FOOD STANDARDS
Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

CONSIDERATION OF MANDATORY FORTIFICATION WITH IODINE FOR AUSTRALIA AND NEW ZEALAND

INTERNATIONAL EXPERIENCE WITH IODINE FORTIFICATION PROGRAMS

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1. Introduction

Universal salt iodisation, or USI[1], is the recommended strategy for the control of global iodine deficiency (WHO and UNICEF, 2004). USI, as defined, is rarely achieved and most countries practice a modified version of USI, where either all household salt is iodised and/or particular manufactured foods use iodised salt. Iodisation may be mandatory or voluntary. Many developed countries such as the United States, Canada, Switzerland, Belgium, the Netherlands, Denmark and Germany have introduced legislation allowing and in some cases mandating, the iodisation of household salt and/or use of iodised salt in some processed foods (de Benoist, 2004). The history and practice of iodisation policy and legislation in some countries with economies similar to Australia is outlined below.

2. Background

One third of the world's populations still live in areas with a risk of iodine deficiency (de Benoist, 2004). Since the 1990s, the World Health Organisation (WHO) and UNICEF iodine supplementation programs have successfully eliminated or reduced the risk of iodine deficiency disorders in many developing countries (de Benoist, 2004). Mandatory iodisation of household salt is the most common strategy for iodine fortification in these countries. It is particularly effective in developing countries because table salt is the major dietary source of salt, in contrast to developed countries like Australia, where manufactured foods provide 75-80% of dietary salt (James and Ralph, 1987; Mattes and Donelly, 1991). The advantages of using salt as a vehicle for iodine fortification are:

- salt production is restricted to a few producers;
- salt iodisation technology is easy to implement;
- in most instances the addition of iodine to salt does not affect colour, odour or taste when added to the food;
- the quality of iodised salt can be monitored at production, household and retail levels; and
- salt iodisation is cost effective (Venkatesh Mannar and Dunn, 2006).

There are other strategies used worldwide to combat iodine deficiency. Iodine oil, taken orally or intravenously, is useful in the short term, where particular populations are severely iodine deficient and do not have access to iodised salt (de Benoist, 2004). However it is expensive and labour intensive to administer. Iodisation of the water supply has been used successfully in iodine deficient regional populations in China, (Delong, 2002) Malaysia, (West, 2005) and Thailand (Delange *et al*., 2000a). Iodine has also been used to fortify food. It can be added directly, as in margarine in the Philippines, (Capanzana *et al.*, 2007), or to noodles, bananas and eggs in Thailand (Delange *et al.,* 2000a).

More commonly, iodised salt is substituted for non-iodised salt during food processing. Bread is a popular choice as a vehicle for iodised salt in European countries because it is a staple food with a fairly small variability in salt content.

[1] Universal salt iodisation (USI) – the iodisation of all salt used for human and animal consumption.

Bread is manufactured using iodised salt in Tasmania, Austria, Belgium, Bulgaria, Denmark, Germany, Italy, Netherlands, and Switzerland (Arbeitkreis Jodmangel, 2006). Several other processed foods have successfully used iodised salt, for example sausages and pickles in Germany (Remer and Neubert, 1998) and cheese and meat products in Switzerland (Als *et al*., 1995a; UNICEF, 2006).

Milk and dairy foods are a major source of iodine in many developed countries (Great Britain, Denmark, USA, Belgium, Australia, New Zealand) (Eastman, 1999; Delange *et al*., 2000b; Rasmussen *et al*., 2002; Merck, 2005; USFDA, 2006). The iodine in milk is often due to iodophors used in the dairy industry or from iodised animal feeds (Dunn, 1998; Eastman 1999; Kreiner, 2006). In many European countries where animal feed is iodised, animal products e.g. milk, eggs and meat provide a considerable amount of dietary iodine (Lee *et al*., 1994; Arbeitkreis Jodmangel 2006). These sources of iodine are hard to monitor and regulate as there are seasonal differences in the use of animal feed (Pennington, 1990; Pearce *et al*., 2004) and technological changes occur, for example iodophors are being replaced as equipment sanitisers. The iodine content of milk and dairy products can vary as much as 10 fold (Dunn, 1996).

