

Final report Review of use of iodized salt in processed foods

Justus M. de Jong, 14 August 2007

Executive summary.

Realization and sustainability of optimal iodine nutrition may be undermined in countries where the majority of household salt is iodized and where processed foods constitute a large and ever increasing share of the daily diet, since the majority of these foods are made with non-iodized salt and the consumption of iodized household salt is decreasing.

The seemingly obvious solution to incorporate iodized salt in processed foods is often hampered by inadequate legislation, lack of awareness about the effects of iodine deficiency and reluctance of food producers to use iodized salt due to concerns about adverse effects of iodine on the quality and acceptance of their products.

With an initial focus on Europe and North America, this report presents a review of the current use of iodized salt in the processed foods industry

Including a limited number in other continents in total 65 countries have been reviewed.

The review shows a very diverse picture concerning the legislation and practical application.

Compulsory use for all food products, voluntary use for all or a restricted number of food products, no permission to use iodized salt at all or lack of legislation on the subject have been observed.

With WHO's 2004 Report on the Global Status of Iodine Nutrition as reference, it has been concluded that compulsory use of iodized salt in households and in processed foods does not guarantee fast realization of optimal iodine nutrition and that optimal iodine nutrition can be realized through different iodine fortification programs.

Reviewing examples of implementation of the use of iodized salt in processed foods show that conditions for success and sustainability are awareness of the risks of iodine deficiency, adequate legislation in line with a country's dietary customs and "legislation culture", regular monitoring of iodine nutrition status and dietary intake and cooperative role of salt industry and food producers.

Aspects which need to be addressed when applying iodized salt in processed foods are the choice of food product(s), possible effects of iodine on food products, loss of iodine at processing and storage, efficacy and effectiveness of iodized food product(s), costs for food producers to replace non iodized salt by iodized salt and differences in legislation that might affect business opportunities for salt and food producers.

Regarding the effects of iodized salt on processed foods, in total 35 publications and reports have been reviewed, with more than 20 food products investigated. The publications reviewed include also the retention of iodine at processing, storage, cooking and heating of the food products as well as the nutritional aspects of iodine in processed foods.

As regards the publications and reports with a focus on possible adverse effects, a very limited number of adverse reactions on product quality and appearance have been reported, only observed at high iodine content and when using potassium iodate.

It can be concluded that provided low iodine fortification levels are used, no adverse effects are observed in most food systems.

Since reports on use of iodized salt with iodate as source for pickling vegetables are controversial, use of iodide should be considered in the application.

The reported assessments of iodine stability show substantial losses of iodine, dependent on product and condition.

However it has been observed that in the studies examined different analytical methods have been used to assess the iodine content in foods.

In recent publications the more advanced analytical method ICP-MS has been used to determine iodine in food samples, and earlier losses of iodine might be based on inappropriate analytical methods.

The review resulted in the following recommendations for the Iodine Network.

- Communicate the message that use of iodized salt does not effect the quality and appearance of most commonly used food products.
- For use in pickling vegetables the consequences of using potassium iodide in stead of potassium iodate should be investigated.

- Investigate and compare the reported methods analytical methods for the determination of iodine in food products. Such investigation might result in an appropriate and commonly accepted method.
- When legislation in a country implies voluntary use of iodized salt in processed foods, Network members should work in National Coalitions on involving the food sector and support the set up of an adequate program for the iodine fortification of processed foods.
- The Network should consider having the scope of the Country assessments extended with the use of iodized salt in processed foods.

1. Background.

Iodine nutrition through regular consumption of adequately iodized salt is the key strategy to cope with the devastating effects of iodine deficiency.

The perception is that efforts to implement Universal Salt Iodization (USI) have mainly been focused on iodization level of household salt so far.

Therefore in many countries which apply salt iodization programs, the majority of table salt is iodized and the major part of processed foods is made with un-iodized salt.

There is a general consensus that in the industrialized countries already about 75% of the Na intake as salt is consumed through the food we buy.

The discretionary use of table salt or cooking salt, contributing about 15% of the total intake, is at best constant to decreasing.

The remaining 10% of the Na intake is derived from the natural content in the diet.

This trend, which is in particular observed in the developed countries but more and more also in countries in the developing world, will consequently undermine adequate iodine nutrition.

A seemingly obvious and simple solution would be the use of iodized salt in processed foods.

However two aspects frustrate this solution.

Firstly in many countries, permitting iodization of table salt, the use of iodized salt in processed foods is not permitted or if permitted restricted to certain food products or segments.

