



Environmental Impact Assessment of Food Irradiation Technology as A Comparative Study with Some Other Food Preservation Methods



Essam. A. El Gameel, Suzan. R. Amin[#]

Department of Food Irradiation Research, National Center for Radiation Research and Technology, Egyptian Atomic Energy Authority, Cairo, Egypt.

THIS study discussed the environmental impact of food irradiation technology as a comparative study with food preservation using refrigerators and chemicals. The comparison included multiple axes indicating the impact of the method of preservation on the atmosphere, soil, waterways, workers, health safety for the consumer, contributing to reducing food-borne diseases, resource depletion productivity and societal acceptance. The environmental assessment of development projects considered is one of the sustainable development tools to reduce negative effects on the environment and work on balancing the current and future requirements of limited resources. Food preservation projects have an important impact in achieving food security and sustainability at the national level and enhancing competition in foreign markets. The results indicated that the method of preservation by irradiation is the best of these methods in terms of low harmful effects on the environment, while the method of preserving food by chemicals is considered the most harmful to the environment.

Keywords: Environmental, Irradiation, Refrigerators, Chemicals, Food, Safety.

Introduction

The environmental assessment of development projects considered is one of the sustainable development tools is to reduce negative effects on the environment and work on balancing the current and future requirements of limited resources. Food preservation projects have an important impact in achieving food security and sustainability at the national level and enhancing competition in foreign markets. Various preservation of food from the environmental aspect, and irradiation technology is one of the most effective techniques used in food preservation and adopted at the international level by the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency for several decades, as it contributes to the purification of food from all contaminants (bacterial, fungal and insectivorous) and prolonging the food preservation period while preserving its nutritional value, quality and freshness in the light of preserving the health

of the consumer. Its commercial application has been licensed since 1984 in about 41 countries and for about 55 types of food, and the international trade volume of irradiated preserved foods is estimated at about 500 thousand tons annually. In 2011, the Egyptian Authority for Standardization and Quality issued a standard for preserving the Food by irradiation according to what was issued by the Codex Authority, which is the responsible for the specifications of food handling and trade globally, and the Egyptian Ministry of Health has licensed the use of irradiation in food preservation. Several feasibility studies have been conducted for the commercial application of food irradiation technology in Egypt, which included marketing studies financial and social analysis. Therefore, this environmental study is an important complement to such studies (Nature Publishing Group, 1954; Heinis, 2009; Daramola & Eziyi, 2010; Yousefi & Ayat, 2014; Ilić & Petar, 2015; Amit et al., 2017; Eustice, 2018).

[#]Corresponding author email: dr.suzan.raies@gmail.com

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Data

This study is based on the following data

- Scientific references specialized in environmental assessment of projects.
- Scientific references specialized in the environmental impact of different food preservation methods.
- Scientific references specialized in food preservation methods.
- Publications of the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the International Atomic Energy Agency, the National Center for Radiation Research and Technology (Egypt).
- A questionnaire form for the opinions of technical experts.
- Economic and statistical references of importance in the subject of the study.
- The special experiences of researchers in the field of food irradiation economics.

Research Methodology

This study was conducted aiming at comparing three food preservation methods namely, irradiation, refrigeration and chemical method. The researchers of the present study prepared several tables, each representing one of the axes and evaluating the environmental impact of the method of preservation so that each axis includes the most important environmental effects of the method of preservation in the same axis, giving an assessment of the severity of the negative impact of degrees (3, 2, 1, 0 indicating very dangerous, dangerous, somewhat dangerous, not dangerous in order). The evaluation was performed through a questionnaire prepared by the researchers of the present study, in which the opinion of technical experts in the field of specialization was surveyed, and the average value

was placed in Tables 1-7. The appropriate statistical analysis (Chi-Square Test) was conducted to find out the extent of significant differences between the different conservation methods in terms of environmental impact, where the evaluation axes were:

- 1- Assessment of the environmental impact of food preservation technology on the atmosphere.
- 2- Assessment of the environmental impact of food preservation technology on soil and waterways.
- 3- Assessment of the environmental impact of food preservation technology on its employees.
- 4- Assessment of the environmental impact of food preservation technology on consumer safety and health.
- 5- Assessment of the environmental impact of food preservation technology on the depletion of scarce productive resources.
- 6- Assessment of the environmental impact of food preservation technology on waste recycling.
- 7- Assessment of the environmental impact of food preservation technology in terms of societal acceptance.

