

## Supporting Document 1 (Approval)

### Food Irradiation in Australia, New Zealand and other countries

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## 1.0 Introduction

Irradiation is a physical treatment in which food is exposed to a defined dose of ionising radiation<sup>1</sup>. It is used on food in more than 40 countries worldwide. Irradiation of food can control insect infestation, reduce the numbers of pathogenic or spoilage microorganisms, and delay or eliminate natural biological processes such as ripening, germination or sprouting in fresh food. Like all preservation methods, irradiation should supplement rather than replace good food hygiene, handling, and preparation practices (Groth, 2007; Arvanitoyannis, 2010; Follett and Weinart, 2012).

This supporting document serves to provide:

- an overview of the current permissions and consumption of irradiated foods in a range of countries which supports the general safety of irradiated foods in other countries
- current risk management of food irradiation in Australia and New Zealand and the responsibilities of FSANZ and other authorities in maintaining the safety of irradiated foods
- general information on consumer awareness, understanding and acceptance of food irradiation.

## 2.0 Worldwide permissions and consumption of irradiated foods

Permissions to irradiate a food vary considerably in different parts of the world and they are based on either a case-by-case or a generic approach (without any foods specifically listed) as adopted by Codex (see Table 1).

**Table 1: Summary of specific countries permissions for irradiated foods**

Country	Food	Dose range (kGy)
European Union	Dried aromatic herbs, spices and vegetable seasonings	10
Canada <sup>2</sup>	Onions	0.15
	Potatoes	0.15
	Wheat, flour	0.75
	Whole or ground spices and dehydrated seasonings	10
	Fresh Beef to control microbial decontamination	1.5 to 4.5
	Frozen ground beef to control microbial decontamination	2.0 to 7
	Poultry to control microbial decontamination	1.5 to 3
	Shrimp and Prawns to control microbial decontamination	1.5 to 5
	Mangoes (Disinfestation)	0.15 to 1

<sup>1</sup> [http://www.who.int/ionizing\\_radiation/about/what\\_is\\_ir/en/index.html](http://www.who.int/ionizing_radiation/about/what_is_ir/en/index.html)

<sup>2</sup> In Canada, permission to irradiate beef, poultry, shrimp, prawns and mangoes are still in the process of Final Approval.

Country	Food	Dose range (kGy)
USA <sup>3</sup>	Fruit and vegetables (to control insects and other arthropods and to inhibit maturation (e.g., ripening or sprouting))	1
	Poultry to control foodborne pathogens	4.5
	Beef (Refrigerated) to control microbial decontamination	4.5
	Beef and poultry (Frozen) to control microbial decontamination	7
	Dry or dehydrated aromatic substances (e.g., spices and seasonings) to control microorganisms	30
	Fresh foods to control microorganisms	1
Australia/New Zealand	Eggs for control of salmonella	3.0
	Herbs, spices and herbal infusions (Disinfestation or decontamination)	2 to 30
	Tropical fruits (mango, breadfruit, carambola, custard apple, litchi, longan, mangosteen, papaya and rambutan) to control pests of quarantine concern	0.15 to 1
Thailand	Persimmons to control pests of quarantine concern	0.15 to 1
Thailand	Selected tropical fruits (mango, mangosteen, lychee, longan, rambutan and pineapple) for disinfestation	0.4
Philippines	Mangoes for disinfestation	1
	Onions for sprout inhibition	0.3 to 1
	Garlic for disinfestation	0.3 to 1
Vietnam	Seafood for decontamination	2 to 7.5
	Frozen Fruits for decontamination	2 to 3
	Dragon fruits to control pests	1
Indonesia	Mango to control insects	0.75
	Papaya, mushroom, tomatoes, bananas and broccoli for shelf-life extension	1-2
	Fresh meat and chicken for decontamination of pathogens	5-7
India	Fresh meat and chicken for decontamination of pathogens	0.25 to 0.75
	Spices for decontamination	2.5 to 4
	Raisins, figs and dried dates to control insects	6.0 to 14
	Fresh seafoods for shelf-life extension	0.25 to 0.75
		1 to 3

The 1983 Codex standard for irradiated foods (revised 2003) requires that the maximum absorbed dose to a food should not exceed 10 kGy, except when necessary to achieve a legitimate technological purpose<sup>4</sup>. No specific foods are mentioned, although the standard states:

- *The irradiation of food is justified only where it fulfils a technological need or where it serves a food hygiene purpose and should not be used as a substitute for good manufacturing practices.*

International Standards for Phytosanitary Measures 18 (ISPM No. 18) – *Guidelines for the Use of Irradiation as a Phytosanitary Measure*, International Plant Protection Convention, 2003 (ISPM, 2003) provides technical guidance on the specific procedures for the application of ionising radiation as a phytosanitary treatment for pests or articles.

