



report

# Development of radiation processing in Latin America and the Caribbean Region



## FOREWORD

This document endeavours to provide an overview of radiation processing using isotope and accelerator technology in Latin America and the Caribbean region.

Every effort has been made to ensure the accuracy of the contents, but the information from this large and diversified region is fragmented. Please inform the iia of any errors and omissions so that we can improve this report.

## THANKS

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## Uses of Irradiation

For more than half a century, radiation technologies have been used in Latin America and the Caribbean region. The first experiments typically took place in nuclear research institutes using self-shielded cobalt-60 or cesium-137 irradiators to explore potential applications. The limitations regarding the size of samples or the volumes that could be processed sometimes led to the construction of small and medium size panoramic irradiators with a bunker that could accommodate 0.1 to 1 MCi of cobalt-60. More rarely these institutes acquired small accelerators. Often with the assistance of the International Atomic Energy Agency (IAEA), these institutes actively promoted the development of radiation processing and were most successful where economic development and private investment capacity had reached a sufficient level. Radiation processing has reached a significant commercial scale in Brazil, Mexico, and Argentina, the three largest economies in the region in terms of GDP. They also happen to be the three countries where there are nuclear power plants in operation. Costa Rica, Puerto Rico and the Dominican Republic are particular cases where government policies attracted foreign investment and turned the country into major medical device manufacturing locations, which in turn generated investment in radiation sterilization. Elsewhere, the pattern is one of small government-owned irradiation facilities providing service on a semi-commercial scale to process modest volumes of products for third parties, typically spices and medical devices. Several manufacturers of cables and wires also have accelerators in-house to cross-link their products.

Food irradiation is the application that initially generated the most enthusiasm given its theoretical potential to improve food security. Several decades later, only small volumes of food are irradiated in the region, mostly to improve food safety and biosecurity. Developments having taken place outside the region and some local research led to the progressive adoption of the most common applications of irradiation, namely enhancement of polymers, sterilization of single-use medical devices, microbial control of pharmaceutical, veterinary, and packaging products. Secondary applications include conservation of cultural assets, coloration of gems and sterilization of biological tissues.

A significant recent development is the use of irradiation as a phytosanitary measure for fresh fruit and vegetables in Mexico, which is favored by the proximity of the US market and strict US biosecurity rules. Other countries in the region also wish to adopt phytosanitary irradiation but do not have adequate irradiation facilities yet.

*Table 1: Quantities of fruits irradiated for phytosanitary purpose in Mexico*

tons	2017	2018	2019	2020	2021
Starfruit	51	70	92	120	147
Chile manzano	1,100	1,168	1,088	1,285	1,510
Pomegranate	171	343	61	218	177
Guavas	13,376	12,264	12,301	11,622	13,300
Figs	109	412	443	445	696
Pomelos					1,620
Mandarine			12	85	308
Mango	1,939	110	5,801	10,043	11,803
Orange				1495	3,760
Pitahaya	342	378	472	596	755
Dragon fruit	173	442	510	1125	965
TOTAL	17,261	15,187	20,787	27,034	35,044

Source: SENASICA

Finally, the implementation of the Sterile Insect Technique initiated more the twenty years ago has been a success story. Based on the release of insects rendered sterile by irradiation, the resulting control of wild populations of invasive pests has benefited agriculture in many areas of the region.

# Brazil

Brazil, the largest regional economy, currently has the largest number of commercial accelerators and gamma irradiators. The Institute of Energy and Nuclear Research (IPEN) played an important role in the promotion and development of radiation processing in the country, where crosslinking of polyethylene for insulation of wires and cables and sterilization of medical devices are the main commercial applications.

## 1.1 Commercial service facilities

### Sterigenics

In 2015, Sterigenics (now part of Sotera Health) acquired the three irradiation facilities of Companhia Brasileira de Esterilização (CBE) having a total processing capacity of 12 million cubic feet. One of the CBE facilities was originally owned and operated by a company named Embrarad. Founded in 1978 in the region of Sao Paulo, CBE had been the pioneer of gamma sterilization before operating the largest electron accelerator (Rhodotron TT200) in Latin America. Sterilization of medical devices is the main business.

### Acéletron (Irradiação Comercial)

Acéletron (Irradiação Comercial), located in Rio do Janeiro, provides various irradiation services using two 10 MeV linear accelerators of 18kW each one. This facility treats medical supplies, cosmetics, herbal medicines, polymers, and food such as spices, dried fruits, and dried vegetables.

