Imported food risk statement
Hijiki seaweed and inorganic arsenic

Commodity: Hijiki seaweed

Alternative names used for Hijiki include: *Sargassum fusiforme (*formerly *Hizikia fusiforme, Hizikia fusiformis, Crystophyllum fusiforme, Turbinaria fusiformis),* Hizikia, Hiziki, *Cystophyllum fusiforme,* deer-tail grass, sheep-nest grass, chiau tsai, gulfweed, gulf weed ,hai ti tun, hai toe din, hai tsao, hai tso, hai zao, Hijiki, me-hijiki, mehijiki, hijaki, naga-hijiki, hoi tsou, nongmichae.

Analyte: Inorganic arsenic

Recommendation and rationale
Is inorganic arsenic in Hijiki seaweed a medium or high risk to public health? ☑ *Yes* ☐ *No* ☐ *Uncertain, further scientific assessment required* **Rationale:** • Inorganic arsenic is genotoxic and is known to be carcinogenic in humans. Acute toxicity can result from high dietary exposure to inorganic arsenic.

General description
Nature of the analyte: Arsenic is a metalloid that occurs in inorganic and organic forms. It is routinely found in the environment as a result of natural occurrence and anthropogenic (human) activity (WHO 2011a). While individuals are often exposed to organic and inorganic arsenic through the diet, it is the inorganic species (which include arsenate V and arsenite III) that are more toxic to humans. Only inorganic arsenic is known to be carcinogenic in humans (WHO 2011a). Inorganic arsenic contamination of groundwater is common in certain parts of the world. Dietary exposure to inorganic arsenic occurs predominantly from groundwater derived drinking-water, groundwater used in cooking and commonly consumed foods such as rice and other cereal grains and their flours (EFSA 2009; WHO 2011a; WHO 2011b). However fruits and vegetables have also been found to contain levels of inorganic arsenic in the range of parts per billion (FSA 2012). Seafood is a major contributor to total (inorganic plus organic) arsenic dietary exposure and was, for example, estimated to contribute to approximately 90% of exposure in the United States (Borak and Hosgood 2007). The predominant species of arsenic in seafood is, however, the less toxic organic form, with a minor contribution from the more toxic, inorganic species (Borak and Hosgood 2007). In seaweed inorganic arsenic contributes to at least 50% of the total arsenic concentration (Almela et al. 2002; Rose et al. 2007; WHO 2011a). Bioaccumulation of inorganic arsenic in seaweed varies between the species and within different parts of a single seaweed strand. Inorganic arsenic uptake is influenced by environmental

factors such as season, temperature and pH (Burger et al. 2007; Katayama et al. 2008a; Sharma and Sohn 2009). Reports have consistently demonstrated that specific types of seaweed, particularly those of the *Sargassaceae* family (which comprises approx. 494 members (Guiry and Guiry 2015), contain higher levels of inorganic arsenic than other seaweed types; levels have been reported above the ML in the Australia New Zealand Food Standards Code (the Code) (Almela et al. 2002; Laparra et al. 2003; FSA 2004a; Almela et al. 2005; Almela et al. 2006; Rose et al. 2007; Besada et al. 2009; Smith et al. 2010; Diaz et al. 2012; FSANZ 2013; Brandon et al. 2014). *Sargassum fusiforme* (otherwise known as Hijiki), is a well-known member of this family and is commonly consumed in Japanese cuisine.

However, reports suggest that other members of this family also accumulate and retain inorganic arsenic at levels above the Australian ML in the Code, some with inorganic arsenic levels greater than those reported for hijiki (Whyte and Englar 1983; Katayama et al. 2008a; Yokoi and Konomi 2012; Rahman et al. 2012; Leal-Acosta et al. 2013; Grinham et al. 2014; Naeem et al. 2015; Katayama et al. 2015; Guiry and Guiry 2015). Whether these seaweed varieties are imported into Australia, and subsequently consumed is unknown. Like other types of seaweed, it is likely that preparation prior to consumption is variable in different countries and regions.

Adverse health effects:

Acute toxicity as a result of high exposure (~50 μg/kg bw) to inorganic arsenic can result in gastrointestinal disturbances such as nausea, vomiting and diarrhoea within an hour of ingestion (WHO 2011a). Chronic toxicity is associated with cancer, dermal lesions, cardiovascular disease, developmental effects, neurotoxicity and diabetes (ATSDR 2007; WHO 2011a). Population groups with compromised nutritional status (i.e. low protein intake) are considered to have a significantly higher risk of developing cancers from exposure to inorganic arsenic (WHO 2011a).