3. History of iodisation and iodine deficiency disorders

Iodine deficiency disorders (IDD) have been recognised in Europe since the 19th Century. IDD/goitre and cretinism were endemic in the mountainous and remote regions of Europe. Iodising salt was first suggested to treat IDD over 150 years ago by Boussinggault and the technology was further developed in the USA in the early 20th Century (WHO and UNICEF, 2004). Switzerland was the first European nation to establish an iodised salt program in 1922 (WHO and UNICEF, 2004). The USA was also a pioneer, first using iodised salt in 1920 (WHO and UNICEF, 2004). Poland introduced iodised salt in the 1930s as did several other European countries; France, Romania, Slovenia and Yugoslavia in the post world war II period (ICCIDD, 2002a). Many of these early programs were not sustainable due to war, political upheaval, and/or changes in trade or industry practices (Gerasimov, 2002; WHO and UNICEF, 2004).

It was thought IDD was under control in mid-20th Century Europe, and as a consequence many health authorities relaxed the constant surveillance and vigilance necessary to maintain adequate iodine status. Iodine deficiency is again a problem in many parts of Europe, which now has the lowest household access to iodised salt of all the WHO regions[2] (WHO and UNICEF, 2004). In response to an increasing focus on iodine deficiency by WHO, several European countries have instigated or re-instigated iodine fortification legislation over the last 10 to 15 years. Of the 32 western and central European countries reviewed by the ICCIDD in 2002 (Delange *et al*., 2000b; ICCIDD, 2002a), 14 had iodine sufficiency (MUIC > 100 µg/L), 12 were iodine deficient (MUIC < 100 µg/L) and 5 had inadequate data available for an assessment. Table 1 summarises details of the iodisation policies of many Western and Central European countries, the United States of America and Canada.

[2] Who regions are Africa, America, SE Asia, East Mediterranean, Europe and West Pacific

Table 1: Iodine Fortification Policies of Western and Central European Countries, America and Canada

	Salt Iodisation Policy								
Country	**Y/N**	**Year**	**Concentration (ppm)**	**Mandatory/ Voluntary**	**Household**	**Food industry**	**Animal feed**	**Monitoring**	**Iodine nutritional status**
Austria	yes	1963/90	20	mandatory	yes 95%	no	yes	regular	sufficient
Bosnia	yes	2001		mandatory	yes 100%	yes	yes	regular	sufficient
Bulgaria	yes	1994		mandatory	yes 100%	yes	no	regular	sufficient
Canada	yes	1949	76	mandatory	yes 100%	no	no?	none	sufficient
Croatia	yes	1996	25	mandatory	yes 90%	yes	yes	regular	sufficient
Czech	yes	1950	20-34	mandatory	yes 100%	yes	yes	regular	sufficient
Denmark	yes	2000	13	mandatory	yes >90%	yes, baking	no	yes	sufficient, regional variation
France	yes	1952	10-15	voluntary	yes 55%	no	yes	no	deficient
Germany	yes	1991	20	voluntary	yes 84%	yes 30-35%	yes	yes	some deficient areas
Italy	yes	2005	30	mandatory	yes 3%	no	no	planned	deficient
Macedonia	yes	1999	20-30	mandatory	yes 100%	yes	yes	regular	sufficient
Netherlands	yes	1968	50	voluntary	yes 65%	bread some crackers	no	none	sufficient
Poland	yes	1935/97	20-40	mandatory	yes 90%	recommended	planned	planned	some deficient areas
Romania	yes	1956	15-20	voluntary to be mandatory	yes, only 25%	yes	yes	planned	deficient
Slovak Rep	yes	1966	19	mandatory	yes 85%	yes	no	regular	sufficient
Slovenia	yes	1953	20-30	voluntary	yes ?	yes	no	regular	deficient
Switzerland	yes	1922	20	voluntary	yes 94%	bread, cheese	yes	regular	sufficient
Turkey	yes	1999	40	mandatory, not enforced	yes 20-64%	yes	no	planned	deficient
Yugoslavia	yes	1951	12-18	mandatory	yes 73%	yes	yes	planned	regional variation
USA	no	1920	76	voluntary	yes 70%	some	yes	none	sufficient