Results and Discussion

Assessment of the environmental impact of food preservation technology on the atmosphere

Air pollution results from the entry of any substances into it that leads to physiological and economic damage to humans, plants and animals. When comparing food preservation methods, it could be found that among the atmospheric pollutants are fumes of grain preservation with chemicals and Freon gas resulting from the leakage of refrigerators, as shown in Table 1 (Dunlap & Andrew, 2012; Sovacool, 2014; Yousefi & Ayat, 2014; Amit et al., 2017).

TABLE 1. Assessment of the negative environmental impact of food preservation technology on the atmosphere

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- The fumes of preserving the grain after harvesting	0	0	3
2- The possibility of freon gas leakage	0	2	0
3- The possibility of producing ozone gas	1	0	0
4- The need for special precautions to prevent radiation leakage	1	0	0
5- The need for special precautions to prevent the leakage of chemicals into its production plants	0	0	1
Total	2	2	4

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0)

Assessment of the environmental impact of food preservation technology on soil and waterways

Agricultural soil becomes contaminated if it loses its physical, chemical and biological properties, which may also leak to it from pesticides used in food preservation directly or through acid rain, which may also require special precautions to prevent its leakage as shown in Table 2 (Nature Publishing Group, 1954; Heinis, 2009; Environment Agency et al., 2012; Yousefi & Ayat, 2014; Ilić & Petar, 2015; EEA, 2020).

Assessment of the environmental impact of food preservation technology on its employees

About 2500 chemicals are included in the composition of the pesticide and the sensitivity to it varies. Once exposed to it, the most sensitive individuals die, while the irradiation technique is used through the control room where the radioactive source is located in a water well that prevents radiation leakage inside tin-coated concrete walls to prevent radiation leakage and the source is not lifted in Table 3 (Nature Publishing Group, 1954; Heinis, 2009; Environment Agency et al., 2012; Yousefi & Ayat, 2014; Ilić & Petar, 2015).

Assessment of the environmental impact of food preservation technology on consumer safety and health

Refrigerators discourage microbial contaminants from food without killing them so that their activity with food returns after leaving the refrigerator again, in addition to the continuation of the activity of cold-loving microbes inside the refrigerator. However, chemical preservation, despite being efficient in getting rid of insects, fungal and microbial contaminants, it cleanses the surface of the food not inside it, as in the case of dates, where the eggs of insects placed inside the fruit remain intact to return to hatch after chemical preservation. The serious impact on the safety and health of the consumer comes from the remnants of these chemicals in the food intake. On the other hand, irradiation is effective

in purifying the inside and outside fruits and foods of all insect, fungal and microbial contaminants, which contributes to the reduction of food borne diseases without leaving harmful residues or any negative health effects on the consumer that reported in Table 4. Several international and local studies have been conducted in this regard. The FAO, the WHO and the IAEA recognize irradiated preserved foods up to a dose of 10 kGy without the need for new tests for health safety, while preserving the value and quality of food, which is greatly affected when kept in refrigerators. About 600 million people annually suffer from food-borne diseases and death. About 420,000 people face annual losses of about 110 billion dollars (Nature Publishing Group, 1954; WHO & FAO, 1988; Heinis, 2009; Yousefi & Ayat, 2014; Ilić & Petar, 2015; WHO, 2016; Amit et al., 2017; Martindale, 2017; Eustice, 2018).

Assessment of the environmental impact of food preservation technology on the depletion of scarce productive resources

Electricity is one of the most scarce and expensive productive resources in the industrial sector, including food preservation projects, where the electricity consumption per kilogram of food varies according to the different method of preservation. Reducing food losses can be achieved by removing food contaminants and prolonging its shelf life. As previously mentioned, chemical preservation cleanses the surface of the food without its interior part, and refrigerators discourage microbial activity without killing microbes, and both cause quantitative and qualitative food losses, while irradiation works to remove all insects, fungal and microbial food contaminants completely from the surface of the food and its interior part, with preserving the value, quality and freshness of the food, and then preserving the resources used in its production (Table 5) (Nature Publishing Group, 1954; Heinis, 2009; Yousefi & Ayat, 2014; Ilić & Petar, 2015; Amit et al., 2017; EEA, 2020).

TABLE 2. Assessment of the negative environmental impact of food preservation technology on soil and waterways

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Leakage of pesticide residues into soil and waterways	0	0	3
2- Acid rain	0	0	3
3- The need for special precautions to prevent the leakage of radioactive waste	1	0	0
4- The need for special precautions to prevent leakage from chemical plants	0	0	1
Total	1	0	7

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0)

TABLE 3. Assessment of the negative environmental impact of food preservation technology on its employees

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Possible effect of grain preservation fumes on workers	0	0	3
2- Special precautions to prevent workers in chemical units from being exposed to fumes	0	0	1
3- The need for special precautions to prevent workers from being exposed to radiation leakage	1	0	0
4- The need for special precautions to prevent workers from being exposed to Freon gas leakage	0	1	0
Total	1	1	4

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0).