Based on evidence that inorganic arsenic (primarily AsIII and AsV) in drinking water is causally related to an increased incidence of cancer in the human bladder, skin and lungs, the International Agency for Research has concluded that arsenic is a human carcinogen (IARC 2012). JECFA withdrew the provisional tolerable weekly intake (PTWI) of 15 μg/kg bw (equivalent to 2.1 μg/kg bw/day) because inorganic arsenic is genotoxic in humans and the estimated dietary exposure is in the region of the lower limit benchmark dose [range, 2.0–7.0 μg/kg bw/day]. A threshold-based health based guidance value such as a PTWI is no longer considered appropriate as a safe level of exposure to inorganic arsenic (WHO 2011a).

Consumption patterns:

Since there was an insufficient number of respondents in either the 2007 Australian National Children's Nutrition and Physical Activity Survey or the 2011 – 2012 Nutrition and Physical Activity Survey (part of the 2011-2013 Australian Health Survey) to permit reliable estimates of seaweed consumption in Australia, an alternative approach was adopted (DOHA 2008; ABS 2014). FSANZ has assumed in its risk assessment that all population groups consume an amount of seaweed that is likely to be an upper level of consumption (FSANZ 2013). In the absence of any additional data in relation to seaweed consumption in Australia, alterations to the existing ML for inorganic arsenic in seaweed cannot be justified at this time.

Key risk factors:

There are a number of risk factors related to the consumption of seaweed. These include:

- The inconsistent uptake of inorganic arsenic by brown seaweed varieties and the unpredictable influence of external factors (e.g. temperature, season and pH) on the degree of uptake
- Physical similarities between some brown seaweed species and the potential difficulty in differentiating between those that typically contain high levels of inorganic arsenic than those with lower levels. This may impact all points in the food chain from seaweed harvesters, importers and potentially consumers
- Use of generic/non-specific terms such as 'kelp' and 'seaweed' in product ingredient lists which gives no indication of the type of brown seaweed in the product
- Individual consumer sensitivity to the effects of inorganic arsenic.

Risk mitigation:

A number of risk mitigation strategies have been established in Australia to reduce the risk of dietary exposure to unsafe inorganic arsenic levels through food. These have included:

- Introduction and maintenance of an ML in the Code for inorganic arsenic in seaweed since 1991
- Introduction and maintenance of MLs for other commodities in Schedule 19 of the Code, which can contribute to the dietary exposure of inorganic arsenic, such as:
    - Crustacea (2 mg/kg)
    - Fish (2 mg/kg) and
    - Molluscs (1 mg/kg)
- Schedule 20 of the Code permits a Maximum Residue Limit (MRL) for the arsenic containing herbicide, monosodium methyl arsenate (MSMA – CH_4AsNaO_3) in sugar cane of 0.3 mg/kg. The residue definition for MSMA is as total arsenic.

Consumer advisory statements have also been released by many countries in relation to the consumption of seaweed containing high levels of inorganic arsenic. This advice had been to avoid the consumption of these seaweed types, despite some evidence that appropriate preparation can significantly reduce inorganic arsenic levels (Sugawa-Kataytama et al. 2005; Katayama and Sugawa-Kataytama 2007; Rose et al. 2007; Katayama et al. 2008b; Katayama et al. 2015).

The advice includes statements from:

- Canadian Food Inspection Agency (CFIA) in 2001 (CFIA 2012)
- United Kingdom (UK) Food Standards Agency (FSA) in 2004 and reiterated in 2010 (FSA 2004a; FSA 2010)
- The Hong Kong Centre for Food Safety (HK CFS) in 2004 (CFS 2011; CFS 2012)
- FSANZ in 2004 (FSANZ 2013)
- New Zealand Ministry for Primary Industries (NZ MPI - formerly known as the New Zealand Food Safety Authority) (MPI 2004a; MPI 2004b)
- Food Safety Authority of Ireland (FSAI 2010a; FSAI 2010b).

Compliance history:

The imported food compliance data sourced from the Imported Food Inspection Scheme of the Australian Department of Agriculture and Water Resources for June 2006 – October 2014 showed that of the 28 samples tested under the risk category for inorganic arsenic applied to seaweed there were six failures, a 21.5% failure rate. Inorganic arsenic concentrations in samples that failed ranged between 22 to 92 mg/kg.

There were 17 notifications on the European Commission's Rapid Alert System for Food and Feed (RASFF) for arsenic (species not specified) in seaweed (also listed as algae, kelp, hijiki or hizikia) from January 2006 – December 2014 with arsenic concentrations ranging from 1.38 to 122 mg/kg (EC 2014).