The American Society for Testing and Materials, *ASTM F1355-06 Standard Guide for Irradiation of Fresh Agricultural Produce as a Phytosanitary Treatment* (ASTM, 2006) also provides for procedures for the radiation disinfestation of fresh fruits as a quarantine treatment.

## 2.1 Worldwide consumption of irradiated foods

A survey in 2005 showed a total of 405,000 tons of food was irradiated world-wide (Kume et al 2009) but this was an underestimate as many companies and jurisdictions did not fully reveal the amounts treated for commercial reasons.

<sup>3</sup> In the USA, food irradiation is considered as a food additive under their legislation.

<sup>4</sup> [http://www.codexalimentarius.net/download/standards/16/CXS\\_106e.pdf](http://www.codexalimentarius.net/download/standards/16/CXS_106e.pdf)

The annual amount treated has grown since 2005 due to the increase in the number of irradiation facilities in China and Asia generally.

Almost half the food irradiated comprises herbs, spices and condiments. Together with dried vegetables, these foods and food ingredients were 46% of the total tonnage of food irradiated, according to Kume et al (2009), followed by garlic and potatoes (22%), grain and fruit (20%), meat and seafood (8%). According to Bustos-Griffin et al (2012), horticultural produce irradiated for sprout inhibition includes 88,200 tons per year for potatoes (Japan, China and India) and onions (China and India).

Potatoes have been irradiated on the northernmost island of Japan (to overcome a special supply problem) since 1973. Annual amounts have fallen from an original 15,000 tons per year to approximately 8,000 tons (ICGFI 1995, Kume et al 2009).

Garlic is irradiated in increasing amounts in China, with the total amount uncertain but possibly several thousands of tons per year. Some specialty foods that are irradiated (ICGFI 1995) are a fermented sausage (Thailand) and frog legs (Belgium, France and Netherlands totalling 2,551 tonnes in 2007 (EC 2009)).

The overall list of foods other than minor ingredients that are being irradiated is substantial including minced beef, chicken, sweet potato, potato, garlic, many fresh fruits, dried fruits and vegetables, and dried fish. Some 30 countries have food irradiation facilities (IAEA 2012). China is currently the biggest user of irradiation, with significant usage in the USA, Belgium, Vietnam and South Africa.

Despite new applications of food irradiation being essentially barred in the EU since 1999, food is still being irradiated, for example, 8,154 tons in 16 approved irradiation facilities in eight Member States in 2007 (EC 2009). The foodstuffs irradiated include: dried aromatic herbs, spices and vegetable seasonings, fresh and dried vegetables, dried fruits, various dehydrated products, starch, poultry meat, other types of meat, fish and shellfish, frog legs and frog parts, shrimps, egg white, egg powder, dehydrated blood, gum Arabic.

The USA is the second greatest user of food irradiation by volume after China. No consumption data are available, but the amounts sold into the retail trade are known approximately. As the foods have been retailed for several years in a few thousand retail outlets (Eustace & Bruhn 2006), it may be presumed that retailers are actually selling most of the product. Since 2000, the USA has been retailing irradiated minced beef, chicken and fresh fruits in significant quantities and about 70-80,000 tons of herbs, spices and condiments are also treated. Annual amounts have varied, but approximate values from recent years (2010-11) are shown in **Table 2**.

**Table 2. Typical annual amounts\* of irradiated foods sold at retail in the USA (2010-11)**

Food	Source	Tons	Ref/Comment
Ground Beef & Chicken	Mainland USA	8,000	Salvage (2012); Kume et al (2009) Mainly from the mid-West and retailed by Schwann's, Wegman's and Omaha Steaks (Eustace & Bruhn 2006)
Guava	Mainland USA	500-750	Hal (2011)
Sweet Potato	Hawaii	3,300	Hal (2011)
Rambutan, longan, apple banana, dragon fruit, mangosteen	Hawaii	1,200	Hal (2011)
Guava	Mexico	9,000	Hal (2011)
Grapefruit, mango, sweet lime, manzano pepper	Mexico	1,100	Hal (2011)

Food	Source	Tons	Ref/Comment
Mango	India, Pakistan	100	Bustos-Griffin et al (2012)
Longan, rambutan, mangosteen	Thailand	700	Bustos-Griffin et al (2012)
Dragonfruit, rambutan	Vietnam	1400	Bustos-Griffin et al (2012)

\* Amounts are approximate only. It is sometimes unclear whether long tons (UK), short tons (US) or metric tonnes are being quoted.

