance in Egyptian restaurants in a longitudinal framework to provide a deeper understanding of how the decision to adopt actual food processed with irradiation technology in Egyptian restaurants. Future research may also take a, investigate the determinants and outcomes of the acceptance and willingness of food science regulators, chefs, and food professionals about the role that irradiation technology can and should play as a control measure in the framework of HACCP (Hazard Analysis and Critical Control Point) system implementation in Egyptian restaurants.

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