There have been no food recalls in Australia due to the presence of inorganic arsenic in imported or domestic seaweed from 1989 to February 2015.

Surveillance information:

Inorganic arsenic poisoning from the consumption of seaweed is not a notifiable condition in Australia, however cases of foodborne illness in two or more related cases is notifiable in some jurisdictions (DOH 2014).

Illness associated with consumption of seaweed contaminated with inorganic arsenic

There have been no known published cases of arsenic poisoning directly related to the consumption of hijiki seaweed in Australia. There is however, one case of arsenic poisoning approximately 30 years ago in Australia which was linked to the excessive consumption of a kelp product (species unknown). The level of total arsenic in this product ranged from 30.8-38.3 mg/kg. These levels were in excess of the Australian regulatory limits at

the time (unpublished data).

There have been reported cases of arsenic poisoning from the consumption of kelp products overseas. For example, in both the United States (US) and Canada, there have been reported cases of potential arsenic toxicosis linked to herbal kelp supplements ingested daily over a number of months (Walkin and Douglas 1974; Amster et al. 2007). In one case, the seaweed type in the product was known to be a type of brown seaweed although not within the *Sargassaceae* family.

Data on the prevalence of inorganic arsenic in seaweed

There have been a number or monitoring and surveillance activities conducted in recent years including:

- Survey of inorganic arsenic in seaweed and seaweed-containing products available in Australia (FSANZ 2013).
- New South Wales Food Authority inorganic arsenic in seaweed and certain fish (NSW FA 2010).
- FSA Survey of arsenic in seaweed (FSA 2004b).

Other relevant standards or guidelines

Currently the Code sets a ML for inorganic arsenic in all seaweed; however the former advice to the Department of Agriculture and Water Resources has highlighted hijiki seaweed only. While hijiki seaweed has been shown to contain inorganic arsenic levels in excess of the ML permitted in the Code, there is also evidence to suggest that other members of the *Sargassaceae* family may also contain high levels, as described above.

Approach by overseas countries

Food regulatory counterparts in other countries have issued advisory statements urging consumers to avoid eating hijiki seaweed but none have established specific maximum levels for inorganic arsenic in seaweed; however levels have been set for total (inorganic plus organic) arsenic in other foods.

In the European Union (EU) there are currently no maximum tolerances for arsenic specified in European Commission Regulation (EC) No. 1881/2006, however member states may maintain their national provisions. In the UK, there is a level of 1 mg/kg of total arsenic established in food, although this level specifically excludes seaweed (The Crown 1959; EFSA 2009).

The EU Directive 2002/32/EC specifies undesirable substances in animal feed with a number of MLs for arsenic in seaweed meal and feed materials that are derived from seaweed. Upon request, it must be demonstrated that the inorganic arsenic content is less than 2 mg inorganic As/kg. This is essential if seaweed species such as *Sargassum fusiforme*, syn. *Hizikia fusiforme* are used (EU 2002; EFSA 2009).

Codex Alimentarius has set arsenic MLs for several food commodities, e.g. 0.01 mg/L for natural mineral water; 0.1 mg/kg for edible fats and oils, fat spreads and blended spreads (including margarine and minarine), certain animal fats (e.g. lard, rendered pork fat edible tallow), olive oils and olive pomace oils, and 21 vegetable oils; and 0.5 mg/kg for food grade salt but not for seaweed (EFSA 2009). Food Chemicals Codex has set a limit of not more than 1 mg/kg of inorganic arsenic in kelp as a food ingredient (U.S.Pharmacopeia 2014).

Although all arsenic-based animal drugs are scheduled to be phased out by the end of 2015 the U.S. Food and Drug Administration (FDA) has established maximum residue limits for inorganic arsenic in several animal tissues. These limits range from 0.5 ppm in eggs and uncooked edible tissues of chickens and turkeys to 2 ppm in certain uncooked edible byproducts of swine (US FDA 2013; US FDA 2015).

Canada, through the Canadian Food Inspection Agency's Automated Import Reference System (AIRS), includes additional instructions for seaweed to ensure that it is fit for human consumption. The information specifically references hijiki seaweed and its potential to contain high levels of inorganic arsenic. In Canada, the onus is put onto the importer to demonstrate acceptable inorganic arsenic levels in Hijiki prior to release (CFIA 2015).

Other considerations
Biosecurity restrictions apply to products under this commodity classification including compliance with the Code. Refer to the BICON database It is noteworthy that the database specifies that all dried seaweed for commercial use must be packaged and labelled with full botanical name, including genus and species. Alternatively a declaration must be made by the manufacturer.

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