(ICCIDD, 2002a; WHO and UNICEF, 2004; Arbeitkreis Jodmangel, 2006)

4. International Experience with Iodisation

4.1 Countries with Voluntary Iodisation

Of the 20 Western and Central European and American countries, listed in Table 1 that have iodine legislation, eight have *voluntary* iodisation of salt. Four of these countries have populations with a mild iodine deficiency, including:

- Romania, which has voluntary fortification of salt for household and industrial use. Due to poor uptake, iodised salt is only 25% of the market, there are plans to make iodisation compulsory (ICCIDD, 2002a).

- In Italy, until mandatory iodisation was introduced in 2005, iodised salt was available, but its use was limited to about 3% of sales (ICCIDD, 2003c).

- Slovenia, where iodisation is universal but voluntary. Data from the last 16 years shows that 79% of 16 year olds have goitre (ICCIDD, 2003e).

- France continues to have a mild iodine deficiency even though iodised salt is used in the home and for animals and market coverage is about 55% (ICCIDD, 2002a).

Iodine deficiency also persists in countries such as Greece, Ireland, Hungary and Spain where there is no specific iodine legislation but *voluntary* iodisation is allowed (ICCIDD, 2006). In Ireland, table salt can be iodised but uptake is only 3.3%. There is evidence that sections of the population are iodine deficient (Narwoor *et al*., 2005).

4.2 Countries with Mandatory Iodisation

In most countries where iodisation is mandatory, iodine sufficiency has been achieved. Turkey and Belgium are the exceptions. Turkey is unable to adequately enforce their policy of mandatory universal iodisation and iodised salt has only achieved 20-30% of the market share. Iodisation legislation exists in Belgium but has never been implemented. Both countries remain iodine deficient (Delange *et al*., 2000b).

Some of the central European countries with traditionally high levels of endemic cretinism and goitre, for example Bosnia, Bulgaria, Croatia, Czech Republic and Yugoslavia, have been more aggressive in legislating for universal salt iodisation (ICCIDD, 2002a; Laurberg *et al.*, 2003; WHO and UNICEF, 2004). Other countries with mild to moderate iodine deficiency chose iodisation of household salt only, or selected manufactured foods, for example, Denmark with bakery goods, (Laurberg *et al.*, 2003) and Netherlands with bread (Brussaard *et al*., 1997). These programs have successfully improved iodine deficiency.

4.3 Switzerland

Switzerland is a prime example of a successful iodisation and monitoring program. Historically the Swiss had high levels of IDD including cretinism and goitre. The country implemented legislation in 1922 to iodise salt for human consumption (WHO and UNICEF, 2004). The potassium iodide content of salt has been gradually increased over the last four decades; from 7.5 mg iodine/kg in 1962 to 15 mg iodine/kg in 1980 and to 20 mg/kg in 1998 (Zimmermann *et al*., 2005).

In the 1980s, IDD seemed to be resolved when a sufficient UIC (urinary iodine concentration) of 141 µg/day was found in 112 adults from all over Switzerland (Burgi *et al*., 1990). However, in the 1990s some studies suggested that iodine status was marginally deficient among schoolchildren and pregnant women, (Als *et al*., 1995b) and moderately deficient (70-90 µg/L) in 266 adults (Als *et al*., 2000). Several reasons have been suggested for the decline in iodine status during the 1990s, including:

- the population reducing their use of household salt in response to health messages from the government to reduce sodium intake;
- more imported foods being consumed and an increasing number containing non-iodised salt (Zimmermann et al., 2005);
- food habits changing: an increasing proportion of the dietary sodium is coming from manufactured foods and many of these foods are iodised at low levels, (5-10 mg/kg) or not at all (Als et al., 1995a); and
- the manufacturing industry iodising a smaller range of foods (from 80% to less than 70%) (Zimmermann et al., 2005), to facilitate trade (Als et al., 1995a).

In Switzerland the production and trade of iodised and uniodised salt is controlled by a state monopoly (Als *et al.,* 2004). Iodised salt now has a market share of 94% of household salt and 67% of salt used in commercial food production (ICCIDD, 2002a).