Secondly, if permitted, the reluctance or resistance of food processors to use iodized salt.

A reason for this reluctance or resistance should be the perception of food producers that iodine in the salt will adversely affect the quality and characteristics of their food products, despite studies on a range of processed foods that suggest no negative impact of iodized salt on processed foods.

To consider whether the USI focus of the Iodine Network should be adapted and when relevant to act accordingly, it has been decided to execute a desk study on the use of iodized salt by the food processors.

The major objectives of the study are:

- a review, per country, on the current use of iodized salt in processed foods and all aspects affecting its use, with an initial focus on North America and Europe;
- a document with a list of all relevant studies, published and not published, and other information sources to better understand the phenomena experienced and observed;
- a proposal for actions aimed at optimal iodine nutrition through expansion of the use of iodized salt in processed foods.

2. Methodology

Information for the review on the current use per country has been obtained through distributing questionnaires to and individual communication with (associate) members of Eu Salt and Salt Institute, through cooperation with Unicef's CEE/CIS officers in Geneva who are also working on the subject, through approaching ICCIDD regional coordinators and Unicef's EAPRO regional office and analyzing the IDD Newsletters and country information on the Iodine Network website on relevant info.

Information to document all relevant studies on the subject, in particular on studies concerning the effects of using iodized salt on the quality of foods, on their processing and acceptability has been obtained through searching in public accessible search engines (Google Science) and through the paid databases FSTA (Food Science and Technology Abstracts), FROSTI and FOMAD (Food line Science Database and Food line Market Database) kindly made available by an Eu Salt member.

Information on the aspects that should affect the use of iodized salt in processed foods is mainly obtained through the testimonials on the subject of individual food producers arranged and compiled by Unicef CEE/CIS office.

Though directly involving the food processors is not in the scope of this study, some information on the perception of the industry and their general attitude *vis a vis* salt iodization have been obtained through above testimonials, through interviewing sales people from the salt industry and through thus far one contact with a major food producer in Europe.

A note on the data compiled for Europe.

The European competition law does not permit obtaining and collecting sensitive quantitative data from individual companies in the EU member states.

Such data include the share of iodized /iodated salt in the total amount of salt supplied to the processed food processors.

A related aspect is originating from the structure of the European salt industry. In several cases a country = one company when there is only one national producer like in France and Austria or if there are only two producers like in the Netherlands, Germany and the UK.

3. Review of the current use of iodized salt

3.1 Introduction

Following primarily the focus of the study, info has been compiled from North America (USA and Canada), from 24 of the 27 European Union Member states and from Switzerland. From the remaining 3 countries in the EU: Cyprus, Luxembourg and Malta no info source on the subject could be found.

Additionally the situation in 18 countries from the CEE/CIS region has been collected.

Thus far limited information could be obtained, in addition to what already has been indicated in the ICCIDD /Network sources on iodine nutrition from the other UN regions: Latin –America, Carribean, Middle –East/ North Africa, Africa-Sub Sahara, South Asia and East Asia –Pacific. Only some scattered info has been received and compiled thus far.

Analysis of both the IDD Newsletters from 2002 and Iodine Network Country information underlines the statement in the introduction that thus far efforts to implement Universal Salt Iodization (USI) have mainly been focused on iodization level of household salt.

Nearly all the articles in the Newsletters and the Iodine Network Country information reviewed do lack information on the subject.

Where relevant, further comments and remarks on the situation per region and individual country is given below.

The review on the situation in the focus areas and CEE/CIS region shows that the current situation is far from being uniform.

3.2 North America.

In the **USA**, iodization is permitted on a voluntary basis at a level of 77ppm as KI, however, virtually none of the salt sold to food processors is iodized.

At the consumer level, there is no difference in price between iodized and non-iodized salt and the population gets its iodine through iodized table salt with coverage of 70% of the households and through other sources.

Dairy products and meat, by using iodine containing cattle feed and by the use of iodophor disinfectants in cow milk production, have been major sources.

Through the use of iodated bread conditioners, commercially baked breads have been another major source of iodine in the US diet.

Multivitamin formulations are another source of iodine.

Changes and limitations in the allowable amounts of iodine compounds in cattle feed and concern on the high bread iodine intake should have contributed to the observed reduction in the iodine levels in the diet.

In **Canada** all table salt is iodized at an iodine level of 77 ppm as KI, mandatory by law since 1949, with coverage of near 100% at households.

Iodide is a nutrient under the Food & Drugs Act. The Food & Drugs Act permits iodide to be added to certain foods only - for example infant cereal, foods represented for use in very low energy diets, meal replacements & nutritional supplements.

