Is Food from Japan Safe to eat?

Abstract

The aim of this project was to determine whether the consumption of food cultivated in Japan, after the nuclear accident at Fukushima Daiichi in March 2011, was likely to pose a risk to the health of our members and other custom. This was with a view to facilitating informed marketing and stock management decisions. To achieve this, we investigated differing interpretations of non-harmful levels of Caesium 134 and 137 isotopes in foodstuffs, and measured these against the quantities present (if at all) in a number of key products of Japanese origin, that we sell at the Blue Mountains Food Co-op. Although Caesium 137 was shown to be present in shiitake mushrooms, the amount did not exceed the international safe limits for this radioactive isotope in foodstuffs, suggested by the World Health Organisation and Food Standards Australia and New Zealand. Other products were less than the "lowest reporting limit of 2Bq/kg". All of the products tested in this study contained less than the upper limit suggested by both the WHO and the FSANZ. However, the shiitake mushroom sample presented with levels in excess of the "zero-tolerance" stance taken by Helen Caldicott (physician, author and anti-nuclear advocate). Also, a suggestion made as part of a report on Caesium Exposure by the US Agency for Toxic Substances and Disease Registery that "[any] energy released by... 134Cs and 137Cs... may ionize molecules within cells penetrated by these emissions and result in tissue damage and disruption of cellular function", tends to suggest that there is some risk involved with consuming any quantity of unstable Caesium 137. A grey area exists with regards to these latter claims in relation to all other tested products, due to the difficulty of measuring the presence of radioactivity with accuracy at these doses. As such, it cannot be categorically concluded that food from Japan is either, safe or unsafe for consumption. Our results do tend to suggest that, in general, the consumption of food from Japan is relatively unlikely to pose a major health risk, if in isolation, but perhaps care may need to be considered, with regards to monitoring one's overall consumption of products of Japanese origin, and limiting the use of shiitake mushrooms (i.e. the risk lies with the consumer), may be advisable.

Introduction

Two years has passed since Japan suffered a triple catastrophe: an earthquake and a tsunami, followed by a nuclear accident at the Fukushima Daiichi Nuclear Power Plant. At the time, radioactive material was released from the Fukushima containment vessels, as a result of deliberate gaseous venting and the discharge of coolant water into the sea. Immediately after the event, people began questioning whether Japanese food may have become contaminated by radiation, and whether it may pose a risk to one's health.

Initial concerns focused upon the obvious and immediate issue, of the deposition of radioactive materials from the air, or through rain water, onto the surface of human foods (like fruits and vegetables) and/or animal feed. In addition to this, a large volume of water was used in the process of cooling the reactors, and much of that contaminated water, would surely have run off into the Pacific Ocean, leading to the likely contamination of fish and other sea life. As a result of these early reservations, we at the Blue Mountains Food Co-op, made the decision to delete all stock lines of Japanese sea vegetables and products that were likely to contain such ingredients, viewing the direct dumping of radioactive isotopes into the ocean, as too great a risk factor for contamination of localised sea produce.

As time passed, concerns mounted about the concept of radioactive build-up within food, because radionuclides are transferred through soil into crops, and animals, and also into rivers, lakes and the sea where fish and shellfish are further exposed to radionuclides. The idea was raised that contaminated raw materials could be exported from Japan to other countries, processed there and then sold as the product of that country, and not as Japanese produce. Since the incident, radioactive material has, in fact, been detected in a range of food produce, including spinach, milk, fish and beef, in Japan – the main offenders being tea and mushrooms (pg47-48 *Assessment of the impact on Australia from the Fukushima Dai-ichi nuclear power plant accident Technical Report No.162* http://www.arpansa.gov.au/pubs/technicalreports/tr162.pdf).

Consuming food contaminated with radioactive material will increase the amount of radioactivity a person is exposed to, and could increase the health risks associated with exposure - studies have shown a related increase in the long-term prevalence of certain cancers. The exact effects on specific bodily organs will depend on which radionuclides have been ingested, and the amount being ingested.

It was in light of the above concerns that we committed to stepping up our investigations into the matter of the potential contamination of Japanese foodstuffs. In May of 2012, board director Larry Buttrose arranged to have Helen Caldicott (renowned anti-nuclear environmental activist) present, to us, her views and opinions about whether or not it was safe to be consuming foods cultivated in Japan. Dr. Caldicott was unable to verify the amount of radiation entering the food chain due to a lack of reliable sources, and as such, urged the Co-op to stop ordering "all" foods sourced from Japan. She suggested that the safest approach was to buy foods grown in Australia. However, foods from Japan are popular among Co-op consumers, and as such, the decision was made to have foods from Japan individually tested for radioactivity, before removing any further stock supplies from our shelves. By committing to this project, we hoped to shed some light as to the relative safety, or potential health risks, involved with consuming foods of Japanese origin. We also hoped to obtain some raw data so as to justify any stock retention or deletion decisions, and to educate Co-op members about the issue, so that individuals may make informed purchasing decisions.

Method

1) To gain an understanding of the subject area, we began the project by conducting internet based research into differing notions of non-harmful levels of the oral ingestion of Caesium 134 and 137 radionuclides. We looked at Australian, International and Japanese safe limits, as well as accounting for Dr Helen Caldicott's views, and ideas purported by the US Agency for Toxic Substances and Disease Registry (ATSDR). The primary intention of this was to provide us with a comparative tool, against which to assess the significance of the levels of radiation present, if any, in our food samples.