There are several reasons for the ongoing sustainability of the Swiss iodisation program. These include:

- state control of salt manufacturing since 1909;
- constant surveillance of iodine levels at production sites;
- government keeping the cost of iodised salt the same as non-iodised salt; and
- monitoring the iodine status of the population every five years by a commission which can increase (or decrease) iodisation levels when necessary .

The Swiss program may be threatened by international trade regulations which could block monopolies and prevent artificial low pricing of iodised salt (Zimmermann *et al*., 2005).

4.4 United States of America

Endemic goitre was common in Midwest and Northwest America until the 1920s (Hollowell *et al*., 1998; Dunn, 1998). In 1923, after David Marine demonstrated that iodine treatment could reduce and prevent goitre, health authorities campaigned for the general use of iodised salt as a prophylactic. By the 1930s most table salt was iodised although iodisation remained voluntary (Dunn, 1998). Today, iodised salt constitutes approximately 50-60% of the market and salt is iodised at 100 ppm (ICCIDD, 2002b).

Iodine, in various forms is also used incidentally, (rather than as a prophylactic) as a bread conditioner, in food colouring, as a sanitiser for milking equipment in the dairy industry and in animal feed (Dunn, 1998). This often leads to high but variable amounts of iodine in the food supply (Pennington, 1990; Dunn, 1998). A study examining the iodine content of milk and bread in the Boston area (Pearce *et al*., 2004) found that the iodine content of the different brands of bread varied from over 300 µg per slice to as low as 2 µg per slice. Reports show variations in the iodine concentration in milk ranging from 16-34 µg /100 ml (Pennington, 1990).

The US population also obtains iodine from vitamin supplements, health foods such as kelp, skin antiseptics and certain medications (Hollowell *et al.,* 1998). Most of these sources are unrecognised and none are regulated (Dunn, 1998).

In the United States urinary iodine levels are monitored regularly, as part of the NHANES Survey and dietary iodine intakes as part of the Total Diet Study (USFDA, 2006). Further monitoring is essential, not least because many sources of iodine are incidental and iodine intake can vary regionally and/or seasonally.

In the late 1970s the Total Diet Study reported up to five times the Recommended Daily Allowance in several foods, but primarily in dairy foods (Taylor, 1981). This resulted in the dairy industry reducing their use of iodophors (Egan and Bailey, 2002).

Between the 1971-74 NHANES I survey and the 1988-94 NHANES III survey urinary iodine levels have decreased considerably (Hollowell *et al.,* 1998). This decrease may be due to:

- the reduction in the use of iodophors in the dairy industry;
- the replacement of iodine by bromine salts as the dough conditioner in commercial bread production (Hollowell *et al.,* 1998); and
- voluntary salt reduction, secondary to concerns about the sodium intake and hypertension (Hollowell *et al.,* 1998).

More recent results from the NHANES 2000 report show no significant change from the 1988-94 NHANES III survey. However the survey showed an increased prevalence of mild iodine deficiency in women of child-bearing age. As incidental iodine use decreases or the population reduces its use of discretionary salt in response to health messages, the possibility of further decreases in iodine status increases (Dunn, 1998).

4.5 Germany

Germany has a history of IDD and in the 1970s goitre prevalence was recorded as 30-60% of the population (ICCIDD, 2003a). In 1996 a nationwide survey of 5,932 people from 32 regions showed a 30% deficit in recommended iodine intake (Gartner, 1999). However, studies after 2000 confirm a marked improvement in the iodine status of the German population (ICCIDD 2003a). (Manz *et al*., 2002), (Remer *et al*., 2006). Although mean iodine status appears sufficient, some researchers believe that iodine deficiency continues to exist in particular regions of Germany (Kreiner, 2006).

Iodisation of salt and/or iodine fortification has a complex history in Germany.
East Germany had compulsory iodisation of table salt at 20 ppm and of animal feed at 10 ppm until unification in 1990. Iodisation then became voluntary in both East and West Germany.