Iodide is NOT listed as a permitted nutrient in breakfast cereals, fruit drinks, milk products, simulated meat products, ready breakfast, flour products, precooked rice, for example.

The exception is if the iodide added to the food comes from "table or household salt" which already must contain iodine. But not many food processors are going to be buying table salt. Milk has also been a significant source of iodine.

3.3 European Union and Switzerland.

The review (see Appendix I) shows that the situation differs per state.

From a number of EU member states the situation is outlined in more details below.

In **Bulgaria, Denmark, Slovakia and Romania** the use in processed foods is compulsory, either in all foods or in a limited number of segments.

In **Bulgaria** is use of iodize salt compulsory and applied in all food segments at a level of 28-55ppm iodine as KIO₃ since 2001.

Information on the situation in **Slovakia** is scarce, but use of iodized salt should also be also compulsory for all food segments at a level of 25 ppm KIO₃.

In **Denmark** salt iodized with 8-13 ppm became mandatory for household salt and bread salt in 2000.

However it is only mandatory for all breads and cakes baked in Denmark and sold in Denmark.

In **Romania** iodized salt is compulsory for households and bakeries and rest of food industry at a level of 26-42 ppm from 2003.

However when put in practice only in the bread segment coverage of close to 100% has been realized in 2004. Application in other segments has been put on hold due the strong belief and suspicion related to the quality of pickles industrially (as well as at home) produced with iodized salt.

In **Poland**, Austria and Czech Republic the use of iodized salt in retail (households) is compulsory but not allowed (Poland) in processed foods or only permitted on voluntary base (Austria, Czech Republic).

Observed reports on the situation in the **Czech Republic**, with its mandatory use in households, give different information on the use of iodized salt in the food industry. One report indicates that 70 % of the meat products use iodized salt whereas iodized salt in the other branches is only 14% (**Gerasimov, 2002**) of the whole salt supply. Another source indicates that 65-80% of the food industry is using iodized salt.

In **Austria** the use of iodized salt is permitted in all food products but a roughly estimated market share is only 25%..

In other member states iodized salt is used in households on voluntary base and permitted in processed foods, in all food segments or in a limited number or not allowed at all in processed foods.

When use of iodized salt is allowed on voluntary base, in general the use is limited (estimated shares of <5% up to 25% have been reported).

The relative positive exceptions are Netherlands, Germany, Czech Republic and Spain.

In **Netherlands** iodization of household salt started in 1928 and bread salt is iodized since 1942.

Though legislation changed from compulsory to voluntary use after a decision of the high court in 1984, still 95% of the bread producers are using iodized salt.

Compulsory use was considered to be non –constitutional.

An observed decline in bread consumption in favor of bread replacers and cereals in the 1980's and 1990's, has affected the iodine nutrition of the population, in particular of women.

In 1997 the Dutch authorities decided to increase the level of iodine in bread salt from 45 ppm to a range of 70-85 ppm and to permit the use of that salt in bread replacers (based on grains). Also the use of iodated nitrite curing salt in meat products at a level of 20-30 ppm iodine was permitted from then, all on voluntary base.

However share of iodized salt in these new segments is still very limited.

Simultaneously the iodine content in household salt has also slightly been increased from 25 up to 30-40 ppm iodine.

Increasing the iodine content in table salt in **Germany** in 1981 from 5 to 20 ppm only marginally improved the iodine status of the population.

Therefore additional legislative measures were undertaken. In 1989 addition of iodized salt to industrially processed foods and canteen meals was approved. In late 1991 the use in pickling of meat and sausages was approved. Finally in 1993 a restricting decree on separate labeling of food containing iodized salt was removed.

These measures, regular monitoring and pressure by a national lobbying committee Arbeits-Kreis Jodmangel contributed to the current situation which is rather good, particularly in the meat processing segment. Though the use of iodized salt is not mandatory it is estimated that 60-80% of the meat products is processed with iodized salt.

However USI is far from realized since iodized salt for application in the total food segment has reached a range of only 30-40%.

Without having further details a market share of iodized salt in the order of 25% has been reported for **Spain**.

Regarding **Switzerland**, with its long history of salt iodization, a share in the range of 50- 70% in the food sector has been reported, though the use of iodized salt is on voluntary base and manufacturers (and retailers) must offer both iodized and non iodized salt products.

However a decline in the use in processed foods is reported due to effects of anti- iodine lobby and the fact that export oriented food producers are reluctant to use iodized salt because its limits their market due to meeting regulations in export countries.

