

PRACTICAL APPLICATION OF FOOD IRRADIATION IN TURKEY

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Abstract

Turkey is the world's leading producer and exporter of dried fruits (dried figs, raisins, and dried apricots etc.) and nuts (hazelnuts, walnuts, pistachios, peanuts etc.) all of which have to be fumigated by methyl bromide a few times prior to export. Last fumigation is obligatory before shipment according to current quarantine treatment. Methyl Bromide (MeBr) fumigation is the most commonly used insect quarantine treatment for dried fruits and nuts in Turkey to protect from potential infestations.

In accordance with the Montreal Protocol, Turkey as an Article 5(1) country will take actions to regulate and take measures to phase-out MeBr use. So, Turkey has to total phase-out in 2015 but according to Turkey MeBr Phase-out Action Plan prepared and published by The Ministry of Agriculture and Rural affairs in 2001, using MeBr should be reduced for stored commodities by 50% by 2002 and phased-out totally by 2004. Irradiation technology is ready as an alternative to MeBr fumigation under the Action Plan of Turkey.

Intensive research studies on food irradiation in Turkey have started in early 1970's and have still been continued. After careful and intensive works of all related authorities and specialists for a long period and with the help of ICGFI, the food irradiation regulation of Turkey was published in Official Newspaper on November 6, 1999. Having the Food Irradiation Regulation has supported to initiate commercialization study in Turkey in Co-operation with IAEA (TUR 5022).

Feasibility study of a commercial food irradiation facility for the potential application of food irradiation in Turkey was prepared by IAEA experts Dr.M.Ahmed and Ir. J.P.Lacroix and together with TUR 5022 Research Team in April 2001 in Izmir, Turkey.

Gamma-Pak Irradiation Facility in Cerkeskoy-Tekirdag got the commercial food irradiation license and registration certificate in Feb. 2002. Practical application of food irradiation is getting more attraction in Turkey in parallel with other countries.

1. Introduction

Intensive research studies on food irradiation in Turkey have started in early 1970's and have still been continued.

After careful and intensive works of all related authorities and specialists for a long period and with the help of ICGFI, the Food Irradiation Regulation of Turkey was published in Official Newspaper on November 6, 1999. Food irradiation regulation of Turkey includes five parts which are;

- Part I.** Objectives, Scopes, Basis and Definition,
- Part II.** Food Irradiation and Radiation Safety Principles of Food Irradiation,
- Part III.** The Radiation Sources Used for Foods Irradiation Plants and Employment, Licensing, Permission and Registration,
- Part IV.** Ensuring the Quality of the Irradiated Foods and Documenting Ensuring the Quality,
- Part V.** Miscellaneous and Last Provisions Distinguishing of the Irradiated Foods and Determination of Irradiation Dose.

Having the Food Irradiation Regulation has supported to initiate commercialization study in Turkey in Co-operation with IAEA (TUR 5022-Implementation of Food Irradiation Technology in Turkey).

2. Feasibility study:

Feasibility study of a commercial food irradiation facility for the potential application of food irradiation in Turkey was prepared by IAEA experts Dr.M.Ahmed and Ir. J.P.Lacroix and together with TUR 5022 Research Team in April 2001 in Izmir, Turkey.

The following items were focused in the feasibility study;

1. Production and export data of dried figs, raisin, dried apricots, hazelnuts, pistachio, spices etc. in relation to establishing a commercial irradiation facility were gathered and evaluated.
2. The most suitable location for a commercial irradiation facility in terms of target food products requiring treatment was selected. Also, processing, storage, handling, distribution and transport of the treated products were considered.
3. Type (Co-60, EB machine) and size of the irradiation plant were recommended. Their specifications and estimated cost were provided.
4. Details of economic and financial factors such as cost/benefit analysis, financial projections for the irradiator such as its amortization, areas of expenditures, break-even points, internal rate of return, losses and gains, working capitals, etc were provided.

5. The conditions in the country concerning plant safety, general safety measures, radiation protection measures and services, etc were assessed. Local requirements in terms of laboratories, personnel, training need and major equipment for smooth and effective operation and management of the facility were identified.