In *West* Germany, prior to unification, restrictive regulations on food additives had limited the use of iodised salt in many manufactured foods. The iodisation salt level for household use was low. However in 1981 the salt iodisation level increased from 5 to 20 ppm but this only marginally improved iodine status for West Germans (Remer and Neubert 1998).

In 1989, it became legal in West Germany to add iodised salt to industrially processed foods and canteen meals.

After unification, many more restrictive regulations on food additives were removed. In 1991, when the use of iodised salt in the pickling of meat and sausage was mandated, iodine status improved significantly.

Iodine status improved again after 1993 when new legislation made labelling of iodised manufactured foods unnecessary (Remer and Neubert 1998).

Iodised salt for household use now has 84% (ICCIDD, 2002a) of market share but only 30-35% of salt used in the food industry is iodised (Remer *et al*., 2006; Kreiner, 2006). The use of iodised salt in manufactured foods has decreased since 1996 (ICCIDD 2003a).

In Germany an important incidental source of iodine is from animal feed which was iodised in 1995 to improve animal health. Iodisation of animal feeds wasn't fully adopted until 2000. The improved iodine status of the German population after 2000 may be due in part to the more widespread use of iodised animal feeds. A longitudinal study of 358 children aged 6-12 years reported that the contribution to iodine status from milk and eggs almost doubled from the period 2000 to 2003 compared with 1996 to 1999 (Remer *et al*., 2006). This demonstrates the significant 'carry over' effect on iodine status of humans consuming products from animals fed on iodised feed.

4.6 Netherlands

While severe iodine deficiency, for example cretinism, is not prevalent in the Netherlands, goitre is common in the south eastern regions. Iodine supplements have been used since 1935 (Wiersinga *et al*., 2001). Iodised salt for baking bread or 'bread salt' has also been used as a prophylactic since 1942 (Brussaard *et al.,* 1997). Legislation for the mandatory iodisation of salt used in bread was first enacted in the Netherlands in 1968. A high court case in 1982 found that mandatory iodisation of bread salt was unconstitutional and since then bakeries have been able to choose to use iodised or non iodised salt in their bread (Grit, 2006).

During the time that iodisation was mandatory, the majority of bakers believed that iodine fortification of bread was beneficial to their industry. Due to a widespread education campaign iodisation was also well accepted by the population and iodised bread was considered a healthy basic food. Once the habit of iodine fortification was established in the baking industry most bakers chose to continue using iodised salt in their bread although it is no longer compulsory (Grit, 2006).

Since mandatory fortification was repealed in 1982, several studies from 1987-92 reported inadequate iodine status, especially in women. Surveys conducted in the 1980s found a high prevalence of goitre (35% in women and 18% in men) (ICCIDD, 2003d). In a move to improve the iodine status of the population, the fortification level of bakers' salt was raised in 1999 to 75-85 mg iodine /kg salt. Permission was also given to use bread salt in bread replacers and some meat products. This was in response to a decline in bread consumption in favour of bread replacers like crackers, rusks and breakfast cereals. The use of iodised household salt has also declined since mandatory iodisation was repealed (Grit, 2006).

Several studies since 2000 demonstrate that these measures have been effective in improving the iodine status of the population (Wiersinga *et al.,* 2001).

The Netherlands is now considered iodine replete (ICCIDD, 2003d).

It could be said that voluntary iodisation has been effective in the Netherlands. However, this may be because the Netherlands once had *mandatory* fortification which meant that iodisation was already well established and accepted by industry and consumers.

4.7 Denmark

In Denmark, fortification of food with nutrients is only allowed if:

- the population is deficient in that nutrient;
- the fortification will lead to an effective increase of the nutrient; and
- the effect on the population is monitored (ICCIDD, 2003b).

In 1982 it became illegal to sell iodised salt in Denmark after a working group found iodine enrichment 'nutritionally irrelevant'(Rasmussen *et al*., 1996).

Several studies had demonstrated an inadequate iodine status and a high incidence and prevalence of iodine related deficiencies in the Danish population (Rasmussen *et al*., 1996).