Obviously above outline of the situation is reflected in the **legislation** on the subject that is differing from country to country, as illustrated in the Table 1 below.

3.4 CEE/CIS

In the member states of the UN CEE/CIS region (excluding the few current EU member states in that region, which have been elucidated above) the situation is as follows.

In 13 states: **Armenia, Azerbaijan, Belarus, Bosnia Herzegovina, Croatia, Georgia, Kazakhstan, Kyrgyz Republic, Macedonia, Moldova, Serbia, Tajikistan and Turkmenistan** the use of iodized salt in all processed foods is compulsory.

In **Turkey** the use of iodized salt is not permitted.

Legislation of the use in **Albania, Russian Federation, Ukraine and Uzbekistan** is still missing. In practice no use of iodized salt in Albania, Ukraine and Uzbekistan and limited use in the Russian Federation.

In **Russia** iodized salt that is used in processed foods, is mainly applied in bread baking, for production of condiments and instant noodles.

The situation in Ukraine and in the Russian Federation is influenced by the wide spread belief that of the quality impact of iodized salt on food products.

The **legislation** in major part of the former countries of the Soviet Union is identical being a level of 40 +/-15 ppm iodine as KIO₃.

Note: Currently Unicef CEE/CIS office Geneva is working on a detailed report on the situation in the region.

Table1, Review of current regulations concerning use of iodized salt in processed foods in EU member states and CEE/CIS countries

Country	Legal status	Permitted iodine source	Iodine content (mg/kg)	Permitted applications
Albania	no legislation	KI	25	
Armenia	compulsory	KIO ₃	50	All food products
Austria	voluntary	KI, KIO ₃	30	All food products
Azerbaijan	compulsory	KIO ₃	40+/-15	All food products
Belarus	compulsory	KIO ₃	40+/-15	All food products
Belgium	voluntary	KI, NaI, KIO ₃	6-45	All food products

Bosnia & Herzegovina	compulsory	KI	20-30	All food products
Bulgaria	compulsory	KIO3	28-55	All food products
Croatia	compulsory	KI	25	All food products
Czech Republic	voluntary	KIO3	20-34	Limited use
Denmark	compulsory	KI	13	Bakery products
Cyprus	?			
Estonia	no legislation			
Finland	voluntary	KI	21-26	All food products
France	not permitted			
Germany	voluntary	KIO3	20	All food products
Georgia	compulsory		40+/-15	All food products
Greece	voluntary	KI	40-60	?
Hungary	voluntary	KIO3	15	All food products
Ireland	no legislation			
Italy	voluntary	KI, KIO3	30	All food products
Kazakhstan	compulsory	KIO3	40+/-15	All food products
Kyrgyzstan	compulsory	KIO3	40+/-15	All food products
Latvia	no legislation			
Lithuania	no legislation			
Luxembourg	?			
Macedonia	compulsory	KIO3	20-30	All food products
Moldova	compulsory			
Malta	?			
Netherlands	voluntary	KI, KIO3	70-85; 20-30	Bread(replacers); meat
Norway	voluntary	KI	5	?
Poland	not permitted			
Portugal	voluntary	KI	20	?
Romania	compulsory	KIO3	26-42	Bread, other segments on hold
Russian	no legislation			
Serbia	compulsory	KI	12-18	All food products
Slovakia	compulsory	KIO3	25	All food products
Slovenia	voluntary	KI	20-30	All food products
Spain	voluntary	Ki,KIO3	51-69	All food products
Sweden	voluntary	KI	50	All food products
Switzerland	voluntary	KI, KIO3	20-30	All food products
Tajikistan	compulsory	KIO3	45+/-5	All food products
Turkey	not permitted			
Turkmenistan	compulsory	KIO3	40+/-15	All food products
Ukraine	no legislation			
United Kingdom	voluntary	KI	10-22	All food products
Uzbekistan	no legislation			

3.5 Australia & New Zealand

In **Australia and New Zealand** the mandatory level of iodization of household salt is 25 to 65 ppm.

Thus far it is possible to voluntarily include iodized salt in a range of food stuffs.

However the majority of food companies use non-iodized salt for processed foods.

Based on an observed low iodine intake and monitored iodine deficiency, very recently the Foods Standards Australia New Zealand (FSANZ) has drafted a final proposal that iodized salt at a level of 35-55ppm iodine will be added to bread on mandatory base.

The current deficiency is suggested to be related to a/o reduced use of iodine based cleaning products in the dairy industry and a decreased consumption of iodized salt, due to greater use of non-iodized salt and a reduction in total salt intakes.