The company Tech-Ion operates a gamma irradiator in Manaus for a few years. When its activities ceased the sources were transferred to IPEN. In December 2016, United Corporation for Innovations (UIC), a subsidiary of the Russian state nuclear corporation Rosatom, and Brazilian company CK3 signed a memorandum of understanding for the development, construction, and operation of an Irradiation Centre in Brazil, but the project seems to have been delayed.

## 1.2 In-house facilities

### Johnson and Johnson

The company operates a Nordion irradiator (JS-6500) with a design capacity of 1 MCi since 1978. Johnson & Johnson is the world's largest and most broadly based healthcare company and uses this irradiator for product sterilization.

### Cables and wires manufacturers

The table below summarizes the on-site use of electron beam irradiation, mostly to cross-link polyethylene.

Company / organization	Location	Characteristics
Acome (cables)	Irati, Paraná	Radiation Dynamics – 0.5 MeV
Bridgestone - Firestone (tyres)	Camaçari, Bahia	Energy Science, 0.3 MeV
Cryovac Brasil (packaging)	Vila Leopoldina, São Paulo	0.5 MeV
Curwood Itap (packaging)	Guarulhos, São Paulo	RPC Industries, 0.3 MeV
Michelin (tyres)	Rio de Janeiro	
Prysmian (cables)	Sorocaba, São Paulo	Radiation Dynamics – 1.5 MeV
Sumimoto Rubber (tyres)	Fazenda Rio Grande	
Unipac Embalagens (packaging)	Limeira, São Paulo	Energy Science, 0.3 MeV

### 1.3 Irradiators in research institutions

#### **Institute of Energy and Nuclear Research/ Instituto de Pesquisas Energéticas e Nucleares (IPEN)**

IPEN has extensive research programs in radiation technology including enhancement of materials, synthesis of new materials, preservation of cultural heritage, sterilization of biomaterials, tissue irradiation, food irradiation and environmental applications. IPEN has a range of irradiation equipment:

- Cobalt-60 gamma irradiator

The irradiator is fully automated with a 1 MCi capacity and was designed and built by IPEN for a semi-commercial irradiation service activity. Applications include sterilization of medical supplies, prostheses and tissues, conservation of cultural heritage, modification of polymeric materials, color change in gems and quartz, etc.

- Electron accelerators

IPEN has two 1.5 MeV electron accelerators (97 and 37 kW). One is used for irradiation of cables, wires, and heating blankets with the second used for mostly for research and development.

#### **Centro de Desenvolvimento da Tecnologia Nuclear (CDTN - Nuclear Technology Development Center)**

Located in Belo Horizonte, this institute has operated a Nordion type GB-127 (GammaBeam) multipurpose panoramic dry storage irradiator since 2004. Given its small cobalt-60 load, it is mainly used for research with a limited commercial activity in the classic applications of irradiation.

#### **Centro da Energia Nuclear na Agricultura (CENA/USP - Center for Nuclear Energy in Agriculture)**

Located in Piracicaba (São Paulo), this small gamma irradiator is used for the sterilization of male insects for the application of the sterile insect technique. Research is on-going to fight the Zika virus by controlling the spread of the mosquito *Aedes aegypti*.

# Mexico

With an estimated 3 million curies of cobalt-60 installed in three main plants gamma irradiation is predominant in Mexico, but accelerators are now also being installed. About half of the installed gamma irradiation capacity is used to irradiate dried, frozen and fresh food.

## 2.1 Commercial service facilities

### **Sterigenics**

Sterigenics, a Sotera Health company, has operated a Nordion irradiator with a 5 MCi cobalt-60 capacity in Tepeji del Rio, Hidalgo since 2000. Sterilization of medical devices is the main business. In 2008 the plant was certified by USDA-APHIS to irradiate fresh fruits to export to the USA for phytosanitary purpose, but this has been a marginal and irregular activity.

### **Benebion - Phytosan**

This facility started operations in July 2011 in San Luis Potosí near the US border. The main objective was to treat fresh fruits and vegetables on their way to the USA for phytosanitary purpose. The gamma irradiator was designed by Nordion and has a capacity of 1.5 MCi. To date the facility is used for a range of non-phytosanitary applications such as the treatment of dried food and medical supplies.

### **Avantti Medi Clear**

This sterilization facility is strategically located close to the Medical Cluster in Otay (San Diego) at the border between the USA and Mexico, a few miles from the Tijuana International Airport. It started operations in March 2017.