### 3.0 Current Risk Management of irradiated foods in Australia and New Zealand

The mandatory requirements to label irradiated foods, no matter how minor the ingredient in the Code is detailed in section 3.1. This would specifically apply to irradiated tomatoes and capsicums used as an ingredient in processed foods (e.g. a pizza).

FSANZ's responsibility under the FSANZ Act does not incorporate licencing of irradiation facilities and dosimetry requirements in order that irradiated foods are appropriately controlled to ensure the safety of these foods. Rather, these are regulated by other authorities (see section 3.2).

Management of irradiated foods does require enforcement authorities to have available methods of detection for irradiated foods. Current methods available are detailed in section 3.3.

#### 3.1 Labelling of irradiated food in Australia and New Zealand

Standard 1.5.3 requires that if foods have been irradiated or contain irradiated ingredients or components, and are available for retail sale in Australia or New Zealand, then the label must carry a statement to the effect that the food/ingredient/component has been treated with ionising radiation.

If an irradiated food or food containing irradiated ingredients/components is exempt from bearing a label when provided for retail sale (e.g. unpackaged fruits or vegetables, or ready to eat foods) then a statement that the food, ingredient or component of the food has been treated with ionising radiation must be located on or in connection with the display of the food. This statement also applies to ingredients (i.e. on the label of a food made from irradiated tomatoes/capsicums), although subclause 6(2) of Standard 1.5.3 allows for this statement to appear as part of the declaration of that ingredient/component (e.g. within an ingredient list) on the label.

Standard 1.5.3 provides three examples of how the required statement can be displayed on irradiated food for retail sale. These examples are:

- Treated with ionising radiation
- Treated with ionising electrons
- Irradiated (name of food).

None of these words are compulsory, and food manufacturers can choose a different set of words so long as the statement still indicates that the food has been treated with ionising radiation.

The Radura symbol (Figure 1 below) is a standard international symbol indicating that a food product has been irradiated. The Code does not mandate the display of this symbol on the labels of irradiated food, however there is also no prohibition on its voluntary use.

Even if the symbol is used, the food label must still display the mandatory labelling requirements for irradiated foods.



*Figure 1: International Radura Symbol*

FSANZ is not proposing to make any exceptions or changes to how all of these labelling requirements apply to irradiated tomatoes and capsicums as part of this Application.

### **3.2 Irradiation facilities and dosimetry**

The safety of irradiation facilities and of the transport of radioisotopes are matters that are not addressed by the Code, but are regulated by relevant State/Territory authorities under their radiation protection legislation as detailed below.

It is mandatory that any food permitted to be irradiated is treated in a licensed radiation facility. There are currently three commercial irradiation facilities operating in Australia. All three irradiation facilities use gamma radiation from radioactive Cobalt-60. There is an Australian Quarantine and Inspection Service (AQIS) approved treatment facility in New Zealand – Schering Plough Animal Health Upper Hutt, New Zealand.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)<sup>5</sup> regulates Australian Government entities, whereas the activities of non-Australian Government entities are regulated by relevant State and Territory authorities.

The radiation facilities are licensed in accordance with any relevant State, Territory and New Zealand law governing radiation control and operation. In Australia, this responsibility is under the jurisdiction of the following State/Territory Departments:

- ACT Health, Radiation Safety Section
- NSW Department of Environment and Climate Change
- Northern Territory Department of Health and Community Services
- Queensland Department of Health
- South Australia Environment Protection Authority
- Tasmanian Department of Health and Human Services
- Victorian Department of Human Services
- Western Australia Radiological Council, Department of Health.

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<sup>5</sup> <http://www.arpansa.gov.au/>

All matters including occupational health, safety and welfare regulations are regulated by the relevant regulatory authorities, i.e. all national, state, territory and local government Authorities.

In New Zealand, the National Radiation Laboratory (NRL), under delegated authority from the Ministry of Health, regulates all radiation facilities and radioactive substances and apparatus. The NRL administers the Radiation Protection Act 1965 and the Radiation Protection Regulations 1982.