The previous proposal to add iodized salt also to biscuit and cereals has been removed from the final proposal.

Biscuits have been removed from the previous proposal since the product contributes the least to increasing the population's iodine intake, but posed the greatest impost on trade with respect to both imports and exports.

Other arguments were the variable salt content of the different biscuit categories and observed concerns that biscuits with iodized salt could be perceived as legitimizing the product as healthy food.

Removal of breakfast cereals has been based on technological concerns that the particular salt addition to the product might deliver inconsistent amounts of iodine to the products.

The final proposal includes retaining the voluntary use of iodine in iodized salt and reduced sodium salt with slight adjustment of the iodine range: from 25-65 to 35-55 ppm.

In July 2007 the Australian and New Zealand Food Regulation Ministerial Council will consider the proposal.

3.6 Others

China has adopted and implemented USI in 1995.

Since then substantial progress in the coverage of households with iodized salt has been achieved on country level.

However an evaluation on the progress in 2000 showed that still 14 provinces are unable to achieve adequate coverage of households consuming iodized salt.

A recent report, obtained through Unicef EAPRO, on the comprehensive intervention project, implemented since 2000 has mainly been focused on improving use of iodized salt at household level.

As regards processed foods in the report only the situation in Chongqing, one of the ID high risk provinces has been described.

Being hometown of pickled tuber mustard, Chongqing has a century long history of producing this product, which has become a pillar industry locally.

The key reason for the low iodized salt coverage in this region is that the salt market is impacted by the sale of non-iodized salt used in producing this pickled tuber mustard. That salt is cheap, people have a deficient understanding of IDD, and some households can benefit from reselling such salt, so consequently the majority of local residents eat pickled tuber mustard salt. Non-iodized coverage is therefore kept at a high level, which has seriously affected local IDD control.

In **Philippines** the government passed the so-called ASIN Law (An Act Promoting Salt Iodization Nationwide and for Related Purposes) on 20 December 1995 to help alleviate the IDD problems in the country.

The Law requires that all food processors use iodized salt in the production of their products, effective December 1996.

Though no data of market shares are available, Philippines' studies on the subject suggest that implementation is still a challenge.

In **Indonesia** a Presidential decree of 1994 enacted national legislation by mandating that all salt for human consumption must be iodized. That decree was followed by a Ministerial Decree on standards for manufacturing, quality and packaging.

The 2003 Unicef review of progress toward sustained IDD elimination in Indonesia, though primarily focused on iodized salt for households, mentioned that “obtained information indicated that many large food producers are already using iodized salt habitually as ingredient in their product processing”.

However it has been recommended that the authorities should put efforts in verifying and compelling that iodized salt is always used by all food processors, suggesting that the goal as prescribed in the Decree of 1994 has not been achieved.

Regarding **India** no specific information on the use of iodized salt in India could be found. According to information obtained from the Indian Salt Manufacturers Association on salt production and supply, 4.89 million ton iodized salt has domestically been supplied in 2006. Since the total production of edible salt was 5.2 million ton, one might conclude that use of iodized salt in foods industrially processed is common practice.

In **South Africa** the use of iodized in processed foods is allowed on voluntary basis. In a publication on the subject, the use of iodized salt in manufacturing of bread, bread premixes, margarines and flavorings of salty snacks has been reported.

In **Brazil**, where use of iodized salt is permitted on voluntary base in all segments the estimated market share is in the order of 25% with a coverage in soups and seasonings of 100%.

In **Peru** legislation on the mandatory use of iodized (and fluoridated) salt in processed foods at an iodine level of 30-40ppm as KIO₃, is still pending.

In Argentina the use of iodized salt is compulsory in all processed foods. Though official statistic data are lacking, it is estimated that a large percentage is used in all food segments.

Report from a salt producer in **Pakistan** indicates that use in processed foods, catering and restaurants is permitted on voluntary base, and the estimated market share in the segment should be only in the order of 5%.

In **Israel** use in foods is permitted on voluntary base without restrictions. No data on market share are available.

In **Islamic Republic of Iran** non iodized salt is used in processed foods. Since more than 90% of the population consumes foods prepared at home, iodizing household salt only is considered being a better way of controlling iodine intake.

