

Materials(Data)

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Quantity and Economic Scale of Food Irradiation in the World

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The status of food irradiation in the world in 2005 was studied using a questionnaire survey and direct interview. The total quantity and economic scale of irradiated foods in the world were estimated as 405 000 tons and 1.61 trillion Japanese Yen (JPY), respectively. Processed foods totaled 183 000 tons (45%) in Asia and Oceania, 116 000 tons (29%) in the American region, 90 000 tons (22%) in Africa and Ukraine, and 15 000 tons (4%) in the EU. The economic scale, estimated using the price at retail stores converted to JPY using an IMF conversion table, was 1.07 trillion JPY (67%) in the American region, 309 billion JPY (19%) in Asia and Oceania, 181 billion JPY (11%) in Africa and Ukraine, and 50 billion JPY (3%) in the EU.

Key Words : food irradiation, irradiated food, quantity and economic scale, spice

1. Introduction

The progress of food irradiation in the world has been published by the “International Food Irradiation Advisory Group (ICGFI)” of FAO, IAEA and WHO from 1984 to 2004. After the dissolution of ICGFI, the data were taken over by FAO/IAEA, and the latest permission article list was published in January, 2006¹⁾. Irradiated foods were classified into eight classes, and 57 countries were registered. FAO/IAEA published a list in July, 2007 detailing facilities

involved in food irradiation, which included 33 countries and 71 facilities²⁾. Most facilities used for commercial irradiation utilized ⁶⁰Co gamma rays, although ⁶⁰Co and ¹³⁷Cs gamma rays, an electron beam of 10 MeV and X rays of 5 MeV were permitted for food irradiation.

However, detailed information such as statistical data concerning the quantity of irradiated foods in the world was not included in the FAO/IAEA publications. The quantity of irradiated foods was estimated by IAEA to be only about 300 000 tons in 2004.

Under the above conditions, the quantity of irradiated foods in each country in 2005 was surveyed, and the economic scale based on the market price was calculated to clarify the situ-

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Table 1 Quantity and economic scale of irradiated foods in the American region

| Country | Quantity (t) | Economic Scale | |
|---------|--------------|----------------|----------------------|
| | | Local currency | Japanese Yen (M JPY) |
| USA | 92,000 | 7,316 M USD | 849,388 |
| Canada | 1,400 | 55 M CAD | 5,207 |
| Brazil | 23,000 | 2,348 M BRL | 218,519 |
| Total | 116,400 | | 1,073,114 |

ation regarding food irradiation in the world.

2. Examination method

The current status of food irradiation in the world in 2005 was investigated using published data, a questionnaire survey, and direct visits. The global region was divided into 4 for the study on the current status of food irradiation : 1) America, 2) EU, 3) Asia and Oceania, and 4) Africa and other countries, including Ukraine and Israel. The questionnaire investigating food items, purpose of irradiation, amount of product irradiated per year (as of 2005), shipment price, and market price was sent to each country based on the list obtained from IAEA, etc. In major countries engaged in food irradiation such as France, Belgium, the Netherlands, the United States, Canada, Mexico, China, India, Ukraine and South Africa, data were collected by direct visits. In addition, data were obtained by E-mail and direct telephoning to compensate for any lack of data from the questionnaire survey.

For the economic scale study, the market price of a typical product of each irradiated food (e.g. black pepper for spices) was used because it was impossible to obtain the shipment price of each irradiated food. In this case, the market price of irradiated or non-irradiated food was obtained because it was difficult to

obtain the price of irradiated food in many cases or the difference in price between irradiated and non-irradiated foods. The price was then converted into JPY using an IMF conversion table.

3. Result and Discussion

3.1 Status of food irradiation in the American region

In the American region, the quantity of irradiated foods was estimated as 92 000 tons in the United States, 1 400 tons in Canada and 23 000 tons in Brazil, representing a total of 116 400 tons. The economic scale in the United States, Canada and Brazil was 7 316 M USD (849.4 billion Japanese Yen, B JPY), 55 M CAD (5.2 B JPY) and 2 348 M BRL (218.5 B JPY), respectively (Table 1).