The facility includes a 10 MeV - 35 kW vertically mounted electron accelerator from Mevex. It focuses on sterilization of medical devices, but also treats spices and food for pets.

### **E-Beam Agroindustrial**

This electron beam facility is in the final phase of implementation in Aguascalientes and is expected to start operation in 2022. The project intends to focus on food irradiation including phytosanitary irradiation of guavas.

Another phytosanitary irradiation facility, probably an accelerator, is being considered near the Pacific port of Manzanillo in the state of Colima.

## 2.2 In-house facilities

### **ICU Medical**

ICU Medical is a US medical manufacturer specialized in infusion therapy. A Precision Scan SB108, 10MeV - 15kW accelerator was installed on the Ensenada manufacturing site.

## 2.3 Irradiators in research institutions

### **National Institute for Nuclear Research (ININ – Instituto Nacional de Investigaciones Nucleares)**

Operating since 1980 and located in Toluca near Mexico, the ININ irradiator of Nordion design has nearly one million curies of cobalt-60 and provides irradiation services on a commercial scale serving more than 300 companies. Product processed include dehydrated food, spices, medical supplies, cosmetics, and surgical clothing.

### **Universidad Nacional Autónoma de México (UNAM - National Autonomous University of Mexico)**

Since 1986, the Institute of Nuclear Sciences of this university has a small irradiator (Gammabeam 651) for research and processing of small volumes of material for the pharmaceutical and cosmetic industry.

### **MOSCAMED**

The MOSCAMED program aims at stopping the spread of the Mediterranean fly *Ceratitis capitata* in and along the Chiapas state by protecting 1.9 million hectares with more than 250 types of fruit and vegetable products that host the harmful fly and allows growers to sell larger volumes of higher quality produce. Irradiation is used to induce sexual sterility in the male flies by exposing the pupae to gamma irradiation. To produce sterile males, eggs are imported from a mass rearing facility in Guatemala from which more than 1 billion sterile flies can be produced each week. With this quantity, it is possible to contribute both to the maintenance of the Mexico-Guatemala border containment barrier; as well as advancing gradual eradication of the Mediterranean fly in Guatemala.

### **SENASICA**

The SENASICA irradiation facility had several self-shielded units, but the success of the project led SENASICA to start a higher capacity irradiator (Gamma Fit and JS7400 from Nordion) in 2019.

# Argentina

3.1

## 3.1 Commercial service facilities

### IONICS

The origin of the IONICS irradiation plant dates to the late 1980s, when a Belgian group invested in the development of irradiation technology in Argentina with the help of the National Atomic Energy Commission (CNEA). IONICS operates two irradiators containing 1.2 and 1.5 MCi on a site located 30 km North of Buenos Aires. The second unit started operation in late 2018. The products treated include raw materials, finished and semi-finished products and packaging for the food, cosmetics, pet treats, pharmaceutical, veterinary, agricultural, and medical sectors. IONICS irradiates substantial volumes of growth media and envelopes for the multiplication of *Bradyrhizobium japonicum*, a bacterium that will form nodules on soybean roots and allow the plant to consume nitrogen from the air instead of extracting it from the soil.



The Ionics facility

### **CNEA semi-industrial irradiation plant (PISI), CNEA**

Operating at the Ezeiza Atomic Center since 1970, the Category IV gamma irradiator has a 1MCi cobalt-60 capacity. The facility processes a wide range of products including dried foods and spices, pet foods, healthcare products and biological tissues, labware and packaging, and raw materials for pharmaceuticals and cosmetics. The irradiator is also used for research projects in conjunction with the dosimetry, microbiology, entomology, and materials laboratories in the Applications Development Department.

A 13 kCi Gammacell 220 research Irradiator recently upgraded and replenished by Dioxitek is also available for research.

CNEA developed a mobile irradiation unit (IMO-I) consisting of a 10kCi gamma irradiator mounted on a semi-trailer used mainly to irradiate fruit fly pupae for the application of the sterile insect technique currently placed in the province of San Juan. Another mobile irradiator designed by the company INVAP (IMCO 20) is also used to irradiate fruit fly pupae in the province of Mendoza with four cobalt-60 units of 5,000Ci each.

### **3.2 Production of cobalt-60 - Dioxitek**

Argentina is one of a small number of cobalt-60 producers with Canada, Russia, China, and India. Among the three nuclear power plants in operation in the country is the Embalse Rio Tercero (Córdoba) reactor of 680 MWe in operation since 1983. It is a CANDU 6 reactor that produces approximately 3.5 MCi cobalt-60 per year. The sealed sources are encapsulated in a hot cell at the Ezeiza Atomic Center by Dioxitek, a state company (Ministry of Energy, CNEA and Province of Mendoza) created in 1997.