2) In January 2013, and again in March 2013, we collected store samples of key Japanese products (namely Bonsoy, Kukicha Tea, Umeboshi Puree, Genmai Miso, Shitake Mushrooms, Doowa Crackers and Soba Noodles). We mailed these samples to the ARPANSA Radioanalytical Services testing facility in Yallambie, Victoria, to have them analysed for Caesium 134 and 137 radionuclide content. This process involves the use of high resolution gamma-ray spectrometry. Refer to the ARPANSA website for a further explanation of testing procedures. (http://www.arpansa.gov.au/services/radioanalytical/food.cfm)

a) What is the relevance of testing for caesium 134 and 137?

- Both Caesium 134 and 137 are common bi-products of nuclear fission. The three most common radioactive elements emitted from Fukushima are believed to have been Iodine 131, Caesium 134 and Caesium 137.
- Preliminary testing showed that Caesium 134 and 137 was being found in many food samples of Japanese foodstuffs. From March 2011 to the end of May 2012, over 570 samples of imported food were assessed by ARPANSA for Iodine 131, Caesium 134 and Caesium 137, in relation to the Fukushima Dai-ichi NPP accident. A total of 49 samples (7%) tested positive to the presence of Caesium 134 and/or Caesium 137.
- Caesium 134 has a half-life of about 2 years and will remain detectable in the environment for approximately 20 years. Caesium 137 is among the most problematic of the short-to-medium-lifetime fission products, because it easily moves and spreads in nature due to the high water solubility of its most common chemical compounds, salts. It has a half-life of about 30 years and will remain detectable in the environment for more than 300 years. A study published by the Proceedings of the National Academy of Sciences (PNAS), found that caesium 137 had strongly contaminated the soils in large areas of eastern and north-eastern Japan. (*Cesium-137 deposition and contamination of Japanese soils due to the Fukushima nuclear accident* http://www.pnas.org/content/108/49/19530.full.pdf+html?sid=c54b6032-76e6-4007-b341-8deec3ad12cd)

b) Why not test for Iodine 131?

Although Iodine 131 was one of the three most common radioactive elements emitted from Fukushima, a study done by ARPANSA March (2011-May 2012), found that none of the samples tested positive for the presence of Iodine 131. The conclusion was drawn that "after 80 days, Iodine 131, with a short half-life of about 8 days, would have decayed to amounts that would no longer be detectable" (*Assessment of the impact on Australia from the Fukushima Dai-ichi nuclear power plant accident Technical Report No.162* http://www.arpansa.gov.au/pubs/technicalreports/tr162.pdf).

c) Why have we chosen to test these particular products?

- We wanted to have a good representation of our range of stocked Japanese items, and more commonly consumed products. Bonsoy is our best selling soy milk product, genmai miso is our biggest selling Japanese miso (other than miso products already taken off the shelf due to their seaweed content), and Umeboshi Puree is one product that is exclusively produced in Japan – a product of alternative origin could not be found.
- We chose products that had already tested positively for Caesium 134 and 137 radionuclides in localised Japanese testing:
  - *Tea-leaves* **-** In September 2011 radioactive caesium (2,720 Becquerels per kilogram) exceeding the government's safety limit, was detected in tea leaves in Chiba, Japan. Thus we had our Kukicha Tea analysed.

- *Rice* - On 23 September 2011 radioactive caesium in concentrations above the governmental safety limit was found in rice samples collected in an area in the north-eastern part of the Fukushima prefecture. Doowa Crackers contain rice from Japan.
- *Noodles* - In February 2011 noodles contaminated with radioactive Caesium (258 bq/kg) were found in a restaurant in Okinawa. The noodles, called "Okinawa soba", were apparently produced with water filtered through contaminated ashes from wood originating from the prefecture Fukushima. As such, soba noodles came to be on our list of products to be tested.
- *Mushrooms* - In shiitake mushrooms grown in a city in the Ibaraki prefecture, samples contained 830 bq/kg of radioactive caesium, exceeding the Japanese government's limit of 500 bq/kg. Mushrooms are also believed to be good radiation absorbers, and as such, the testing of our shiitake mushrooms seemed imperative.

3) Upon receiving the entirety of our test results, we proceeded to cross-reference our figures with the numerous interpretations of what was deemed a safe level of Caesium 134 and 137 content in foodstuffs. In some cases, this involved a simple and direct comparison of our data with clearly defined safety limits, but entailed some more complex decoding of data, and terminology, with some of the more conditional and subjective conceptions. This final step in the process helped us to derive some insight into the question of whether it is safe to eat food from Japan.

Results

1) Safe levels of radioactive caesium?

Limits for radioactive caesium content in foodstuffs

Limits for Radioactive Caesium	Drinking Water (Bq/L)	Milk (Bq/L)	General Foodstuffs (Bq/kg)	Food items for babies (Bq/kg)
Japan (current limits - since April 2012)	10	50	100 (plus dairy products)	50
Japan (provisional limits during accident and up to April 2012)	200	200 (plus dairy products)	500	200
Australia – FSANZ/ARPANSA* (operational interventional limits in a reactor accident)	300	300	200	200
European Union**	1000	1000	1250	400
United States	1200	1200	1200	1200
FAO/WHO (Codex Alimentarius)	1000	1000	1000	1000
Dr. Helen Caldicott	0	0	0	0
ATSDR***	0	0	0	0