In 1994, the Danish Veterinary and Food Administration responded by establishing a working group to evaluate the need for an iodine fortification program in Denmark. The Working Group concluded that iodised salt in bread gives similar coverage as using iodised salt in all manufactured foods. They concluded the majority of the Danish population was iodine deficient and that the benefits of iodine fortification far outweighed the risks. Careful monitoring of iodine levels in foods and the iodine status of the population were integral parts of the implementation of mandatory iodine fortification strategy (Rasmussen *et al*., 1996).

When salt iodisation was introduced in 1998, it was voluntary. An agreement was made with the salt and food industry with the expectation that iodised salt would cover at least 80% of the market within 2 years. After 18 months, iodised salt covered around 50% of the household market but none for industry. The voluntary approach was found to be ineffective (Laurberg *et al.*, 2003). Consequently, in 2000, salt iodisation was made mandatory for household use and for commercial bread and cake production (Pedersen *et al*., 2006).

Monitoring was mandatory and the population was monitored carefully for iodine intake and the occurrence of thyroid disorders. Monitoring of the population occurred on two levels:

- Regular monitoring of iodine levels in salt, bread and cakes at retail outlets and sales of iodised salt.
- A long-term study of a cohort of 4649 subjects living in two areas of Denmark with different ground water iodine levels (Aalborg and Copenhagen) was launched to assess the effect of the fortification program on the population (Laurberg et al., 2006).

The legislation has been well supported by industry with 97% of rye bread and 905 other brands of bread using iodised salt (Laurberg *et al*., 2006). A study assessing the increase in iodine intake after fortification (Rasmussen *et al*., 2007) found a desirable increase in iodine intake.

4.8 Canada

During the first half of the 20th Century, iodine deficiency was common in Canada. Fortification of salt and bread with iodine was voluntary and public health campaigns advised consumers to choose fortified products or take supplements. Unfortunately, this strategy proved ineffective. Iodine deficiency remained a problem because most people still chose to eat the unfortified alternatives (Bowley, 2003).

Mandatory iodisation of table salt was introduced in Canada in 1949. Reports indicate that in spite of this mandatory approach, it took until the 1970s to gain compliance on a broad basis (Bowley, 2003). Mandatory fortification of table salt exists in the whole of Canada. The coverage of iodised table salt in Canada has reached almost 100% (ICCIDD, 2001).

Milk has also been a significant source of iodine for Canadians. From 1987 data, the iodine content of milk ranged from 122 µg/L in Newfoundland to 517 µg/L in Manitoba. (ICCIDD, 2001). This is due to iodophors used in the dairy industry and also to use of animal feeds with added iodine. The use of iodine in animal feed is similar to that in the US and Europe. As in the USA and Europe the iodine levels in milk are higher in winter months because animals are more reliant on being hand feeding, (with iodised animal feed) and less on grazing on natural pasture grasses.

5. Conclusion

International experiences with iodine fortification has shown that mandatory fortification is a more reliable and stable method to ensure that the population achieves a safe, predictable and adequate iodine intake. This review of international experience with iodine fortification has shown:

- Of the 20 European countries (also including the USA and Canada) with effective iodine legislation, those with mandatory fortification almost all had achieved ‘sufficient’ iodine status.

- Of the countries (listed in table 1) with voluntary fortification legislation, only half have achieved an adequate iodine status.

- Many countries with voluntary fortification, for example Switzerland and the USA, which were originally successful in improving iodine status, now find changes in food habits, manufacturing practices and imports/exports, have resulted in decreases in the amount of iodine in the food supply.

- Many countries have found voluntary fortification with or without a public education campaign unsustainable or ineffective in the long term and have introduced mandatory fortification. Denmark, which is similar to Australia in many ways, is a case in point.

- In industrialised countries people obtain more than 75% of their salt and therefore most of their iodine, from processed foods. However, in Switzerland and Germany industry appears to be decreasing the fortification level of processed foods and or the range of foods fortified with iodine.

- Mandatory fortification of bread with iodised salt has been successful in addressing iodine deficiency in populations identified as deficient.

- Mandatory fortification can deliver a predictable and appropriate level of dietary iodine. Dietary iodine from sources such as iodophor use and animal feeds frequently result in erratic, unpredictable and unsustainable amounts of iodine in the food supply.

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