3. Regulation studies:

- As a candidate country to be a member of European Union (EU), Turkey has been completed adaptation studies of Food Irradiation Regulation of Turkey to 'EC Food Irradiation Directives'.
- **Turkish MeBr phase-out action plan:** Food irradiation technology was considered as an alternative to MeBr fumigation in Turkish MeBr phase-out action plan.
- **Certification and licensing:** Gamma-Pak Irradiation Facility in Cerkeskoy-Tekirdag got the commercial food irradiation license and registration certificate in Feb. 2002.

4. Market development and legislation:

Since the majority of exports of dried fruits and nuts are shipped to EU countries, EU member countries should import irradiated dried fruits and nuts from Turkey. At present, only The Netherlands and France import irradiated dried fruits and nuts.

That's why, The Request Report of Turkey was prepared on 'Putting Dried Fruits and Nuts' in EC Food Irradiation Directives Positive List (It is under process at present).

5. Training:

- Workshop on 'Challenges and Opportunities for Trade in Irradiated Food' was organized on 14-15 June 2001, in Izmir / Turkey,
- Food irradiation seminar in February 2001 for private sector and academics,
- TV and radio programs were prepared on food irradiation.

6. Consultancy:

Consultancies have been given to Ministry of Health, Ministry of Agriculture and Rural Affairs (MARA), Private Food Industry, Exporter Unions, Universities and Research Institutes on Food Irradiation Technology and Legislation.

7. Status of production and market of the most important products, which have been fumigated with methyl bromide

7.1.Dried figs

Production:

Although many fig varieties are grown throughout Turkey, "Sari lop" variety with its big size, sweet, fleshy, light colored character and soft skin is the main variety for dried figs. This is intensively grown in Izmir and Aydin provinces of the Aegean Region. Annually approximately 45-55 thousand tons of dried figs are produced in Turkey. This level of production equals to 50-55% of the total world production. Generally 30% of the fresh production in Turkey is consumed domestically and the rest 70% is exported..

Immediately after collection, figs are subject to a first fumigation with methyl bromide followed by bulk storage in warehouse and checked for aflatoxin (1% of lots are normally contaminated by *Aspergillus flavus*). Next operations in the factories will be successively sorting according size, washing with NaCl solution, mechanical cleaning, drying, packaging, storage and checking again for aflatoxin. If the storage exceeds 20 days before export, a second fumigation will be performed. The whole process after collection from the producer's field to the processing end is completed within 2 days and the export take place for the most part in October and November.

Turkish Dried Fig Production by Years

Years	Production (Tons)
1994	48.605
1995	49.975
1996	50.155
1997	45.225
1998	50.981
1999	48.675
2000	55.645

Source: Ministry of Agriculture and Rural Affairs

Export:

Turkey has the biggest share in world dried fig exports as a consequence of the monopoly acquired in production. It is stated, that 60-70% dried figs subject to world imports is exported from Turkey.

The ratio of exported dried figs over the production has increased by years. While export versus production ratio was about 60% in 1980s, this figure was about 66% in 2000.

As it can be seen from the figures, in terms of export revenues, the highest figures were achieved in 1995 and in quantity terms the highest figures were achieved in 1994 so far.

Turkish Dried Fig Exports by Years (Volume (V):
\$ US 1.000, Quantity (Q): Tons)

Years	Q	V
1993	36.522	65.345
1994	46.634	72.975
1995	42.738	79.994
1996	39.737	73.233
1997	33.997	62.000
1998	37.253	71.631
1999	40.222	70.278
2000	36.759	59.802

Source: Undersecretariat For Foreign Trade

Turkish Dried Fig Exports to Top-Ten Countries by Years (Value (V):
\$ US 1.000, Quantity (Q): Tons)

Country	1998		1999		2000	
	Q	V	Q	V	Q	V
1. France	6.387	12.847	6.417	12.451	6.132	10.994
2. Germany	7.838	14.669	8.573	13.723	7.470	10.745
3. Italy	4.839	8.962	5.617	9.338	4.163	6.653
4. Switzerland	1.935	4.398	2.085	4.729	1.847	3.918
5. Spain	1.802	3.324	2.367	3.645	2.279	3.393
6. The Netherlands	1.167	2.182	2.040	3.651	1.801	2.829
7. England	1.528	3.077	1.737	3.225	1.371	2.577
8. Egypt	1.072	2.488	783	1.686	966	2.115
9. Israel	957	2.118	952	2.000	1.014	2.016
10. Sweden	989	1.990	906	1.805	847	1.488
Others	8.740	15.575	8.744	14.025	8.868	13.075
TOTAL	37.254	71.631	40.222	70.278	36.759	59.802

Source: Undersecretariat for Foreign Trade.