The New Zealand legislation controls the use of ionising radiation and requires:

- users of radioactive materials or irradiating apparatus to hold a licence (users will also normally be required to comply with a Code of Safe Practice)
- importers, exporters and dealers of radioactive material to obtain a consent
- vendors and purchasers of irradiating apparatus to notify all transactions
- transporters of radioactive material to comply with transport regulations

The Applicant has provided FSANZ with extensive details of the procedure undertaken to ensure proper dosimetry. This will ensure compliance in accordance with the desired dose for each treatment that is required for approval by regulatory agencies and for developing quality control procedures.

A Codex Recommended Code of Practice for Radiation Facilities for Processing of Food (CAC 2003) and ASTM International Standards provide internationally accepted guidance on the establishment and routine operation of irradiation facilities, including detailed advice on dosimetry and record-keeping.

### **3.3 Methods of verification for irradiated foods**

Current detection methods for irradiated food are able to detect whether a food has been irradiated or not, but cannot accurately measure absorbed doses. Detection tests, however, can assist to enforce labelling requirements for identifying irradiated foods.

The control of the dose is managed by proper validation of the process prior to routine processing and is established and controlled by accurate dosimetry and maintenance of records by irradiation facilities under the existing State/Territory or New Zealand irradiation licensing requirements.

The currently available techniques are limited to foods containing bone, fat-containing foods or light emission<sup>6</sup>:

- EN 1784:2003 Detection of irradiated food containing fat - Gas chromatographic analysis of Hydrocarbons
- EN 1785:2003 Detection of irradiated food containing fat - Gas chromatographic/mass spectrometric analysis of 2-alkylcyclobutanones
- EN 1786:1996 Detection of irradiated food containing bone - Method by (electron spin resonance) ESR spectroscopy
- EN 1787:2000 Detection of irradiated food containing cellulose by ESR spectroscopy
- EN 1788:2001 Thermoluminescence detection of irradiated food from which silicate minerals can be isolated
- EN 13708:2001 Detection of irradiated food containing crystalline sugar by ESR spectroscopy

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<sup>6</sup> Source: [http://ec.europa.eu/food/food/biosafety/irradiation/anal\\_methods\\_en.htm](http://ec.europa.eu/food/food/biosafety/irradiation/anal_methods_en.htm)

- EN 13751:2002 Detection of irradiated food using photostimulated luminescence
- EN 13783:2001 Detection of irradiated food using Direct Epifluorescent Filter Technique/Aerobic Plate Count (DEFT/APC) - Screening method
- EN 13784:2001 DNA comet assay for the detection of irradiated foodstuffs - Screening method
- EN 14569:2004 Microbiological screening for irradiated food using LAL/GNB procedure.

Detection of irradiated food containing cellulose by ESR spectroscopy (*EN 1787:2000*) may have practical application in fruit and vegetables; however, the technique is limited to detection of irradiated fruits for up to three weeks after treatment.

## 4.0 Consumers and food irradiation

A summary of the relevant research related to consumer awareness, understanding and acceptance of food irradiation is at **Appendix 1**. As demonstrated by markets in various nations consumers are willing to purchase food that has been irradiated (Bruhn 1995; International Consultative Group on Food Irradiation 1999). Australian and New Zealand consumers are generally aware of food irradiation but also hold concerns about the use of the technology. The response to food irradiation is not dissimilar to their response to other new food technologies, where perceived risks and benefits of the technology will inform subsequent decisions made by consumers. While aware of food irradiation, consumers' understanding is limited and this may contribute to perception of increased risk. Information and education may assist in addressing the information gap.

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## **Appendix 1 – Summary of available literature on consumers and food irradiation**

Previous irradiation applications have highlighted the interest of some stakeholders in consumer responses to food irradiation. Submissions claim various levels of consumer awareness, understanding and acceptance of food irradiation, and do so with varying levels and quality of evidence. This summary provides a brief discussion of consumer's awareness, understanding and acceptance of food irradiation based on the available social science and consumer literature. The summary thus provides contextual and background information based on existing empirical studies.

This summary draws upon the literature identified by the applicant. This was supplemented through a targeted literature search to identify additional relevant studies. The following electronic abstracts and databases were interrogated<sup>7</sup>: SocINDEX; PsychINFO; Nutrition Abstracts and Reviews; and Food Science and Technology Abstracts. We also draw on a recently published Evidence Review of Public Attitudes to Emerging Food Technologies commissioned by the UK FSA (Lyndhurst 2009).