**These limits apply only for the first year in the event of a nuclear reactor accident in Australia. For all imported foodstuffs, Australia adopts the Codex Alimentarius (WHO) limits.*
***These limits apply only to foodstuffs produced in the EU. When Japanese agricultural products are imported to the EU, Japan's provisional limits are applied.*
****These figures have been deduced from ideas expressed in a profile report on Caesium (http://www.atsdr.cdc.gov/toxprofiles/tp157-c2.pdf), and are not a reflection of a study undertaken by the ATSDR that specifically identifies any recorded ill-health effects from radioactive Caesium exposure. Such long-term studies have never been carried out.*

The above table displays Japan's current limits for radioactive caesium content in foodstuffs, as well as the provisional limits applied during the accident. Australia's limits for radionuclides in foodstuffs during a localised nuclear emergency, are shown for comparison. Also shown are the upper limits set by the European Union and the United States, as well as the Codex Alimentarius International Food Standards (U.N. Food and Agricultural Organisation and the World Health Organisation) guideline levels, applied to foods for human consumption, and traded internationally.

- Japanese Limits
After the accident, the Japanese government quickly introduced regulations that required all food produced in affected areas to be tested for, Iodine 131, Caesium 134 and Caesium 137 contamination, against the government's provisional limits (refer to above table). Any food that exceeded the Japanese government's limit could not be sold, and was withdrawn from distribution. The Japanese government introduced new lower statutory limits in April 2012, which

were more cautious than earlier provisional limits, and limits set by other international bodies, in assuming that almost all foodstuffs will contain some level of contamination. The government's goal was to avoid a cumulative exposure of 1 mSv of radiation per year. The limits were calculated by working backward from the figure of 1 mSv of radioactive caesium, which is the maximum allowable annual dietary intake for an ordinary person, according to the Japanese Ministry of Health, Labour and Welfare. If somebody were to eat only food containing 100 Bq/kg of caesium, and continued to do so for one year, the total radiation dose during that period is estimated by the Japanese Ministry of Health as 0.7 mSv, below the 1 mSv ceiling (http://www.mhlw.go.jp/english/topics/2011eq/dl/new_standard.pdf).

- Australian Limits
In the case of the Fukushima incident, Australia adopted the limits set by the FAO and WHO Codex Alimentarius for the first year after the disaster. There are no Australian regulatory limits for radionuclides in food that can be applied beyond one year after a local or overseas nuclear emergency. Instead, Food Standards Australia and New Zealand (FSANZ) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) provides risk based assessment advice on radionuclide contaminates in food as required. For contamination of food arising from radiation practices, assessments are based on a reference level of 1 mSv per year for members of the public. This level may vary for someone employed in a field with an expected risk of radiation exposure, wherein the maximum 1 mSv per year dose, specified by the Codex Alimentarius, would have to be reduced by the amount of expected radiation dose from other sources of exposure, to ensure that the level of 1mSv per year is not exceeded. The method used by the WHO and FAO for this assessment is outlined in **Appendix D**.

- European Union Limits
The European Union have previously established upper limits for radioactive caesium content with allowances for infant foods and for liquids. These limits are applied for products of the European Union only, and the more stringent limits set by the Japanese government are adopted for any imported produce.

- United States Limits
The United States have an across the board DIL (Derived Intervention Level) of 1200 Bq/kg for both Caesium 134 and 137, for all foodstuff irrespective of whether it is intended for the consumption of babies, and a DIL of 1200 Bq/L for all liquids. These figures were changed in 1998 from a uniform level of 370 Bq/kg (http://www.fda.gov/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm078341.htm).

- World Health Organisation (WHO) /U.N. Food & Agricultural Organisation (FAO) Limits
An annual limit of equivalent radiation dose of 1 mSv per year was established by the Codex Alimentarius Commission, a body linked to the U.N. Food and Agricultural Organization and the World Health Organization, which is responsible for setting international food safety standards. The Codex's highest permissible level of radioactive caesium for general foodstuffs is 1,000 Becquerels per kilogram, which is purportedly aimed at keeping an individual's yearly radiation dose under the 1 mSv umbrella. The 1000 BQ/kg guideline level applies to radionuclides contained in foods destined for human consumption and traded internationally, which have been contaminated following a nuclear or radiological emergency. They apply to food after reconstitution or as prepared for consumption (i.e. not to dried or concentrated foods). According to the Codex Alimentarius publication, "as far as generic radiological protection of food consumers is concerned, when radionuclide levels in food do not exceed the corresponding Guideline Levels, the food should be considered as safe for human consumption. For foods that are consumed in small quantities, such as spices, that represent a small percentage of total diet and hence a small addition to the total dose, the Guideline Levels may be increased by a factor of 10" (www.**codex**alimentarius.org/input/download/**standards**/17/CXS_193e.pdf).

> **Note:** See **Appendix D** for an explanation of how the WHO calculates internal radiation dose for consuming a particular quantity of Bq/kg, and **Appendix C** and **Appendix E** for further explanation of key ideas.

- Dr. Helen Caldicott
Dr. Caldicott is of the firm opinion that any exposure to radioactive isotopes of Caesium comes with an increased risk of ill-health, particularly cancer. She does not believe in the phenomena of a "safe" limit for the oral ingestion of radioactive Caesium. For further information about Dr. Caldicott's stance on consumption of food from Japan, please follow the links provided in the **Resources** section of this report, where you will find film excerpts of Dr. Caldicott's May 2012 presentation.

Drinking

- US Agency for Toxic Substances and Disease Registry (ATSDR)
According to a report released by the US Agency for Toxic Substances and Disease Registry entitle *Caesium* (http://www.atsdr.cdc.gov/toxprofiles/tp157-c2.pdf)...