# Costa Rica

Costa Rica has one of the highest standards of living in Central America. Many foreign companies have been attracted by the Free Trade Zones where they benefit from investment and tax incentives. Medical device manufacturing has become a specialty of the country with more than 80 companies employing over 40,000 people.

## 4.1 In-house facilities

### **Baxter International**

Baxter International has been present in Costa Rica since 1987. The Cartago plant has 1200 employees and is Costa Rica's fourth-largest exporter with finished goods sent to the USA and 60 other countries across the globe. Most of its production is exported to the US. The company uses a 10 MeV – 15 kW accelerator for sterilization.

### **ICU Medical**

ICU Medical has been present in Costa Rica for 20 years and has 2,500 employees on the Heredia site. The production capacity was expanded in 2021 and a 10 MeV - 15 kW linear accelerator was installed for in-house sterilization.

### **Steris**

The development of medical manufacturing in the country eventually attracted specialized contractors. In 2009 Beam One, now part of Steris, installed a 10 MeV – 18 kW accelerator from Titan Corporation in Alajuela. Steris also operates an ethylene oxide sterilization facility.

### **Pfizer (Hospira)**

Over the years, Hospira, the largest producer of generic injectable pharmaceuticals in the world (now part of Pfizer) expanded its operation in Costa Rica and installed an electron accelerator that has now been dismantled.

## 4.2 Irradiators in research institutes

Costa Rica has several irradiators in research institutes:

- In 2015 the Technological Institute of Costa Rica (Center for Research and Extension in Materials Engineering) was equipped with a cobalt-60 self-shielded irradiator from Hungary.
- The Ministry of Agriculture and Phytosanitary Services has RAD-Source RS2400 X-Ray irradiator where samples can be irradiated in 5 cylinders of 3 liters each.

# Other Countries

## 5.1. Bolivia

The Bolivian Nuclear Energy Agency (ABEN) constructed a multipurpose gamma facility in El Alto city with the support of the Russian company Rosatom. The facility is expected to start operation in 2022 with an initial load of 200 kCi. A smaller unit to be used for research purpose is also planned.

## 5.2 Chile

Chile had an early start in radiation processing, but the technology never reached an industrial scale. A Marsh gamma irradiator with dry storage was installed in 1978 at the Aguirre Center of Nuclear Studies and later upgraded. The products that are processed are mostly food (dehydrated and frozen) and medical supplies. Additionally, the Chilean Nuclear Energy Commission (CHEN) has three self-shielded gamma irradiators used for experiments.

In the Arica Parinacota region, the Agricultural and Livestock Service operates a small irradiation at the Sterile Insect Production Center (CPIE).

Following a USDA-APHIS ban on Chilean plums treated by methyl bromide, during the 2021-2022 season, 200 tons of plums exported to the US were irradiated at the Gateway plant in Mississippi. This episode has rekindled the interest to create a commercial irradiation plant in Chile.

## 5.3 Colombia

The Colombian Geologic Service has operated a gamma irradiator with a 100 kCi cobalt-60 capacity since the 1980s. It was initially used for research on effects of irradiation of materials. The facility was refurbished in 2021 and is now used for sterilization and decontamination purposes.

## 5.4 Cuba

The Center for Technological Applications and Nuclear Development (CEADEN) has two irradiators. The first one, an ISOGAMMA LCC irradiator has a design capacity of 24 kCi of cobalt-60 and was installed in 2012. The second unit is a PX-γ-30 irradiator that was installed in 1994. Both irradiators are used for research purposes.

The Institute of Investigations for the Food Industry (IIIA) has a gamma irradiator with a capacity of 110 kCi in which small quantities of dried and dehydrated food products are treated.

The National Center of Agricultural Health (CENSA) also has an ISOGAMMA LCCo Irradiator with a design capacity of 24 kCi that was installed in 2017. It is used for research purposes.

## 5.5 Dominican Republic

In Haina, Fenwall International (part of Fresenius Kabi) manufactures and exports aphaeresis systems for the collection of plasma and platelets, as well as medical devices for the separation of blood. They operate two electrons beam irradiators: a 10MeV - 15kW accelerator from Surebeam and a 650keV, 0.094mA accelerator from Varian.