Disinfestation study on dried figs (2001):

Main purpose was establishing the disinfestation dose for dried figs in commercial packages. Studies were carried out on dried figs of the commercial cartoon packages (12.5 kg) which contained retail packages of 250 g. Observed pests on commodity were *Cadra (Ephestia) cautella* (Wlk.), fig moth; *Plodia interpunctella* (Hbn.), indianmeal moth and *Carpophilus* spp., dried fruit beetles.

Dried fig samples were packed as commercial cartoon packages (CCP), (12.5 kg) which contained retail packages (RP) of 250 g and during the whole treatment. Samples were not fumigated with Methyl Bromide or any chemicals. After the packaging, figs were transported to the facility and irradiated within 24 hours. 12 CCP of figs were divided into 3 replicates and each replicate irradiated at 0, 0.5, 0.75 and 1 kGy. They were stored in a clean and insect free room at $15 \pm 2^{\circ}\text{C}$ and $48 \pm 3\%$ relative humidity conditions. Storage conditions were simulated as in commercial warehouses of dried figs. Maximum measures were taken to prevent reinfestation of the irradiated products. After one month of the irradiation, one carton (CCP) from each treatment of the products were taken at random, opened and each RP were examined, as same as second and third replicates were examined after second and third months for the following parameters :

- Number dead larvae
- Number dead pupae or adult
- Number larvae and adults alive
- Number punctures in each package

Results: Dried fig samples were packaged, transported, irradiated and stored on 27 September and 28 September, respectively (within 24 hours). First observation were made on sixth day after irradiation. After 1, 2 and 3 months storage of CCP observations are summarized in Table 1. There was a decline in number of alive larvae with storage periods. Although, at the beginning of storage at 0.5 and 0.75 kGy doses alive larvae were observed after 1,2, and 3 months storage. Number of alive larvae was zero at 0.75 and 1 kGy. On the other hand, adult larvae were not detected after each period examination at different applied doses. Also, alive beetles were not detected each examination. Number of punctures were only detected on packages of control treatment. For the first month, 17 punctures were observed on CCP and for the other months 10 punctures on RP, 25 punctures on CCP, 8 punctures on RP, 14 punctures on CCP were observed on second and third months, respectively. We found only a puncture in CCP for the third month on treatment of 0.5 kGy. There was no correlation among the number of mold, applied doses and storage periods.

The results of disinfestation study on dried figs at different dose range

	No. dead larvae	No. dead pupae	No. dead adult	No. alive larvae	No. alive adult	No. dead beetles	No. alive beetles	No. puncture	No. mould
<i>After 6 days of irradiation (3 Oct, 01)</i>									
0 kGy	21	-	-	118	-	-	1	-	36
0.5 kGy	3	-	-	65	4	6	-	-	23
0.75 kGy	42	-	-	24		6	-	-	14
1 kGy	80	-	-	-		-	-	-	34
<i>After 1 month (6 Nov, 01)</i>									
0 kGy	18	6	1	90	2	12	82	17	126
0.5 kGy	14	-	-	5	-	12	1	-	109
0.75 kGy	16	1	-	-	-	7	-	-	122
1 kGy	24	-	-	-	-	35	-	-	125
<i>After 2 months (4 Dec, 01)</i>									
0 kGy	35	-	1	58	2	9	45	35	170
0.5 kGy	17	-	-	1	-	10	-	-	153
0.75 kGy	13	-	-	-	-	43	-	-	190
1 kGy	30	-	-	-	-	9	-	-	155
<i>After 3 months (9 Jan, 02)</i>									
0 kGy	19	1	-	22	-	18	87	22	188
0.5 kGy	25	-	-	-	-	4	-	1	115
0.75 kGy	8	-	-	-	-	13	-	-	132
1 kGy	27	-	-	-	-	16	-	-	149

In conclusion, applied dose is dependent on storage period of dried figs. For longer storage periods 0.75 and 1 kGy doses seem to be minimum applied doses in commercially packaged dried figs.