4. Studies on effect of iodized salt on the quality, processing and acceptability of foods

4.1 Introduction

In total 35 publications and reports on the subject have been found, read and analyzed. The review is based on full papers/publications (obviously preferred) and reports as well as on abstracts of difficult accessible publications and reports. The oldest mentioned study is from 1926 and the most recent study has been reported in 2007. The major part of the analyzed studies has been published in the 1990's and in and beyond 2000

Studies collected have been conducted in 14 countries with major contributions from; USA: 5, Germany: 7, China: 5, Switzerland and Jordan: 3. Other countries in which investigations have been done are: Philippines, India, Netherlands, Thailand, Romania, Moldova, South Africa, New Zealand/Australia and Denmark.

Twenty one (21) studies have especially been focused on the potential adverse effects on the quality of the food products (color, taste, texture, smell) of the products by of the use of iodized salt in processing.

In 4 studies much more emphasis has been put on the iodine retention during processing and storage, besides dealing with the adverse effects of iodized salt on the quality.

In 5 studies conducted in India and China the focus was primarily on the effect of cooking and heating methods on the stability of iodine in foods.

Knowledge on iodine retention is also of relevance since the 2001 WHO recommendation concerning the iodine level in salt at the point of production (within the range of 20-40 ppm) is based a/o on the assumption that in typical circumstances “another 20% of iodine is lost during cooking before consumption”.

The remaining studies collected are related to the nutritional and technological aspects of iodine in certain food products.

In the studies more than 20 food products have been processed with iodized salt.

Products which have been subject of more than one study are: bread, cheese, meat (products), canned products, pickled vegetables and boiled potatoes.

Note: In 2006 the Institute of Nutrition of the Mahidol University, Thailand started a study on iodine stability and sensory qualities of fermented fish and fish sauce produced by using iodized salt (40-60ppm KIO₃).

Results of the study, which is supported by Unicef EAPRO, are expected to be reported end 2007.

The following are summaries and major findings of the studies.

4.2 Replacement of non-iodized salt with iodized salt, focus on adverse effects.

Short after introduction of iodized salt in Switzerland **Koestler and Wegmüller (1926)**, as cited by **Hostettler (1953)**, investigated the effect of iodized salt (3.8 ppm and 38 ppm) on the quality of **Emmentaler cheese**. The quality of the cheese was evaluated after 4 months and no influence of iodine at either level was observed. Hostettler (1953) also referred to another study on the influence of iodized salt on the quality of **Gruyère cheese**. After 77 days and 8 months of ripening, no difference between the iodized and non-iodized cheese could be detected.

Furthermore, based on the other theoretical considerations, Hostettler argued that it is unlikely that iodized salt would have any effect on the quality of cheese:

Including a storage period for 2-3 months, **Kojima and Brown (1955)** did not observe undesirable effects of iodized salt (0.02%KI, KIO₃) on **canned tomato juice, canned green beans, yellow sweet corn, bottled pickles olives and canned or bulk sauerkraut** .

In his thesis **Ei Wakeil (1958)** concluded that no identifiable quality changes could be observed when using iodine/iodide mixtures, iodized salt and iodophor in **canned sweet corn, canned tomato juice and canned sauerkraut**.

Only a flavor change in tomatoes at high level of the iodine/iodide mixture (200 ppm) was observed.

Kuhajek and Fiedelman (1973) concluded that no apparent adverse effects could be observed on **bread, frankfurters and potato chips** throughout processing and storage when salt with 77 ppm iodine as KI, KIO₃ and CaIO₃ was used and sensory panels could not detect differences in potato chips.

Iodine stability was generally acceptable with at least 50-80% retention of iodine throughout processing and storage.

Skudder et al (1981) observed little detrimental effects on the quality of **milk** from addition of potassium iodate before ultra high temperature (UHT) treatment at a level of about 10 ppm iodate.

Milk with about 20 ppm became bitter during subsequent antiseptic storage. However this iodate concentration in milk is considerably (15 times) higher than that anticipated to be added through iodized salt.

Sevenants and Sanders (1984) reported an unacceptable flavor in an experimental **cake mix** prepared with potassium iodide containing salt, caused by a reaction of iodide with cresol present in the lemon flavoring of the cake mix.

Harrison et al (1986) investigated the effect of iodized salt, non-iodized salt and potassium chloride of three levels on properties of **liquid yolk and functionality in mayonnaise**. There was no difference in emulsification capacity of yolk treated with iodized salt but that that treated with uniodized salt had a significantly lower emulsification capacity. No significant difference was found in stability between mayonnaise made with 10% iodized and un-iodized salt.