The literature on consumer response to food irradiation is limited, with few studies incorporating Australian or New Zealand samples. The work by Gamble et al. (2002) provides some initial work with both Australian and New Zealand samples. Australian and New Zealand studies that explore consumers' response to food technologies will sometimes include food irradiation (e.g. Cox et al. 2007); these have been included as appropriate. Additionally, FSANZ has commissioned some general studies on consumer attitudes and these may include food irradiation (e.g. TNS Social Research 2008). However the bulk of the published literature is based on US samples, with fewer studies in other countries (Bruhn 1995; International Consultative Group on Food Irradiation 1999; Lyndhurst 2009).

The literature is also limited in its focus. The majority focus on consumers' awareness and attitudes regarding food irradiation. Some will incorporate measures of intention to purchase. Few studies explore actual purchase decisions and behaviour of consumers. The bulk of published US studies focus on meat, in particular beef, as the commodity of concern, with few studies on other commodities. However, there is a growing risk perception literature regarding food technologies that are generally relevant to food irradiation (e.g. Sparks and Shepherd 1994; Frewer et al. 1996; Frewer et al. 1997; Cardello et al. 2007; Henson et al. 2007).

### **1. New food technologies and risk perception**

In general consumer responses towards the irradiation of food are not dissimilar to the responses to other new food technologies, for example genetically modified foods and nanotechnology. These have been characterised as one of 'wariness, unease, uncertainty, and sometimes outright negativity' (Lyndhurst 2009). While the use of particular technologies may be new to consumers, the pattern of response is not new. Consumer and public response to the initial introduction of now widely used and accepted food technologies are similar to the contemporary response to new food technologies as the initial public opposition to canning and pasteurisation attest (Lyndhurst 2009; Cox et al. 2007).

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<sup>7</sup> Search terms were "food irradiation" and "consumer". The search was limited to peer reviewed articles. Abstracts were reviewed and articles selected for the review based on their relevance to consumer awareness, values and behavioural response to food irradiation.

Gamble et al. (2002)<sup>8</sup> found that 60% of Australians and 68% of New Zealanders were aware of the term food irradiation. Levels of acceptance are lower than levels of awareness; 48% and 22% of aware Australian and New Zealanders reported negative responses to food irradiation (Gamble et al. 2002). The types of concerns identified by Australians and New Zealanders include: exposure to radiation, reduction in nutrition and wholesomeness of foods, damage to the environment, occupational health for workers and the use of irradiation as a substitute for safe food production (Gamble et al. 2002).

The risk perception literature demonstrates the wariness of consumers to new food technologies such as food irradiation is linked to perceptions of risk associated with the technology and perceived lack of benefits accruing to the consumer (Slovic 1987; Frewer et al. 1997; Henson et al. 2007; Cox et al. 2010). Generally the factors that influence risk perceptions include the degree to which the risk is voluntary or involuntary, immediate or delayed, observable or unseen, degree to which the risk is known to science or not, and the degree of control the individual has over the risk (Slovic 1987; Frewer et al. 1997, Cardello et al. 2007; Henson et al. 2007).

Food irradiation is often perceived as a high risk, low benefit technology (e.g. Sparks and Shepherd 1994; Frewer et al. 1997; Cardello et al. 2007; Henson et al. 2007). This is not unexpected given the characteristics of food irradiation where the technology may not be voluntarily chosen by the consumer, is not under their control, is unobservable and where there is a perception of uncertainty surrounding the science. Additionally benefits may not accrue to the consumer, but rather to others such as producers, exporters and the environment (Frewer et al. 1997; Cox et al. 2010).

## **2. Australian and New Zealand response to food irradiation**

As noted above, 60% of Australians and 68% of New Zealanders were aware of the term irradiation, with the levels of acceptance being lower. Australians were significantly more likely than New Zealanders to report negative responses to irradiation (48% in Australia versus 22% in New Zealand) and significantly less likely than New Zealanders to report positive responses (19% in Australia versus 30% in New Zealand). When tested through a set of belief statements, respondents held negative beliefs about food irradiation (Gamble et al. 2002).

Gamble et al. (2002) provided respondents with information about two scenarios – one of which included the use of irradiation to remove insect pests from imported tropical fruit. Following the provision of information respondents were asked to identify their preferred treatment for insect pests on imported fruit: 45% of Australian respondents preferred irradiation, 22% preferred heat treatment, 13% preferred none, 8% preferred fumigation and 12% responded with don't know. Significantly more New Zealand respondents indicated they preferred irradiation at 56%, while 13.5% preferred none, 12.5% preferred heat treatment, 8% preferred fumigation and 10% responded with don't know. Sex and age differences were also observed. Those who reported they were aware of food irradiation did not respond differently to those who were not aware. Results such as these suggest that given appropriate information some Australian New Zealand consumers may select irradiated fruit if offered the choice.