“Exposure to radioisotopes of caesium is a significant health concern. [Any] energy released by radioactive isotopes can result in significant damage to living cells. Both 134Cs and 137Cs emit beta particles and gamma rays, which may ionise molecules within cells penetrated by these emissions and result in tissue damage, and disruption of cellular function.”

The ATSDR report (http://www.atsdr.cdc.gov/toxprofiles/tp157-c2.pdf) made the following claims about the general effects of radiation exposure...

“Generally, acute radiation doses below 15 rad (0.15 Gy) do not result in observable adverse health effects. At doses in the range of 15–50 rad (0.15– 0.5 Gy), subclinical responses such as chromosomal breaks and transient changes in formed elements of the blood may be seen in sensitive individuals. Symptoms of acute radiation syndrome are observed at radiation doses above 50 rad (0.5 Gy), characterized by transient hematopoietic manifestations, nausea and vomiting, and moderate leukopenia at doses near 100 rad (1 Gy), progressing through more serious hematopoietic symptoms, clinical signs, and gastrointestinal symptoms with increasing dose (100–800 rad or 1–8 Gy), and usually death in persons receiving total doses ≥1,000 rad (10 Gy). Other health effects from acute or continued exposure to ionizing radiation may include reproductive, developmental, and latent cancer effects.”

> **Note:** For a translation of how the Rad doses quoted here relate to the Becquerel levels indicated in the test results for our product samples, please see **Appendix E**.

The ATSDR report (http://www.atsdr.cdc.gov/toxprofiles/tp157-c2.pdf) states the following about Caesium specifically...

“Due to the ionizing properties of radionuclides such as 134Cs and 137Cs, increased cancer risk would be expected among exposed individuals. However, studies of increased cancer risk specifically associated with exposure of humans to radioactive caesium isotopes were not located. Long-term cancer studies on exposed individuals have not been completed to date.”

2) Our test results

Table of reported levels of radioactive caesium levels in BM Food Co-op samples

Product	**Batch#**	**Date sent**	**Result (Bq/Kg)**
Bonsoy	B.B. 22.11.14. /AH12	15/1/13	Less than 2
Kukicha Tea	B.B. 07.06.2014 no batch#	15/1/13	Less than 2
Doowa Crackers	Lot 60/2013	15/1/13	Less than 2
Soba Noodles	B.B. 09.10.2014	15/1/13	Less than 2
Shiitake Mushrooms	No information Received 25/2/13	6/3/13	4.12 + or – 0.49 *
Umeboshi Puree	P7524 No. 229 A/# 510010	6/3/13	Less than 2
Genmai Miso	No information	6/3/13	Less than 2

***Note:** The + or – value for shiitake mushrooms is a calculated allowance for human or mechanical error and the potential for the influence of background radiation.*

- For further understanding of Radiation and its related concepts, please visit http://www.arpansa.gov.au/radiationprotection/basics/index.cfm, and/or see **Appendix C – Technical Terminology**.

- For a full list of products sold at the Blue Mountains Food Co-op that are of Japanese origin, or contain ingredients of Japanese origin, please see **Appendix A**.

Discussion

To determine a true conclusion from the testing and data analysis we have conducted, consideration needs to be made for the degree of accuracy of our test results, and of the regulatory limits against which these results are to be compared.

1) Influencing Radiation

- Is there any caesium in background radiation?

The Caesium-133 isotope is the only naturally occurring Caesium in the environment, however it is a stable form of Caesium, meaning that it is not classed as being radioactive. Radioactive isotopes of caesium (134 and 137) are formed during nuclear fission, in commercial applications such as the generation of electricity at nuclear power plants. High levels of Caesium 134 and 137 have been released to the environment, by way of both underground and aboveground nuclear weapons testing, and as a result of the accident in Ukraine 1986 (Chernobyl). Radioactive caesium can also be released to soil or water in liquid effluents from spent fuel and fuel reprocessing plants. Once released, these radioactive caesium isotopes persist in the environment, for an extended period of time.

- Are background radiation levels excluded from our test results?
It is not possible to completely eradicate the effects of background radiation in the testing process, however, a calculated adjustment is made to the test reading, to compensate for the potential influence of background radiation. In our test samples, this reading was presented as + or – 0.49 for the shiitake mushrooms, which presented with detectable levels of Caesium 137.

- So, what about radiation from Chernobyl?
In terms of our test samples from Japan, there is some minor possibility that Caesium from Chernobyl may have made its way into Japanese soils, and thus could have had some influence on our test results. It is very unlikely though, and significant levels would not be expected, in consideration of Japan's distance from the site, and the time that has passed since the incident at Chernobyl.

As a sideline study, we took the opportunity to test a product of Turkish origin (Turkish Apricots), so as to give us some representation of the radioactive status of foodstuffs that may have been locally affected by the Chernobyl outfall. It was suggested by Helen Caldicott that it still may not be safe to consume foods cultivated within a certain proximity to the site of the 1986 Ukraine disaster. Although this was by no means a conclusive study, the apricots also showed a reading of under 2 Becquerels/kilogram when tested for both Caesium 134 and 137, also placing them in the category of uncertainty related to the ranging interpretations of safe limits, and the lack of concrete long term studies in the subject area.

2) Reliability of safe limits
As one embarks upon the task of trying to decode all the varying data and formulae for determining a safe level of radioactivity in foods, the first thing that becomes obvious is that there are a lot of different opinions on the matter, a lot of inconsistencies, many variables and even more literature aimed at both confusing, and comforting, concerned readers.