1) The United States

The United States is the most positively advanced country for commercial food irradiation in the world, and the total quantity was about 92 000 tons. Meat and poultry (ground-beef meat and chicken meat) represented 8 000 tons, fruits and vegetables 4 000 tons, and spices 80 000 tons. These estimates were obtained from the Minnesota Beef Council because statistical data could not be obtained. The total economic scale obtained from a local retail

Table 2 Quantity and economic scale of irradiated foods in Europe

| Country | Quantity (t) | Economic Scale | |
|----------------|--------------|----------------|----------------------|
| | | Local currency | Japanese Yen (M JPY) |
| Belgium | 7, 279 | 113 M EUR | 15, 713 |
| Germany | 472 | 8 M EUR | 1, 073 |
| France | 3, 111 | 62 M EUR | 8, 036 |
| Netherlands | 3, 299 | 136 M EUR | 18, 289 |
| Czech Republic | 85 | 1 M CZX | 9 |
| Hungary | 111 | 236 M HUF | 227 |
| Poland | 687 | 109 M PLN | 7, 063 |
| Croatia | 16 | 3 M HRK | 89 |
| Total | 15, 060 | | 50, 498 |

price was 7 316 M USD (frozen meat : 94 M USD, fruits and vegetables : 22 M USD, spices : 7 200 M USD).

2) Canada

Commercial irradiated food only involved spices, and amounted to 1 400 tons of spices irradiated in facilities of Quebec, Ontario and British Columbia according to the Canadian irradiation center MDS-Nordion Co. Most of the irradiated spices were for domestic use in food processing. The economic scale was estimated at 55 M CAD using the market price of 0.99 CAD/25 g as obtained from the domestic black pepper (grain) price, which was a typical product in the market.

3) Brazil

In the Latin American region, food irradiation was studied in Argentina, Brazil, Chile and Mexico. Brazil was the first country to perform high-dose irradiation according to the recommendation of FAO/IAEA/WHO in 1999. Commercial irradiation is being carried out in pri-

vate companies and the total quantity of irradiated foods was 23 000 tons, and comprised 20 000 tons of spices and 3 000 tons of fruits according to the questionnaire survey. The economic scale obtained from the retail price was 2 333 M BRL for spices and 15 M BRL for fruits, representing a total of 2 348 M BRL.

3·2 Status of food irradiation in the European region

Statistical information regarding commercial food irradiation in the EU is provided to the public by the European Commission every year. Seven countries in the EU engaged in commercial food irradiation in 2005. In the old EU signatory countries, the quantities of irradiated foods were 7 279 tons in Belgium, 3 299 tons in the Netherlands, 3 111 tons in France, and 472 tons in Germany. In expansion countries of the EU that joined in 2004, the amounts of commercial food irradiation were 85 tons in the Czech Republic, 111 tons in Hungary, and 687 tons in Poland. Moreover, in the case of Croatia, which is going to join the EU in 2009,

16 tons of foods were irradiated. Thus, the quantities of irradiated foods in EU countries with their respective economic scales were Belgium 113 M EUR (15.7 B JPY), Germany 8 M EUR (1.1 B JPY), France 62 M EUR (8 B JPY), Netherlands 136 M EUR (18.3 B JPY), Czech Republic 1 M CZX (10 M JPY), Hungary 236 M HUF (200 M JPY), Poland 109 M PLN (7.1 B JPY) and Croatia 2.9 M HRK (90 M JPY), yielding a total of 50.5 B JPY.

1) Belgium

Many food items were irradiated commercially, such as frozen frog legs, frozen fowl meat, eggs and frozen prawns. The total quantity and economic scale was 7 279 tons (112 M EUR) and comprised 218 tons (20 M EUR) of spices and dehydrated vegetables, 5 530 tons (53 M EUR) of meat and seafood, and 1 531 tons (39 M EUR) of other food items.

2) Germany

Since irradiated food is prohibited for domestic consumption, only spices and dehydrated vegetables destined for export are irradiated. The quantity of irradiated food was 472 tons and the economic scale was 8.1 M EUR. In addition, it is interesting to note that irradiation of frozen frog legs was permitted in 2006. The reason for this allowance involved the import of irradiated frog legs from Belgium and the Netherlands.

3) France

Spices and dehydrated vegetables, frozen fowl meats and frozen frog legs are irradiated in France. The quantities and economic scale of irradiated foods were 2 789 tons (38.5 M EUR) for meat and seafood, 134 tons (12.1 M EUR) for spices and dehydrated vegetables, and 188 tons

(11.4 M EUR) of other food items, resulting in a total of 3 111 tons (62 M EUR). Commercial food irradiation in France increased in the 1990s, and the 10 000 tons irradiated in 1991 was doubled to 20 000 tons in 1998. However, the amount of irradiated food decreased rapidly afterwards, reaching a low of 3 000 tons in 2005.