TABLE 4. Assessment of the negative environmental impact of food preservation technology on consumer safety and health

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Not completely eradicating microbial contaminants	0	2	1
2- The possibility of the activity of cold-loving microbes.	0	2	0
3- The possibility of food borne diseases caused by bacteria	0	0	1
4- The possibility of food borne diseases caused by fungi	0	0	1
5- The possibility of food borne diseases caused by insects	0	0	1
6- Not completely purifying the inside of the fruit	0	0	3
7- Food borne decreased value and quality of food	0	2	3
8- The possibility of diseases caused by chemical residues	0	1	3
Total	0	7	13

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0).

TABLE 5. Assessment of the negative environmental impact of food preservation technology on the depletion of scarce productive resources

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Electricity consumption	0	2	0
2- Depletion of the soil resource used in the production of food waste	0	1	1
3- Depletion of the water resource used in the production of food waste	0	1	1
4- Depletion of the fertilizer resource used in the production of food waste	0	1	1
5- Depletion of the used human resources	0	1	1
Total	0	6	4

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0).

Assessment of the environmental impact of food preservation technology on waste recycling

Food preservation technology by irradiation can remove all microbial, fungal and insect pollutants present in the waste of agriculture, food factories, fish trade and slaughterhouses, making it suitable for use as animal feed. However, the use of chemicals for the same purpose has health and environmental risks that can be transmitted from animals to humans. In addition, refrigerators often do not contribute to the recycling of waste as shown in Table 6 (Nature Publishing Group, 1954; Heinis, 2009; Environment Agency et al., 2012; Yousefi & Ayat, 2014; Ilić & Petar, 2015; Martindale, 2017; Martindale & Walter, 2017; EEA, 2020).

Assessment of the environmental impact of food preservation technology in terms of societal acceptance

One of the most important technological risks for refrigerators is the possibility of the leakage of toxic Freon gas, which also affects the ozone layer in the atmosphere, while society has concerns about chemicals for their direct effects

on workers and the population, as well as the risks of the possibility of chemicals leaking into their production plants. On the other hand, irradiation, despite the seriousness of its leakage accidents, (they are rare due to the firm precautions), but there are concerns associated with the use of food preservation method by community members in Table 7 (Nature Publishing Group, 1954; Mostafavi et al., 2010; Yousefi & Ayat, 2014; Ilić & Petar, 2015; Amit et al., 2017).

The results of the statistical analysis showed that there are significant differences between the environmental impact of the three food preservation techniques (irradiation - refrigerators- chemicals). The results are listed in in Tables 8 and 9 (Salvatore & Derrick, 2002; Ju & Zhongwen, 2009; Yousefi & Ayat, 2014).

Conclusion

The present study shows that irradiation is the best way to preserve food in terms of low negative environmental impact, while chemicals have most of the negative environmental impact.

TABLE 6. Assessment of the environmental impact of Food Preservation Technology on waste recycling

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Inefficient removal of food waste contaminants	0	3	1
2- Ineffective detoxification of previously secreted toxins	3	3	3
3- Adverse health effects on the feeding animal	0	3	3
Total	3	9	7

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0)

TABLE 7. Assessment of the environmental impact of food preservation technology in terms of societal acceptance

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Concerns the possibility of radiation leakage	2	0	0
2- Concerns the possibility of chemical leakage	0	0	2
3- Concerns the possibility of Freon gas leakage	0	2	0
4- Concerns associated with the use of food preservation method by community members	3	0	2
Total	5	2	4

Extremely Dangerous (3), Dangerous (2), Moderately Dangerous (1), None (0)

TABLE 8. Overall assessment of the negative environmental impact of food preservation techniques

Compare	Food preservation method		
	Irradiation	Refrigerators	Chemicals
1- Impact on the atmosphere	2	2	4
2- Impact on soil and waterways	1	0	7
3- Impact on its employees	1	1	4
4- Impact on consumer safety and health	0	7	13
5- Impact on the depletion of scarce productive resources	0	6	4
6- Impact on the possibility of waste recycling	3	9	7
7- Impact in terms of societal acceptance	5	2	4
Total	12	27	43

Source: Tables 1 : 7

TABLE 9. The results of the statistical analysis between the negative environmental impact of food preservation methods (irradiation - refrigerators - chemicals)

Chi- square	18.23
df	12
Sig	0.1

Source Table (8)

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