7.2. Raisins

Production:

In Turkey there are 1.200 different types of grapes. Among these varieties, seedless "Yuvarlak and Sultani" are the main varieties used for raisin. In 1998, Turkey ranks the first in the world production of raisin. Seedless raisin is grown in Izmir, Manisa and Alasehir of Aegean region in an area of 70.000 ha. About 60% of the total production in this region is seedless Depending on the foreign demand, the tendency in Turkey is towards more production. This is realized both by increasing

viticultural areas by 3% and utilizing modern viticultural techniques to increase the yield. The production figure amounting to 260 thousand tons in 2000 has been the highest level ever achieved yet.

The harvesting of raisins starts in mid June and continues up to the end of August. The processing of raisin is quite simple. After drying (7-9 days up to 12-15 % moisture and 60 % sugar), raisins are sorted following size, washed to get rid off any kind of residue, treated with SO₂ (for color) and packaged for export (bulk or commercial packaging). Before exported, the product is fumigated mostly with MB and a small portion with phosphine in order to control insects (especially Saw Toothed Grain Beetle, *Oryzaephilus surinamensis*) and achieve commodity treatment. It is a very good candidate for irradiation disinfestation, because constant high volume all over the year is available.

Turkish Raisin Production by Years

Years	Production (Tons)
1993	212.300
1994	150.000
1995	179.000
1996	185.000
1997	210.000
1998	250.000
1999	250.000
2000	260.000

Source: Aegean Exporters Unions

Export:

Turkey exports approximately 70% of the annual raisin production to number of over hundred countries. Raisins are among the traditional agricultural products of Turkey. After hazelnuts and tobacco, raisins ranks in third in Turkish agricultural exports. Especially since 1986 Turkish raisin exports have been showing an upward trend.

Seedless raisins mainly constitute total raisin exports. Seedless Sultani packed in more than 2 kg. packs is the main type exported from Turkey. This item makes up more than 90 % of Turkish total raisin exports.

Turkish Raisin Exports by Years (Volume (V): \$ US 1.000, Quantity (Q): Tons)

Years	Q	V	% Change (Q)	% Change (V)
1993	122.851	134.271	-	-
1994	173.246	176.189	41,0	31,2
1995	169.701	189.933	-2,0	7,8
1996	173.060	189.445	2,0	-0,3
1997	180.858	206.229	4,5	8,9
1998	193.142	211.937	6,8	2,8
1999	188.939	202.969	-2,2	-4,2
2000	201.525	196.673	6,7	-3,1

Source : Undersecretariat For Foreign Trade

Turkish Raisin Exports to Top-Ten Countries by Years (Value, (V):
\$ US 1.000, Quantity (Q): Tons)

Country	1998		1999		2000	
	Q	V	Q	V	Q	V
1 England	39.780	46.863	40.729	47.178	45.814	48.824
2. Germany	32.027	34.479	31.072	32.861	32.046	30.053
3. The Netherlands	29.798	31.687	27.600	28.484	28.606	27.291
4. Italy	18.283	20.147	19.215	21.072	17.139	16.367
5. Bel-Lux.	12.563	13.130	11.479	11.566	12.173	11.463
6. Australia	7.144	7.533	7.218	7.516	11.059	11.382
7. France	11.446	12.651	10.596	11.332	10.034	9.859
8. Ireland	4.795	5.299	5.451	5.805	6.084	5.875
9. Spain	4.343	4.499	6.091	6.176	6.477	5.565
10. Brazil	5.393	5.733	6.653	6.412	5.895	4.820
Others	29.183	31.645	22.834	24.566	26.197	25.174
TOTAL	194.757	213.664	188.939	202.969	201.526	196.674

Source: Undersecretariat for Foreign Trade

EU countries are by far the most important destinations for Turkish raisins. 68,1 % of total export is shipped to the UK, Germany, The Netherlands, Italy and Bel-Luxs..