In a representative study of Australian and New Zealand consumers carried out in 2007, 13% of Australian respondents and 11% of New Zealand respondents expressed concern about the irradiation of food or food ingredients (TNS Social Research 2008)<sup>9</sup>.

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<sup>8</sup> Gamble et al (2002) used CATI to collect responses in their survey. They drew a quota sample of 401 respondents in Australia and 404 in New Zealand based on census figures.

<sup>9</sup> The Consumer Attitudes Survey commissioned by FSANZ collected responses to a range of food, food safety and nutritional issues through an online survey of 1202 Australian respondents and 800 New Zealand

In general, issues related to food poisoning, food safety, imported foods and obesity were of highest concern to consumers.

Cox et al. (2007) explored Australians' acceptance of a range of technologies to prevent inter-breeding of wild and farmed prawns, a potentially negative outcome for wild stocks of prawns. Irradiated prawns were the least acceptable to Australian consumers, despite being informed of the need to protect wild stocks from the farmed product. The benefit to the consumer, environmental protection, did not outweigh the perceived risks of the technology. The authors used an attitude to technology scale and found that those who held more negative views about technology also held the most negative views about irradiation. The link between attitude to science and technology and acceptance of food irradiation was also demonstrated in Gamble et al (2002), and is consistent with the international literature.

### 3. Impact of information on acceptance

Of those who were aware of food irradiation, 37% of Australians and 25% of New Zealanders believed it would reduce the nutritional quality of the food and 26% and 19% believed it would expose consumers to radiation (Gamble et al. 2002).

The lack of understanding and knowledge about food irradiation may contribute to the negative risk perceptions that some consumers hold. The provision of information for consumers to enable an informed decision regarding food irradiation may assist in rectifying the lack of knowledge for some consumers. Other consumers may have well developed understanding and knowledge of food irradiation.

Some experimental studies have explored the impact of information provision in the response of consumers to food irradiation. Bruhn (1986) in an early study explored the effects of an education pamphlet and posters on attitude toward food irradiation. Bruhn found the provision of information increased reported willingness to buy irradiated foods, even though they retained concerns about the technology. However in the case of consumers who were strongly opposed to food irradiation the information did not affect any change.

In a simulated supermarket study Rimal et al. (2004) found that point of purchase information on irradiation positively impacted actual purchase. Other studies similarly find that information provision about food irradiation will have an impact on consumers' acceptance (e.g. Frenzen et al. 2001; Gunes and Tekin 2006). However, just as positive information may increase acceptance among consumers, negative information may decrease acceptance by consumers (Lyndhurst 2009).



Labelling is a key point of purchase information source and mandatory labelling of irradiated foods ensures that consumers may factor this into their decision making. The voluntary use of the Radura<sup>10</sup> symbol (left) may also be used, though it is unclear if Australian and New Zealand consumers are aware of the symbol and its meaning. While labelling may inform consumers that a particular food is irradiated, no Australian or New Zealand studies were found that collected data on consumers' understanding of in-situ food irradiation labelling.

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respondents aged 14 years and older. The sample was post-hoc weighted to the age and sex profile of the two countries' populations (TNS Social Research 2008).

<sup>10</sup> The **Radura** is the international symbol indicating a food product has been irradiated. The Radura is usually green and resembles a plant in circle. The top half of the circle is dashed. Graphical details and colours vary between countries.

He et al. (2005) report that over 30% of respondents of a US sample would consider a beef product labelled as irradiated as a warning and would avoid the product and 21% would consider it an assurance of safety and buy it. However survey methods such as these that directly question respondents tend to report higher levels of label information use than when consumers are observed shopping (Grunert and Wills 2007).

#### **4. Consumers' behaviour in response to food irradiation**

Much of the research discussed has focussed on consumers' awareness and attitudes towards food irradiation. However fewer studies have sought to explore purchase behaviour of irradiated foods in a manner that resembles actual purchase situations. The study by Rimal et al. (2004) used a simulated supermarket to study both intended purchase and actual purchase behaviours of consumers with respect to irradiated beef. The study found that there were differences between the levels of intended and actual purchase of irradiated beef. For example 60% of respondents reported they intended to purchase irradiated beef, however only 22% actually purchased irradiated beef. Similarly 10% who reported they would never purchase irradiated beef subsequently did so.

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