- Why are there differing concepts of safe limits?
Both the WHO/FAO and the Japanese government claim that their radiation limits are specifically aimed at keeping an individual's radiation dose below 1mSv per year. So too do the European Union, the United States and Australian regulatory authorites. In fact, all four of the latter nations have borrowed the 1mSv yearly maximum *equivalent radiation dose* figure from the WHO/FAO guidelines. However, their upper limits for radioactive Caesium content in foods are all markedly different. The WHO/FAO upper limit for radioactive Caesium content for general foodstuffs is 10 times higher than the Japanese limit. One argument for this discrepancy is that that, the Japanese people are more likely to be consuming contaminated foods, and more regularly, than people residing further from the Fukushima site. The idea then, is that if doses are kept lower in Japan, the overall cumulative dose can better be controlled. So the theory is that someone in Australia, for example, who might only occasionally consume contaminated foods, can afford to ingest a higher amount in one sitting, as there is less risk that they will exceed the cumulative dose limit of 1mSv per year. It is more understandable that Australian limits differ from Japan's limits, for this reason, however an International limit should surely be representative of the people with the greatest expected exposure. Australians, Americans and Europeans do, however, travel the world (even to Japan, where they might eat a significant amount of Japanese food) and are exposed to a multitude of radioactive sources in general. So assuming that these people are less likely to ingest radioactive Caesium is not necessarily very constructive. Would it not make more sense to have all limits set according to a worst-case scenario basis, and not according to a generalised average?

> **Note:** The Becquerel (Bq) measures the activity of radioactive substances, whereas the Sievert (Sv) evaluates the effects of radiation on the body. See Appendix E for a further explanation of this concept.

- Validity of foundational principles upon which safe limits are based
To give credence to the accuracy of the varying guideline limits, perhaps by rationalising that differences are purely a result of expected ingestion rates in a particular region, one must further trust in the calculations upon which these limits are based.

One commendable aspect of the Australian system of determining radioactive Caesium limits is that there are no Australian regulatory limits for radionuclides in food that can be applied beyond one year after a nuclear or radiological emergency - instead, the Australian Radiation Protection and Nuclear Safety Agency provides risk based assessment advice on radionuclide contaminates in food as required. This insinuates that variability in what constitutes a safety risk is being considered on a case by case basis. This above all else, indicates that Australian authorities are aware that there are so many unknowns with this issue, and further makes one question whether it is relevant, or effective, to set an across the board permissible radiation level to pose as a safety net.

In 1998, the US changed safe limits of radioactive Caesium content in foods from 370 bq/kg to 1200 bq/kg. The justification for this may have been that sufficient time had passed since the Chernobyl incident and/or some localised nuclear leaks, perhaps assuming that by this time, people were likely to have a lessened overall exposure to Caesium radiation. However, individuals have been at an increasingly greater risk of being exposed to other types of radiation, from a myriad of artificial sources, since this time (effecting their overall radiation exposure dose), and Caesium 137 takes about 30 years to decay to half of its radioactive strength - only 13 years had passed since Chernoby when these limits were changed. Limits have not been reduced to pre-1998 levels despite the fact that significant amounts of radiation, believed to have originated from Fukushima, have been turning up in US soils.

In a report compiled prior to April 2012, that dealt with the reduction of provisional food safety limits, the Japanese Ministry of Health stated that it was going to “reduce the maximum permissible dose [of Caesium radiation] from 5mSv/year to 1mSv/year” (http://www.mhlw.go.jp/english/topics/2011eq/dl/new_standard.pdf). So, prior to April 2012 the Japanese ministry argued that 5mSv/year was the upper limit of Caesium radiation exposure, in terms of posing a risk to human health. Unlike Becquerel per kilogram levels (which are a reflection of the activity of radioactive substances), and can vary in terms of translated effect on the human body, a quantified Sievert (Sv) figure which specifically quantifies the effects of radiation on the body, should not be so changeable. Such a large reduction in this figure, perhaps suggests that the yearly millisievert (mSv) limit, that is the basis of calculations for maximum radiation content of foods, is not so reliable.

A news article written by Japanese reporters in March 2011, aimed at publicising the findings of a press conference with the Japanese Ministry of Health and Welfare, gives some interesting insight into the reliability of safety limit figures and how they correspond to human health risk. The article also points out that the instrument used by the Japanese Ministry of Health to determine the effects of radiation on human beings (the ICRP collective dose risk assessment), accepts the basic premise that there is “no dose below which radiation is harmless”.

The following excerpt was taken from *“Japanese Ministry of Health Labour and Welfare’s position concerning Fukushima Daiichi radioactive releases”, March 2011 - http://fukushima.greenaction-japan.org/2011/03/31/553/*:

When asked, “What level of radiation produces an ‘immediate effect’ on human health,” the reply was: “From the Ministry’s standpoint, it’s not clear”. This answer drew looks of bewilderment from the delegation. It was so unexpected that we repeated the question several times, but the reply was the same. This appears to be the official response. Next, concerning the question, “What kinds of physical damage does radiation cause?” the Ministry said, “there’s a risk that it can cause cancer.” When we asked what kinds of cancer, however, the Ministry could not give a definite answer. When we mentioned the collective dose risk adopted by the International Commission on Radiological Protection (ICRP), the Ministry said it had no knowledge of such an assessment. The Japanese government says it uses the ICRP risk assessment to estimate the effects of radiation on human beings. The ICRP assessment, however, holds as a matter of principle that radiation has no threshold dose value (i.e., a dose below which radiation is harmless).