4) The Netherlands

Spices, herbs, dehydrated vegetables, frozen frog legs, frozen or chilled prawns, frozen meats, etc. was commercially irradiated. The quantities and economic scale were 2 022 tons (92.6 M EUR) for spices and dehydrated vegetables, 944 tons (32.9 M EUR) for meat and seafood, and 333 tons (10.4 M EUR) for other food items, resulting in a total of 3 299 tons (136 M EUR).

Recently, the amount of food irradiation decreased rapidly in three countries (Belgium, Netherlands, France) because of the enforcement of EU regulations to report foods and food ingredients treated with ionizing radiation³⁾. Food companies were concerned about public acceptance of irradiated food and stopped irradiation practices. However, special foods such as frozen frog legs have been irradiated at a constant amount even though a label of irradiation is obligatory.

5) Expanded EU nations (Czech Republic, Hungary, Poland)

Among the expanded EU nations approved in 2004, food irradiation was performed in the Czech Republic, Hungary and Poland.

In the Czech Republic, 80 tons of spices and dehydrated vegetables were irradiated and the economic scale was 0.99 M CZK.

In Hungary, irradiated spices and dehy-

Table 3 Quantity and economic scale of irradiated foods in Asia and Oceania

| Country | Quantity (t) | Economic Scale | |
|-------------|--------------|----------------|----------------------|
| | | Local currency | Japanese Yen (M JPY) |
| China | 146,000 | 4,172 M CNY | 232,130 |
| India | 1,600 | 376 M INR | 4,644 |
| Indonesia | 4,011 | 355,475 M IDR | 11,731 |
| Japan | 8,096 | 1,255 M JPY | 1,255 |
| Korea | 5,394 | 161,820 M KRW | 27,186 |
| Malaysia | 482 | 17 M MYR | 1,183 |
| Philippines | 326 | 32 M PHP | 288 |
| Thailand | 3,000 | 636 M THB | 5,967 |
| Vietnam | 14,200 | 213 M USD | 24,729 |
| Australia | 200 | 1 M AUD | 80 |
| Total | 183,309 | | 309,192 |

drated vegetables totaled 100 tons (207 M HUF) and fruits amounted to 11 tons (29 M HUF), representing a total of 111 tons (236 M HUF).

In Poland, the quantity and economic scale of spices, herbs and dehydrated vegetables was 607 tons (91 M PLN) and that of mushrooms was 80 tons (18 M PLN), representing a total of 687 tons (109 M PLN).

6) Croatia (EU joining schedule country)

The quantity and economic scale of irradiated foods was 11 tons (2.0 M HRK) of spices and 5 tons (0.9 M HRK) of other food items, representing a total of 16 tons (2.9 M HRK). It was reported at the 14th International Meeting on Radiation Processing (IMRP 2006) in 2006 that 6 000 tons of spices and 12 000 tons of other foods were irradiated in Croatia. However, we found through direct communication that these estimates involved a mistake concerning the

unit of measurement, and that they did not reflect quantities in tons but kg. At the Institute Ruder Boskovic of Zagreb, only small-scale irradiation was performed.

3·3 Status of food irradiation in the Asian and Oceania region

Asia is a region where commercial food irradiation is currently the most positively developed in the world. The quantity of irradiated foods was estimated as 146 000 tons in China, 1 600 tons in India, 4 011 tons in Indonesia, 8 096 tons in Japan, 5 394 tons in Korea, 482 tons in Malaysia, 326 tons in the Philippines, 3 000 tons in Thailand, 14 200 tons in Vietnam and 200 tons in Australia, representing a total of 183 000 tons with an economic scale of 309.2 billion JPY (Table 3).

1) China

China is the country in which commercial

food irradiation is performed most in the world. The total quantity of irradiated foods is 146 000 tons (garlic : 80 000 tons, spices and dehydrated vegetables : 52 000 tons, health food and functional food : 10 000 tons, cereals : 4 000 tons). The economic scale was calculated as 352 M CNY for garlic, 26 M CNY for spices and dehydrated vegetables, 20 M CNY for cereals and 1 200 M CNY for health food and functional food, representing a total of 4 172 M CNY.

The amount of processing has expanded steadily with 80 000 tons in 2001, 100 000 tons in 2002, and 120 000 tons in 2004. The total amount of garlic produced in China was 11.58 million tons, which represented 75.4% of the world's total production. Therefore, it was found that irradiated garlic was only 0.7% of the total amount produced (irradiated 80 000 tons \times 100/11.58 million tons = 0.7%).