7.3. Dried apricots

Production:

Although apricot production may show large variations according to climatic conditions of the year, Turkey is the leading producing country throughout the world. For the last five years annual production has been measured at 385.400 tons on the average. Turkey realizes about % 17 of the total apricot production of the world with this figure.

Turkish Fresh and Dried Apricot Production by Years (Tons)

Years	Fresh	Dried
1993	230.000	23.023
1994	400.000	66.803
1995	250.000	30.652
1996	206.000	18.343
1997	270.000	34.599
1998	490.000	73.510
1999	538.000	71.422
2000	600.000	80.000

Source: Ministry of Agriculture and Rural Affairs

Apricot cultivation, which spreads in most of the agricultural regions of Turkey, finds its best environment in the Central Eastern Anatolian Region where nearly half of the crops are produced. Due to the composition arising from the ecology of the province, Malatya origin apricots gained economic value in the form of dried apricots for years. Almost all of the fresh crop in this district is subject to drying process and at least 95% of the dried apricots produced, is exported. The process of production of dried apricot is identical to the dried figs but it requires a SO₂ fumigation for microbiological decontamination and color retention. The whole process has to be performed within a period of 4 days including MeBr fumigation. On the other hand, the province of Izmir has been recorded as the main export port of dried apricot.

The most important varieties, according to the quantity produced, are *Hachaliloglu*, *Soganci*, *Kabaasi* and *Cataloglu*.

Export:

Dried apricots are among the traditional agricultural export products of Turkey. The export share of dried apricots, both in terms of quantity and value, has been showing an upward trend.

Turkish Dried Apricot Exports by Years
(Value (V): \$ US 1.000, Quantity (Q): Tons)

Years	Q	V
1993	33.951	83.692
1994	44.927	87.656
1995	50.835	99.146
1996	43.820	106.072
1997	40.509	111.617
1998	50.383	120.362
1999	55.403	126.169
2000	68.128	107.852

Source: Undersecretariat for Foreign Trade

**Turkish Dried Apricot Exports to Top-Ten Countries by Years (Value (V):
\$ US 1.000, Quantity (Q): Tons)**

	1999	2000	1999/ 2000	1999/ 2000	1999	2000
Country	(Q)	(V)	(Q)	(V)	% Change (Q)	% Change (V)
1. USA	15.291	34.186	14.991	27.649	-1,96	-19,12
2. Russian Fed.	761	845	9.263	5.088	1117,17	501,96
3. England	7.020	16.304	6.206	12.329	-11,59	-24,38
4. France	5.529	14.747	5.735	11.639	3,72	-21,08
5. Germany	5.700	13.066	5.263	8.986	-7,67	-31,23
6. Australia	3.810	8.264	3.729	6.126	-2,13	-25,87
7. The Netherlands	2.334	4.955	2.280	3.860	-2,31	-22,09
8. Canada	1.363	3.190	2.058	3.787	51,04	18,73
9. Israel	1.432	3.288	1.669	2.946	16,55	-10,40
10. Spain	1.543	3.671	1.612	2.566	4,52	-30,12
TOTAL	55.350	126.169	68.128	107.852	23,09	-14,52

Source: Undersecretariat for Foreign Trade.

According to the export degree which was put into effect as of August 8th., 1993, dried apricot exports from Turkey is free, however it is controlled by the Government to ensure compliance with the standards.

The two important quality criteria of dried apricots with regard to this standard are, moisture and SO₂ contents, which should not exceed 25 % and 0,25 % by weight respectively. The USA has been the primary importer country of Turkish dried apricots with a share of about 25,6 %. Russian Federation, England, France and Germany are the following important export destinations of Turkish dried apricots in 2000. These top five countries make up for nearly 61% of the Turkish dried apricot exports in 2000.

7.4. Hazelnuts

Today major edible nuts produced and subject to world trade are groundnuts (peanuts), walnuts, almonds, hazelnuts and pistachio nuts. As far as the quantity subject to world trade is concerned, hazelnuts are the second most important commodity throughout the world. Most of them are exported through Istanbul or Giresun. About 1% of total production of nuts was exported from Izmir Port.

Production:

The average annual hazelnut production during the past five years in Turkey has been approximately 476,000 tons in-shell. With its outstanding position, Turkey leads the field among hazelnut producing countries. Turkey realizes almost 70-75 percent of the world's hazelnut crop.