- Is less than 2bq/kg a relevant figure to us in reporting, or do we need something more sensitive?
The detection limit for the analysis of the radionuclides caesium-137 and caesium-134 at the ARPANSA testing facility, is reported as 2 Becquerels per kilogram (2 Bq/kg). Their justification for this is that 2 Bq/kg is much smaller than any regulatory limit of which they are aware, and “much less than the levels of natural radioactivity in many foodstuffs” (http://www.arpansa.gov.au/services/radioanalytical/food.cfm#3). This explanation appeared somewhat feasible until Japan brought in their new far-stricter regulatory limits in April 2012, making it necessary for local Japanese entities to acquire expensive high-precision instruments to measure radiation levels, as the new limits were a considerable reduction from previous provisional limits. For drinking water, the safe limit was reduced to 10 bq/L, deeming readings of under 2bq/kg more significant than originally believed. A reading of 2bq/kg is still under any of the advertised safe limits, but considering re-calculations have already considerably altered Japanese safety limits,

perhaps these limits may be re-revised to lower levels in the very near future. Also, radioactivity accumulates in the body, so it might be useful to know exact quantities (i.e. under 2 bq/kg) to give individuals a concept of their overall consumption of radiation. A brief note about the statement by ARPANSA that 2bq/kg is "much less than the levels of natural radioactivity in many foodstuffs" as a justification for not needing to provide specific quantities that are less than this amount; the particular types of radiation that we are testing for, Caesium 134 and 137, were sometimes detectable in foodstuffs before Fukushima and Chernobyl, but their origin is not "natural". They are formed during nuclear fission, and were first released into the environment in 1945, as a result of early atmospheric nuclear weapons testing. Caesium 134 and 137 behave differently in the human body to the types of "natural" radiation to which we are likely to be exposed. Caesium 134 and 137 are types of *ionising radiation* (see **Appendix C**), with the capacity to "liberate an atomic particle from the atom, alter chemical bonds and produce ions... [This] greatly magnifies the chemical and biological damage per unit of energy of radiation" (http://en.wikipedia.org/wiki/Ionising_radiation). The most significant form of "natural" and *ionising radiation* is airborne radioactive Radon, whose half-life of 3.8 days means that it is likely to decay in the human body rapidly enough to keep harm to a minimum, making it less of a formidable source of radioactive exposure. As such, the safety limits for Caesium 134 and 137 cannot be directly comparable to "natural" radiation.

3) Reliability of Past Studies

Limits set by government and International bodies are marketed in a manner so as to encourage us to believe they are scientifically sound. This creates a sense of confidence that negative health effects will not be experienced, if foodstuffs are regulated as containing radioactive caesium in quantities below these limits. Apart from the fact that the dose absorbed by an individual can be effected by a myriad of variables (eg. age, gender, body mass), and that the likelihood of one experiencing ill-health as a result, can also depend upon a number of variables (eg. exposure to additional sources of radiation, state of one's immune system etc.), there have been no sound long-term studies conducted into the health effects produced by prolonged exposure to caesium radiation, by way of oral ingestion. Many studies have, however, been conducted into the general health effects produced by different modes of exposure to differing sources of radiation. It is through the use of this data that we can gain some sense of the possible consequences of caesium exposure (more than likely an increased risk of cancer), and how much exposure is likely to be a danger to us (at least 1mSv/year – the level currently used by the WHO to justify their current limits). The lack of raw data specific to the issue at hand, however, further confirms that we cannot truly determine whether it is safe to consume food products from Japan.

4) What is the relevance of the figures used for testing regarding US nuts in the following article?

http://www.enviroreporter.com/2012/08/no-place-to-hide-kushima-fallout-findings-widespread/all/1/

This article is a multi-faceted commentary on the perceived effects of the Fukushima outfall on Californian agriculture. Controversially, the article insinuates that seemingly insignificant levels of Caesium radiation (when compared to International and US government safety limits) are far more dangerous than we are being lead to believe. Figures presented in this paper include sub-2 Bq/kg amounts and give weight to the idea explored earlier that it might be relevant and useful to obtain more precise testing data. This article seems to further elucidate the fact that it is very difficult to claim, with certainty, to know what is meant by a safe level of internal radioactive caesium consumption.

Conclusion

Large amounts of radioactive material were released to the environment during the 2011 Fukushima Dai-ichi nuclear accident. The research and testing reported here was undertaken by the Blue Mountains Food Co-op in order to assess the risk, of consuming Japanese foodstuffs, to the health of our members and other custom. Of the foodstuffs tested as part of this project, one in seven of the products had definite detectable amounts of Caesium 137, and all tested below the Codex guideline level of 1000 Bq/kg, the European Union limit of 1250 Bq/kg, the United States level of 1200 Bq/kg, and the current revised Japanese limit of 100Bq/kg. One in seven of the products exceeded the "zero" limit implied by the ATSDR and stated by Dr. Helen Caldicott, but the remaining six remain unquantifiable, in terms of creating a comparison herein, due to the unwillingness of ARPANSA to provide precision measurements below 2 Bq/kg.

In light of the above results, we have assessed that the impact, of consuming Japanese food products, on the health of Co-op members and general custom, is indeterminable. This assessment was based on:

- A lack of precise testing figures.
- An inconsistency between specified safety limits.
- A lack of long-term, case specific studies, by which to truly determine the risk posed to one's health.