## 5.6 Ecuador

The National Polytechnic School in Quito (EPN – Escuela Politécnica Nacional) has two irradiation facilities. The first one is a cobalt-60 category IV panoramic gamma irradiator established in 1981 with a design capacity of 150 kCi. This unit has been disused for some time because the source activity is very low but a source replenishment of 50 kCi should take place with the support of IAEA in 2022. The second unit is a Russian accelerator of the ELU-6U type (6-10 MeV). It is mostly used for research and development, commercial irradiation of medical supplies, spices, and herbs as well as wires and electric cables

The Undersecretariat of Control and Nuclear Applications of MERNNR has a self-shielded gamma irradiator for research and irradiation of samples for third parties. The dose rates are now low.

Ecuador has recently worked with USDA-APHIS to export granadilla and passion fruit that would be irradiated on arrival in the US.

## 5.7 Guatemala

Guatemala has a JL Shepherd self-shielded irradiator with a capacity of 20 kCi of cobalt-60 for the sterilization of insects in the large mass rearing facility in the world. This facility is part of the MOSCAMED program developed as a Cooperation Agreement between the Governments of Guatemala, the United States, and Mexico for the prevention, detection, suppression, and eradication of economically important fruit flies.

## 5.8 Panama

The Panama-United States Commission for the Eradication and Prevention of the Screwworm in Cattle (COPEG) was created in 1994 with the aim of avoiding economic damage caused by the cattle screwworm (*Cochliomyia hominivorax*). A mass insect rearing facility can produce around 20 million sterile pupae per week. Sterilization was initially done in two X-ray machines that were replaced in 2009 by two JL Shepherd gamma irradiators with a capacity of about 20 kCi.

## 5.9 Peru

In 1995 the gamma panoramic irradiator of the Peruvian Institute of Nuclear Energy (IPEN-Instituto Peruano de Energía Nuclear) started operations in Santa Anita (Lima) as a state-owned facility. This facility was later transferred to the commercial enterprise Immune SA who then offered irradiation services to third parties on a modest scale.

IPEN also has three self-shielded Category I units: one Gammacell-220 with cobalt-60 recently replenished to 24 kCi with the support of IAEA, and two with cesium-137.

The National Agricultural Health Service (SENASA) has three small cobalt-60 irradiation units: the panoramic category II irradiator (Gammabeam 127) and two self-shielded category I Shepers units. They are all used for the Sterile Insect Technique and some research and development.

Peru has shown interest in phytosanitary irradiation for several years. A work plan and equivalence agreement that allows the marketing of irradiated fresh produce was signed between Peru and the United States. Fresh products exported to the US are currently irradiated upon arrival in the US. In 2017, the Government of Peru funded pre-investment studies for '*the creation of an agro-industrial irradiation service for post-harvest treatment*'. This led to a plan to create two phytosanitary irradiation plants to be funded by the government. The plants would be of the Underwater Category III and similar to the two operated by Pa'ina in Hawaii and Gateway in Mississippi.

### 5.10 Puerto Rico

STERIS has operated a Nordion gamma irradiator in Vega Alta since 1982 and offers sterilization services to the medical industry.

### 5.11 Uruguay

Since 2010, the Technology Laboratory of Uruguay (LATU) operates a pilot irradiator with a capacity of 80 kCi. The machine was imported from Argentina and is used for research and test purposes.

The University of the Republic of Uruguay (UDELAR) also has a small irradiator (3 kCi) used for research. A 10kCi self-shielded unit is used to sterilize biological tissues at the National Bank of Organs and Tissues.

### 5.12. Venezuela

Located at the Venezuelan Institute of Scientific Investigations (IVIC), a Nordion JS-9500HD cobalt-60 facility PEGAMMA started operations in 2004. Small quantities of spices, dried, pet food and medical devices are treated. Additionally, there is a small customized JS-9500 irradiator for research and development.

## Conclusion

The use of irradiation in Latin America and the Caribbean region has reached a significant scale in a limited number of countries.

The reason that radiation processing has not yet developed as much as in other regions of the world may be the result of different factors:

- The absence or low production of products that require irradiation, in particular medical devices, packaging or advanced polymers;
- A limited investment capacity in the private sector, radiation processing being a rather capital-intensive industry. This is even more difficult where there is political instability or inadequate legal framework.
- The difficulties that seem to exist to transfer knowledge from the research sector to the commercial sector.

The region could benefit from the use of food irradiation, but no projects have come to fruition. Beside the lack of harmonization of food irradiation across the region, like elsewhere, the focus on consumer acceptance rather than on retailers' acceptance has often paralyzed initiatives.