Turkish Hazelnut Production (In-Shell) by Years

Years	Production(1000Tons)
1996	446
1997	410
1998	580
1999	530
2000	470

Source: State Institute of Statistics

Turkish hazelnuts are classified as Giresun or Levant quality and they are divided into two groups as round and pointed according to shape and other properties. Hazelnuts have been exported from Turkey to other countries for the last six centuries. In 1950's the hazelnut was the "leader" in Turkey's foreign currency earnings followed by cotton, sultanas and figs. Today, revenues from hazelnut exports are still at a very important level. Turkey is accepted as the largest exporter of hazelnuts, supplying about 85 percent of the world hazelnut exports. Being the largest producer and exporter, Turkey naturally plays an important role in defining world hazelnut prices. Hazelnuts are marketed in many forms including processed hazelnuts. Shelled hazelnuts and processed kernels however, constitute more than 99 percent of total Turkish exports (in terms of value).

Turkish Hazelnut Exports (Incl. Processed Kernels)
by Years (Value (V): \$ US 1.000, Quantity (Q): Tons)

Years	Q	V
1993	198 044	559 863
1994	200 602	716 608
1995	244 719	770 405
1996	193 533	608 096
1997	190 170	871 531
1998	193 376	834 481
1999	176 117	668 845
2000	160 863	543 014

Source: Undersecretariat For Foreign Trade

Turkish Hazelnut Exports by Year (Value (V): \$ US 1.000, Quantity (Q): Tons)

Country	1998		1999		2000	
	Q	V	Q	V	Q	V
1. Germany	77369	324516	85110	372831	64272	210938
2. Italy	21346	86494	20380	88878	17552	56188
3. France	20274	87103	15199	68665	16745	57549
4. UK	8910	39553	8718	40502	7440	27636
5. The Netherlands	9688	42552	8377	38852	8567	30060
6. Bel-Lux	11108	45817	7474	32632	10840	35720
7. Switzerland	9207	38728	9717	42628	7485	24964
8. Austria	4459	18309	3344	14338	4033	13526
9. Spain	5654	19342	3990	12751	3555	12159
10. Greece	4153	11761	4930	13100	2346	7133
11. Sweden	2115	9948	2216	10943	2214	8394

Source: Undersecretariat for Foreign Trade

The majority of exports are shipped to European Union countries. Almost 86 percent of total exports are directed to the EU. Germany is the leading importer of processed and unprocessed Turkish hazelnuts with a share of approximately 45 percent of the total, followed by Italy, France, the United Kingdom, the Netherlands, Bel-Lux, Switzerland and Austria.

Examining Turkey's processed hazelnut exports over the past five years, it may be observed that there is a steady increase in export volume. Turkey intends on continuing to expand its export of processed hazelnuts, while at the same time

introducing new processed forms to the world markets. Turkey which was exporting mainly shelled and kernel forms to 32 countries before 1980, now exports hazelnuts and the various processed forms of hazelnuts to 75 countries.

8. Irradiation as an alternative to methyl bromide fumigation

Apparently the only alternative to methyl bromide fumigation, when banned (i.e. in 2004 by Turkey and in 2005 by developed countries) is irradiation. A small quantity could be fumigated by phosphine. But phosphine is not a broad-spectrum fumigant. Its action is very slow (at least 72 hrs for a batch, in case of MB only few hours) and is highly corrosive. Large number of insects has developed resistance against it. On the other hand irradiation process is broad spectrum. It passes through the product uniformly and 100% insect kill is achieved. Insect does not develop resistance against radiation. Its application for dried fruits and nuts needs to be approached with the HACCP concept in the handling and processing lines. Good Manufacturing Practice (GMP) and Integrated Pest Management (IPM) plan have to be practiced in pre-harvest condition. If the above conditions are achieved, one irradiation treatment might be sufficient and useful just after final packaging to ensure disinfestations.

Cost of irradiation in comparison with MeBr

The latest fumigation costs amounts to 1 to 3.5 USD/ton of product service charge demanded by irradiation facility could be 10 times higher than the current cost of fumigation. After 2005 US producers will not be interested to produce uneconomic quantities used for phytosanitary treatments in international trade.

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