New information was obtained showing that the facilities for food irradiation in China comprised 103 facilities utilizing ^{60}Co and 6 utilizing electron beam accelerators.

2) India

Irradiated spices and dehydrated vegetables such as coriander, turmeric and red pepper totaled 1 500 tons a year, and 100 tons of onion were irradiated. The economic scale was 375 M INR for spices and 1 M INR for onion, totaling 376 M INR.

3) Indonesia

Information concerning the quantity of irradiated foods was obtained from Indogamma Co., where the foods were irradiated using a ^{60}Co gamma ray irradiation facility (11 PBq). The quantity of processing was 1 008 tons for seafood, 358 tons for spices, 334 tons for cereals and 2 311 tons for other food items (cocoa powder),

representing a total of 4 011 tons. The economic scale for each food was 66 Billion IDR, 57 B IDR, 230 B IDR and 3 B IDR, respectively, representing a total of 355 B IDR.

4) Japan

The only irradiation permitted in Japan is that on potato for sprout inhibition, and commercial irradiation has been performed at the Shihoro irradiation center in Hokkaido since 1974 for more than 30 years. The amount of processing was 8 096 tons and the economic scale was calculated as 1.25 billion JPY. Permission to irradiate spices is currently being discussed at the Ministry level.

5) South Korea

The commercial irradiation of spices and dry pharmaceutical products is conducted by the Greenpia Co. The quantity of irradiated foods is 5 394 tons and the economic scale is 162 Billion KRW. It is thought that EU announcements concerning the infringement of products imported from Asia, especially Asian-type noodles and food supplements, caused the decrease of food irradiation in Korea.

KAERI established the Advanced Radiation Technology Institute (ARTI) in 2007, and the research and development of food irradiation is advancing positively using an electronic accelerator (10 MeV, 1 mA) and ^{60}Co gamma ray irradiation facility (18 PBq).

6) Malaysia

Foods for export are irradiated at the ^{60}Co gamma ray irradiation facility of the Malaysian Nuclear Agency. The quantity and economic scale are 482 tons (382 tons of spices and herbs, 100 tons of nutritional drinks) and 17 M MYR, respectively. An electron beam is not used for

food irradiation, although a ^{60}Co facility and an electron accelerator are registered in the IAEA list.

7) The Philippines

Spices and onions are irradiated for the market using the ^{60}Co gamma ray irradiation facility of the Philippine Nuclear Research Institute (PNRI). The quantity is 326 tons (278 tons of spices, 48 tons of fruits), and the economic scale is 31.6 M PHP. An application to permit irradiation of mango for quarantine processing was submitted to the United States Department of Agriculture (USDA) in July, 2004.

8) Thailand

Spices, fermented sausage, frozen seafood, etc. are irradiated commercially. However, since data from private companies were not available, data concerning the 3 000 tons reported at the RCA Meeting was used and the economic scale was estimated as 636 M THB. Irradiated foods such as fermented sausages with labels can be found in the market. The agreement to export six kinds of irradiated fruits (mango, mangosteen, pineapple, rambutan, laichee and longan) to the United States was concluded in 2006, and the facility at the Thai Irradiation Center passed the inspection to meet with the regulation section of the USDA in 2007.

9) Vietnam

Food irradiation in Vietnam expanded rapidly and is placed at second in Asia. Commercial food irradiation was implemented at the Ho Chi Minh Irradiation Center (VAEC) and Son Son Electron Beam Irradiation Co. Frozen seafood (mainly prawns) totaling 14 200 tons (213 M USD) was irradiated and exported to Russia

and other countries. The irradiation facilities in Ho Chi Minh City are already full, and new irradiation facilities are planned for construction.

10) Other countries in Asia

In Bangladesh, food irradiation of onions, potatoes, dry fish, spices (for export), frozen prawns, fruits and vegetables was tested, but practical irradiation is difficult following the closure of the semi-commercial scale facility in Chittagong.

Although Pakistan is not included in the IAEA list, several foods such as garlic powder and mango are accepted and transported to foreign countries on a trial basis.

Food irradiation is not allowed in Sri Lanka at present, although research is advanced.

11) Australia and New Zealand (Oceania region)

ANZFA (Australia New Zealand Food Authority) permitted the irradiation of spices/herbs in 2001 and tropical fruits for quarantine treatment in 2002.