However, the use of irradiation as a phytosanitary measure for exported produce in Mexico shows the ability to seize opportunities. Mexico is the number one exporter of irradiated fresh fruit and vegetables in the world. Finally, the adoption of the Sterile Insect Technique in several countries is a success story that makes the region a leader for this application.

### **ALATI**

#### **Asociación Latinoamericana de Tecnología de la Irradiación**

(Latin America Association of Irradiation Technology)

An affiliate of iia, ALATI is a non-profit Association that promotes the exchange of scientific and technological knowledge on irradiation, with application to the Latin American reality. The Association aims to bring together irradiators and suppliers of the sector to promote its development in Latin America, representing and defending the interests of the industry in the market and before the states.

[www.alati.la](http://www.alati.la)

## Summary Tables

### Providers of commercial irradiation services

#### *Gamma irradiators ( $\geq 100$ kCi installed)*

Country	Company / organization	Location	Design capacity (MCi of cobalt-60)
Argentina	Ionics	Buenos Aires	2 units – 1.2 MCi and 1.5 MCi
	CNEA	Buenos Aires	1 MCi
Bolivia	ABEN	El Alto	1 MCi
Brazil	IPEN	São Paulo	1 MCi
	Sotera Health (Sterigenics)	São Paulo	3 MCi
	CDTN	Belo Horizonte	60 kCi
	CENA/USP	Piracicaba, São Paulo	2 MCi
Chile	CCHEN	Pudahuel, Santiago	1 MCi
Colombia	Colombian Geological Service (SGC)	Bogotá	100 kCi
Cuba	Food Research Institute for Industry	La Habana	100 kCi
Mexico	Sterigenics	Hidalgo	5 MCi
	Benebion	San Luis Potosí	1.5 MCi
	ININ	Toluca	1 MCi
	UNAM	Mexico City	200 kCi
Peru	PIMU	Lima	500 kCi
Venezuela	PEGAMMA	Miranda	3 MCi

#### *Accelerators (high and medium energy > 5 kW)*

Country	Company / organization	Location	Characteristics	Applications
Brazil	IPEN	São Paulo	1.5 MeV (2)	Research
Brazil	Sterigenics	São Paulo	Rhodotron	Medical sterilization
Brazil	Acéletron	Rio do Janeiro	Surebeam L3 10 MeV (2)	Medical supplies Cosmetics Dehydrated fruits and vegetables
Costa Rica	Steris	Alajuela	Linac 10 MeV – 15 kW	Medical sterilization
Ecuador	Escuela Politecnica	Quito	ELU-6U, 6-10 MeV	Dehydrated food Medical supplies Plastics Spices and herbs
Mexico	Avanti Mediclear	Tijuana	Linac 10 MeV	Medical sterilization
Puerto Rico	Steris	Vega Alta	Linac 10 MeV	Medical sterilization
Dominican Republic	Titan Corporation	Santo Domingo	Surebeam 10 MeV	Food irradiation Medical sterilization

## In-house irradiation facilities

### Gamma irradiators

Country	Company / organization	Location	Characteristics	Applications
Brazil	Johnson & Johnson	Sao Paulo	1 MCi	Medical sterilization
Puerto Rico	Johnson & Johnson	Guaynabo		Medical sterilization

### Accelerators (> 300 keV)

## Medical sterilization

Country	Company / organization	Location	Characteristics
Costa Rica	ICU Medical	Heredia	Linac 10 MeV
	Baxter	Cartago	Linac 10 MeV
Mexico	Avantti	Tijuana	Linac 10 MeV
	ICU Medical	Mexico	Precision Scan SB108, 10MeV

### Cross-linking (cables and wires, packaging)

Country	Company / organization	Location	Characteristics
Brazil	Acome (cables)	Paraná	Radiation Dynamics – 0.5 MeV
	Bridgestone (tyres)	Bahia	Energy Science, 0.3 MeV
	Cryovac (packaging)	Sao Paulo	0.5 MeV
	Curwood Itap (packaging)	Sao Paulo	RPC Industries, 0.3 MeV
	Michelin (tyres)	Rio de Janeiro	
	Prysmian (cables)	Sao Paulo	Radiation Dynamics – 1.5 MeV
	Sumimoto Rubber (tyres)	Fazenda Rio Grande	
	Unipac Embalagens (packaging)	Sao Paulo	Energy Science, 0.3 MeV
Mexico	Condumex (cables)	Mexico City	Linac IBA 1.5 MeV, 15 kW



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