In the interest of the safety of our members, the following recommendations can be made:

- Monitor, and perhaps, minimize one's consumption of shiitake mushrooms.
- Consume foodstuffs from Japan in moderation, and be mindful of one's overall intake of these foods.
- If in doubt, avoid foods of Japanese origin.
- Consider overall exposure to all sources of radiation, relating to lifestyle choices (e.g. frequency of flying, medical imaging scans, mobile phone use, television and computer use etc.)

Where to from here?

As a result of this project the Blue Mountains Food Co-op will commit to the continual labelling of products with Japanese origin, or on products containing ingredients of Japanese origin, to reflect that they are, as such, from Japan. This will include the updating of labels (as per any further test results) with some reference to testing results. A process of discussion between the Board of Directors and the stock manager will take place, in the near future, to determine whether a need exists to delete any product lines whose sales decrease significantly as a result of the release of the above findings.

The Blue Mountains Food Co-op are currently involved in negotiations to determine whether or not we will continue to monitor the levels of Caesium 134 and 137 in the Japanese food products that we stock, in the interest of providing accurate and current advice, to members of the Co-op and to other custom. This would include the continual monitoring of safety limit determinations for radioactive Caesium content and the continuation of product testing. In the event of deciding to undergo further testing, the pursuit of an alternative and precision testing procedure may prove to be worthwhile. The Board of Directors of the Blue Mountains Food Co-op Ltd will meet regularly to discuss the situation, and will keep the larger Co-op community informed as to any further decision making.

The Blue Mountains Food Co-op Ltd has also looked into the way other co-operatives have responded to the post Fukushima food situation to investigate alternative and/or additional actions we may be able to take. Alfalfa House (Enmore) has responded to the situation by finding suitable alternatives to popular Japanese products that have been produced outside of Japan. Maple St Co-op (Maleny) have removed most seaweed products of Japanese origin from their shelves and are investigating the possibility of purchasing a Geiger counter to monitor store stock on a regular and ongoing basis. Maple St are generally committed to sourcing all their products locally and will not purchase overseas products if there is a local or Australian option available, irrespective of the cost. Discussions are currently underway with both Alfalfa House and Maple St Co-operatives, with the intention of investigating the possibility of creating a financial support network and information sharing arrangement, so that we can all move forward in making sound and well-researched supply decisions in the interest of the health and safety of our members.

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Appendices

A) What products do we sell that contain Japanese ingredients?

- Black Sesame Rice Crackers
- Bonsoy Soy Milk
- Brown Rice Chips
- Brown Rice Vinegar
- Genmai Cha Tea
- Genmai Miso
- Green Tea
- Hatcho Miso
- Kukicha/Bancha Tea
- Kuzu
- Mirin
- Mugi Miso
- Nigari Flakes (to be discontinued-poor sales)
- Pickled Ginger
- Shiro Miso
- Shitake Mushrooms
- Soba Noodles
- Tamari Rice Crackers
- Umeboshi Plums
- Umeboshi Puree
- Umeboshi Vinegar
- Wasabi Chips
- Wasabi Powder
- White Sesame Rice Crackers

B) Cost analysis of the project

Wages - Approx. 30hours (Mike and Kalindra) x $20/hr = $600
Testing - $120 per test x 8 (incl. Turkish Apricots) = $960
Cost of products sent for testing - Approx $200
Postage - Approx $40

APPROXIMATE TOTAL COST = $1800

C) Technical Terminology

- **Radiation =** energy in transit in the form of high speed particles and electromagnetic waves. We encounter electromagnetic waves every day. They make up our visible light, radio and television waves, ultra violet (UV), and microwaves and are part of a large spectrum of energies. These examples of electromagnetic waves do not cause ionizations of atoms they interact with because they do not carry enough energy to remove electrons from atoms. Radiation can be ionising or non-ionising.
- **Ionising radiation =** radiation composed of particles that individually carry enough kinetic energy to liberate an electron from an atom or molecule, ionising it. Ionising radiation is generated through nuclear reactions, either artificial or natural, by very high temperature (e.g. plasma discharge or the corona of the Sun), via production of high energy particles in particle accelerators, or due to acceleration of charged particles by the electromagnetic fields produced by natural processes, from lightning to supernova explosions.
- **Sievert (Sv) =** the International System of Units (SI) derived unit of equivalent radiation dose, effective dose, and committed dose. Quantities that are measured in sieverts are designed to represent

the stochastic biological effects of ionising radiation. or equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of m**illisievert** (1 mSv = 0.001 Sv) or **microsievert** (1 µSv = 0.000001 Sv). To determine equivalent dose (Sv), you multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the type of incident radiation. One sievert is equivalent to 100 rem.