Two hundred tons of fruit (180 tons of mango, 20 tons of papaya) were irradiated in Australia and sold in New Zealand in 2005. The economic scale was estimated as 1.0 M AUD. A private company in Australia is positively developing the food irradiation business sector, and is planning to construct an electron beam accelerator.

3·4 Status of food irradiation in Africa and other regions

Data were amalgamated for Africa and other regions (former Soviet Union and Middle-East region). In the African region, 18 185 tons of spices and honeys were irradiated in the Republic of South Africa, and 550 tons of spices were irradiated in Egypt. In Ukraine, 70 000

Table 4 Quantity and economic scale of irradiated foods in Africa and other countries

| Country | Quantity (t) | Economic Scale | |
|--------------|--------------|----------------|----------------------|
| | | Local currency | Japanese Yen (M JPY) |
| South Africa | 18,185 | 4,110 M ZAR | 165,784 |
| Egypt | 550 | 11.1 M EGP | 697 |
| Ukraine | 70,000 | 140 M UAH | 10,000 |
| Israel | 1,300 | 108 M NIS | 4,543 |
| Total | 90,035 | | 181,024 |

tons of grain (42 000 tons of wheat, 28 000 tons of barley) were irradiated, and 1 300 tons of spices were irradiated in Israel. The total amount of irradiated foods in Africa and other regions were 90 035 tons (Table 4), and the economic scales were South Africa 4 110 M ZAR (165.8 B JPY), Egypt 11.1 M EGP (700 M JPY), Ukraine 140 M UAH (10 B JPY), and Israel 108 M NIS (4.5 B JPY).

1) South Africa

Data regarding food irradiation in the Republic of South Africa were obtained from the South Africa Gamma Processors Association. Spices were the main irradiated product, representing 15 875 tons from facilities in Cape Town, Johannesburg, and Durban. The irradiated spices were mainly used by food-processing manufacturers. Furthermore, 90% of domestic spices such as black pepper are irradiated, and irradiated black pepper and paprika powder with labels were seen being sold in supermarkets and at the airport. Irradiated honey and other food items represented 2 310 tons, and the total amount of irradiated food was 18 185 tons. The economic scale of spices was calculated as 3 969 M ZAR using the market price of a domestic black pepper (grain), and 141 M ZAR for honey, representing a total

of 4 110 M ZAR. The export of irradiated citrus fruits, grape and peach from South Africa to the United States is scheduled for 2008.

2) Egypt

The quantity of irradiated spices and dry vegetables was 550 tons, and the economic scale calculated on the basis of the cost of black pepper in the supermarket was 11.1 M EGP.

3) Ukraine

Electron beam facilities for grain irradiation were established in Odessa port in 1980 and grain irradiation continued for the purpose of disinfestation. The quantity of irradiated grain was 42 000 tons for wheat and 28 000 tons for barley, totaling 70 000 tons. Other grains such as corn, rye, oat, etc. are also irradiated as the need arises. The economic scale was estimated as 140 M UAH, although this calculation is based on the price in 2007 and is the same as the data of other countries even though the price differed three times in 2005 and 2007. It was reported at IMRP in 2006 that 400 000 tons of grain were irradiated every year, but that report represented old data of the former Soviet Union.

We succeeded in seeing details of the Odessa grain irradiator, which was one of the most fa-

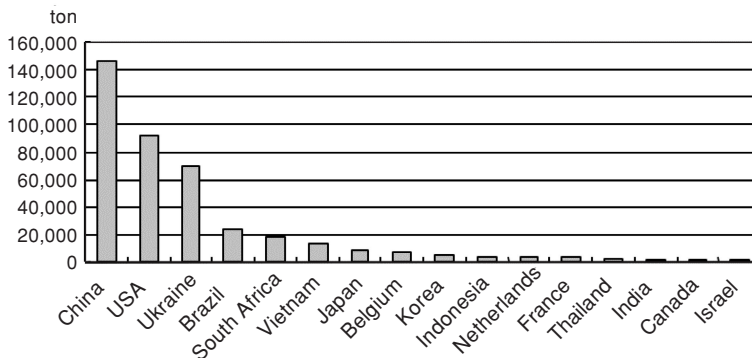


Fig. 1 Quantity of food irradiation in the world in 2005.

mous facilities for food irradiation in the world. The facility operated without any serious trouble for 27 years after its construction in 1980. The technology of this facility comprising two ELV 8(2.5 MeV, 30 mA) accelerators was transferred to China and is operating in Guangzhou.