Wirth and Kuhne (1991) did not find any changes in sensory properties, no influence on curing characteristics of nitrite and no additional nitrosamine formation when iodized salt containing 20 ppm iodine both as iodide and iodate, is used in a wide range of **meat products**. However iodide is oxidized by nitrite to molecular iodine which in turn is lost by evaporation. Consequently adding iodide when using nitrite containing salt for meat curing does not contribute to the dietary iodine supply (**Buergi, 2003**)
During preparation of the meat products only 25% of the iodine from iodate is lost in boiled sausage and only 7% in fermented sausage.
For the estimation of the iodine content in the food products authors applied a wet chemical method with references to papers published in 1975 and 1980.

West et al. (1995) observed no significant differences in sensory properties such as flavor and appearance of **rice and potatoes** boiled in water when using high levels (up to 400ppm as iodide and iodate) of iodized salt.

They cited work of **Ballauf et al (1988)** who concluded that only a small portion of the iodine added to cooking water is absorbed. In potatoes: 0.3-0.5%, in rice about 6% and in macaroni 10-16%. Most iodine (70-80%) stays in the cooking water.

In a short article, **Badran et al (1996)** concluded that iodized salt has no effect on any of the sensory characteristics (color, taste and consistency/texture) of **traditionally prepared pickles**. The article did not disclose iodine source and level of the salt used.

Margrander (1996) investigated the use of iodized salt and iodized nitrite curing salt in the production of aspic products. No differences between the sensory and technological characteristics of the test samples and normal **meat products** of the same type were observed.

Doman et al. (1999) investigated the effect of potassium iodide containing iodized salt at different concentrations on the quality of **fermented cabbage**. No change in micro flora composition, lactic acid production and sensory characteristics was reported with iodide level up to 6 ppm after 7 days of production and 90 days storage.

When investigating the iodine content of salt used in the manufacturing of **bread, bread premixes, margarine and salty snack flavorings** **Harris et al. (2003)** observed the unintentional use of iodized salt in three foods processed (bread, margarine and flavoring). Authors suggest that the successful country wide distribution of the relevant products serves a strong indication that iodized salt does not cause adverse effects

Amr and Jabay (2004) investigated the effect of salt iodization, using different salts types and 40 ppm iodine as iodide or iodate, on the quality of **pickled vegetables: cucumbers, turnips, carrots, cauliflowers and olives**.

They concluded the following:

- salt iodization has no significant effect on neither the rate at which salt penetrates through the pickled vegetables nor on the iodine content and on the taste of the products, regardless salt and iodine source used.
- addition of iodine potassium iodate to both crude and refined salt resulted in significant darkening and discoloration of most pickled vegetables regardless of the salt source.
- when using potassium iodate, also significant softening of the pickles has been observed, though being less pronounced when using high Ca-wet mined salt.
- none of above negative effects was noticed when potassium iodide was used.

-salt iodization as such has no significant effect on both vitamin A and C content of vegetables.

In a study undertaken in **China, NN (2004)** which concise report has been obtained through **CNSIC**, the effects of iodized salt (50-60 ppm iodine) used in preserved **Sichuan pickles** have been investigated. After 3 months no prominent difference in the sensorially tested color, luster, fragrance, taste and texture of the product has been observed. Also physically estimation of colors and tissue rigidity showed no prominent difference when using iodized salt. Iodine is lost in the first round of pickling production where pickling water is not preserved.

The same source **CNSIC**, provided also a concise report **NN (2004)** of a study on the use of iodized salt (62 ppm iodine) in **soy sauce** processing. After 3 months preservation, in 1 of 4 sensorial and physical estimations of color and luster of the product a prominent difference has been observed in using iodized and non iodized salt. Nevertheless author(s) concluded that there is no prominent difference in color and luster between iodized and non iodized soy sauce. Regarding iodine retention 40 % of iodine is lost after the sample preparation step. After 3 months preservation 58% of iodine is retained.

The third concise report **CNSIC** provided, **NN (2004)** is concerning a study on the use of iodized salt in **bottled potherb mustard**. Author(s) concluded that after 3 months preservation no prominent difference was observed in fragrance, texture and taste between non-iodized salt and iodized (41 ppm) salt. Darkening of the color of both the whole bottle and of stem and leaves has been observed at increasing the longer the preservation time. Though author(s) considered the effect still within limits accepted by customers, improving the pickling technology has been recommended to improve the product quality. Iodine retention after washing during bottling is about 50% and remains constant at preservation during 3 months.

Mencinicopschi et al. (2004) investigated the effect of the use of iodate salt in preserving vegetables by pickling (**cucumbers, green tomatoes and white cabbage in brine**) and marinating (**red sweet peppers in vinegar**).