- **Becquerel (Bq) =** a unit used to measure radioactivity. One Becquerel is that quantity of a radioactive material that will have 1 transformation in one second. Often radioactivity is expressed in larger units like: thousands (kBq), one millions (MBq) or even billions (GBq) of a Becquerels. As a result of having one Becquerel being equal to one transformation per second, there are 3.7×10^{10} Bq in one curie.
- **Radiation dose =** the energy absorbed by a unit of mass. It is measured in gray (GY) units (1 Joule is absorbed by 1 Kg mass). 1 GY = 1 Jkg old writings used 1 Gy = 100 rad
- **Rad =** a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations.
- **Gray (Gy) =** a unit also used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One gray is equal to one joule of energy deposited in one kg of a material. The unit gray can be used for any type of radiation, but it does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centi-grays. One gray is equivalent to 100 rads.
- **Radionuclide =** an atom with an unstable nucleus, characterized by excess energy available to be imparted either to a newly created radiation particle within the nucleus or via internal conversion. During this process, the radionuclide is said to undergo radioactive decay, resulting in the emission of gamma ray(s) and/or subatomic particles such as alpha or beta particles.[1] These emissions constitute ionizing radiation. Radionuclides are often referred to by chemists and physicists as radioactive isotopes or radioisotopes
- **Isotopes =** two atoms which have the same number of protons but different numbers of neutrons are called isotopes of each other. Isotopes have identical chemical properties and cannot be separated by chemical methods.
- **Iodine-131 (^{131}I) =** an important radioisotope of iodine. It has a radioactive decay half-life of about eight days. It is used extensively in medical diagnostics and Iodine-131 is also one of the most commonly used gamma-emitting radioactive industrial tracer. It is also called radioiodine.
- **Half-life ($t_{1/2}$)** = the time required for a quantity to fall to half its value as measured at the beginning of the time period. In physics, it is typically used to describe a property of radioactive decay, but may be used to describe any quantity which follows an exponential decay.

D) WHO/Codex Alimentarius Calculations

Calculating the mean internal dose to the public from contaminated foods

The determination of the mean internal dose to the public, *E*, in mSv, due to annual consumption of imported foods containing radionuclides can be estimated using the following formula as defined in the Codex (FAO and WHO 2010).

$$E = GL(A) \times M(A) \times eing(A) \times IPF$$

where:

- *GL(A)* is the Codex guideline level (Bq/kg)
- *M(A)* is the mass of food consumed each year (age dependent) (kg)
- *eing(A)* is the ingestion dose coefficient (age dependent) (mSv/Bq)
- *IPF* is an import factor (dimensionless). This is a ratio between imported contaminated foods and the total amount of food consumed.

When assessing the mean internal dose to the Australian public from foods imported to Australia from Japan the following assumptions were made:

- The mass of contaminated food consumed each year is 550 kg (adult) or 200 kg (infant) (FAO and WHO 2010)

- The IPF was assumed to be equal to 0.1, the default recommended by the Codex (FAO and WHO 2010)
- Ingestion dose coefficients are taken from ICRP Publication 71 (ICRP 1996)

E) The effect of radiation on the human body

To have a thorough understanding of the significance of the data, testing calculations and proposed safe limits of radiaton ingestion, it is necessary to, first, establish a relationship between the amount of radiation in the food, and the effect this will have upon the human body in the event of ingestion.

- Measuring radiation dosage

Radiation dosing can be viewed as an amount of energy absorbed by the body.

- **The rad**

The *rad* is a unit of absorbed radiaton dose, defined in terms of the energy actually deposited in the tissue. One *rad* is an absorbed dose of 0.01 joules of energy per kilogram of tissue.

- **RBE**

To accurately assess the risk of radiation, the absorbed dose energy in *rad* is multiplied by the relative biological effectiveness (RBE) of the radiation to get the biological dose equivalent in rems. The RBE is a "quality factor," often denoted by the letter Q, which assesses the damage to tissue caused by a particular type and energy of radiation. For alpha particles, Q may be as high as 20, so that one *rad* of alpha radiation is equivalent to 20 rem. The Q of neutron radiation depends on their energy. However, for beta particles, x-rays, and gamma rays, Q is taken as one, so that the *rad* and *rem* are equivalent for those radiation sources. Both Cs-137 and Cs-134 emit beta radiation and gamma radiation.

- **The maze of units**

- The effective dose is labeled as Sievert (Sv)
- An old unit for effective dose had been the rem (röntgen equivalent man)
- 1 rem = 1 rad times RBE
- 1 Millirem (mrem) = 0.001 Sievert
- 1 Sv = 100 rem
- The unit of the activity of radioactive material is Becquerel (Bq): 1 Bq = 1 decay/second.
- The old unit of activity replaced by Bq, is Curie (Ci):
- 1 Ci = 3,7 X 10^{10} decays/second = 3,7 X 10^{10} Bq.

- **Energy dose**

The rays of radiation have an interaction with the mass of the body which is being irradiated. This is called energy dose. The unit is Gray (Gy) , which means that 1 joule is absorbed by 1 kg of body.
- 1 Gray (Gy) = 1 J/Kg

The old unit of energy dose was Rad (Radiation absorbed dose)Radiation absorbed dose 1 Gray (Gy) = 100 Rad

- How does Rad dose relate to Becquerel levels?

The contamination of soil, food and water is given in Becquerel/square metre, or Becquerel/Kg or litre.

- **Becquerel**

- One Becquerel (Bq) means one disintegration per second.

The Becquerel (Bq) measures the activity of radioactive substances, whereas the Sievert (Sv) evaluates the effects of radiation on the body.

- **Dose Equivalent**

A measure of the biological damage to living tissue as a result of radiation exposure. Also known as the " biological dose," the dose equivalent is calculated as the product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest.

- **Sievert**

The dose equivalent, measured in sievert, defined as the dose of absorbed radiation that has the same biological effect as a dose of one joule of gamma rays absorbed in one kilogram of tissue.

- **Conversion Becquerel/Sievert and Sievert/Becquerel**

1 Bq = 0,0125 microsievert
1 microsievert = 80 Becquerel

- **Examples**

- Eating an amount of food with 80.000 Becquerel Caesium 137 is equivalent to approx. one millisievert (mSv).
- Eating 200 g mushrooms contaminated with 4.000 Becquerel Caesium 137/Kg is equivalent to 0.01 mSv.