4) Israel

1 300 tons of spices are irradiated and the economic scale, as calculated using the market retail price of black pepper and detailed in the JETRO survey, was 108 M ILS.

4. Overview of Food irradiation in the world

Figure 1 shows countries listed in order of the amount of irradiated foods. The number of countries that processed more than 1 000 tons was up to 16. More than 70 000 tons of food was irradiated in the top three countries, represented by China, the United States, and Ukraine. The quantities of irradiated foods in each region were 183 309 tons (45%) in Asia and Oceania, 116 400 tons (29%) in the American region, 90 035 tons (22%) in Africa and Ukraine, and 15 060 ton (4%) in Europe (Fig. 2). The total quantity was 404 804 tons.

The economic scale in each region was calculated as 1.07 trillion yen (67%) in America, 309

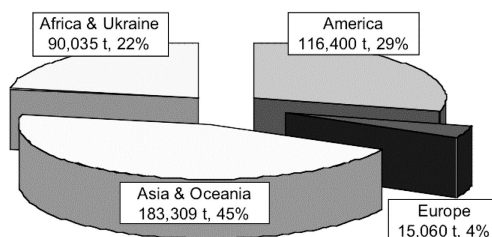


Fig. 2 Quantity of food irradiation in each region in 2005.

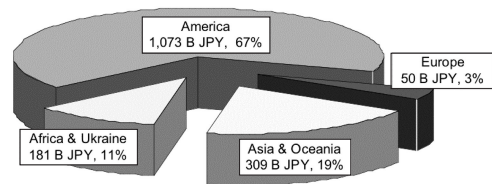


Fig. 3 Economic Scale of food irradiation in each region in 2005.

billion yen (19%) in Asia and Oceania, 181 billion yen (11%) in Africa and Ukraine, and 50 billion yen (3%) in Europe (Fig. 3). The economic scale in the American region was larger than that of Asia, although the quantity in Asia was the largest. This is thought to result from the fact that the main products in the American region included many expensive spices, while many low-cost items such as garlic and potatoes were included in the Asian region.

The Asian region has progressed the most in terms of food irradiation in the world. Not only China, but also Vietnam and many other coun-

tries have rapidly extended commercial food irradiation. Furthermore, Thailand, India, the Philippines and Australia are expected to expand fruit irradiation for quarantine treatment in the near future.

In North America, the irradiation of spices for disinfection is steadily performed in the United States and Canada. Irradiation to prevent food-borne diseases is more important, and is expected to increase following the increase of Ready to Eat Food in the United States. In Latin America, only Brazil is developed for the commercial irradiation of spices and fruits, but the development of fruit irradiation for quarantine treatment is expected in many other countries.

Commercial irradiation has not progressed in the African region to a significant degree, except in the Republic of South Africa. Many countries in the African region have serious problems with food safety and food shortage, but only a few countries possess an irradiation facility. As food irradiation can become the means to solve these food problems, the rapid development of food irradiation is expected in this region.

Steady irradiation has been performed for a long period (30 years) in Ukraine and Japan. The irradiators in Odessa for grain and Shihoro for potato are designed for a single purpose. Our experiences concerning the usefulness of the Odessa and Shihoro single-purpose irradiation facilities suggest that commercial irradiation will remain unchanged for a long period.

Commercial food irradiation in the old EU signatory countries is decreasing because of the enforcement of a European Union regulation to check irradiated foods at the product marketing stage. The checking is aimed to enforce correct labeling or detect non-authorized

products. It is important to distinguish a compliance issue (breach of rules for labeling and license) from a food safety issue. The safety of irradiated foods has been proved internationally. However, the decrease of food irradiation in the EU may support the misunderstanding that irradiated foods are not safe. We hope to better understand the advantages of food irradiation and expand the range of irradiated foods with proper labeling in the market.

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要 旨

世界における食品照射の処理量と経済規模

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世界の食品照射の状況について、2005年の各国における実施状況をアンケート調査及び主要国における現地調査により求めた。照射食品の処理量を地域別に見てみると、アジア・オセアニア地域が18.3万トン(45%)、アメリカ地域11.6万トン(29%)、アフリカ・ウクライナその他の地域が9万トン(22%)、ヨーロッパが1.5万トン(4%)であった。地域別の経済規模で見ると、アメリカ地域10700億円(67%)、アジア・オセアニアが3100億円(19%)、アフリカ・ウクライナが1800億円(11%)、ヨーロッパが500億円(3%)と求められた。