Both iodized rock salt (37 ppm iodate) and iodized re-crystallized salt (56 ppm iodate) have been used.

The recipes for preparing pickles were the most commonly used in households.

The authors concluded that the use of iodated did not affect the pickling and marinating processes.

The iodine in the brine did not influence the nutritional level of lactic acid and vitamin C.

With the exception of the cucumbers, where a slightly different but not unacceptable taste was noted, the use of iodated salt did not affect the sensory properties of the products: color, consistence, taste and smell.

Authors recommend for a better assessment of the influence of iodized salt experiments at industrial scale.

In a not (yet) published study of **NGO Sarmis Chicinai Moldova (2005)** the effects of iodized salt on **pickled and marinated vegetables** have been investigated .

Both industrial food canning factories and households, each with their own recipes have been involved.

Organoleptic testing was conducted after storage of the products for six months.

No difference has been observed between industrially produced vegetables with iodized and non iodized salt.

However the quality of homemade pickles appeared to be lower for both iodized and non-iodized products, probably due to a longer storage time than commonly used.

Zimmermann et al. (2005) investigated the effect of iodized salt on **soft dairy cheese**.

The study showed that iodized salt could be used in stead of non- iodized salt.

It is claimed that 100 grams of Camembert produced from cow's milk and goat's milk with iodized salt contribute one quarter and one half, respectively of the recommended iodine intake for adults (200mcg/day).

The iodine content of the cheese processing compounds: curd, cheese and homogenized milk was detected by means of the sophisticated intra coupled plasma spectrometry (ICP-MS).

4.3 Replacement with iodized salt and iodine retention

In a few studies referred to in the previous paragraph also some attention has been paid to iodine retention.

In the following studies the emphasis was both on the effects of replacement of non-iodized salt with iodized salt and on iodine retention due to processing and storage.

Azanza et al. (1998) investigated the use of iodized salt in commercially processed Philippine food products.

Effects of iodized salt on the quality of **dried salted and smoked fish products, nitrite cured pork meat and fermented plain and flavored shrimp pastes** were investigated and evaluated.

Generally no significant differences were detected between the physicochemical, microbiological and sensory characteristics of the test products prepared with iodized (62 ppm iodine) and non-iodized salt.

However, losses of the iodine, absorbed by the test samples during salting were recorded due to the subsequent boiling, drying, fermenting and heating processes in the different operations. The recorded decrease ranged from 33 to 93%, except for the nitrite cured pork meat.

Note: the Ichikawa(1985) method for iodine analysis of food samples was used to determine the iodine content of all food samples.

Capanzana et al. (?) investigated the effects of iodized salt on the quality of selected processed Philippine food products: **dried salted fish, cured meat products, fermented small shrimps, anchovies and pickled cucumber.**

Physicochemical, sensory and microbiological properties were tested as well as stability and quality during storage for 3-6 months, dependent on the product, using commercially used packaging materials.

No significant differences in the physico-chemical properties of test products, except for color (color of meat products improved) and iodine content have been assessed.

Food products with iodized salt were still rated acceptable though slight differences observed during.

During storage the test food products were stable in terms of color and iodine content.

Iodine retention during storage ranged from 67 to 96 %.

Also a substantial amount of iodine in processed food was retained after cooking.

Authors suggested not advising the use of iodized salt for cucumber fermentation due to the iodine loss during subsequent washing and pickling.

Amr and Jabay (2004) (see also paragraph 4.1) conducted a study on the quality and residual iodine content of **French fries, boiled potatoes, luncheon meat, canned green beans and flat bread**, prepared with potassium iodide and -iodate containing (40 ppm) crude and refined salt..

The results show that in general iodine addition has no adverse effects on the sensory properties of the foods prepared.

An exception was the luncheon meat which color and taste were adversely affected by iodate addition. Authors suggested the presence of impurities in the salt likely to be responsible for the effects.

As regards retention of iodine the following results were reported.

Iodized salt added to

- French fries before frying resulted in complete loss, addition after frying resulted in retention;
- potatoes before boiling resulted in complete loss;
- luncheon meat retained 24% when iodide was added and 63 % when iodate was added.
- canned green beans resulted in complete loss due to exposure of high temperature and retorting
- dough for flat bread resulted in retention of 32-50% after fermentation and baking.

Seen the observations authors advised to use iodide instead of iodate since in most cases of the study more iodine was retained when iodide was used.

Note: residual iodine in the food products was determined following AOAC (1995) method.

Within the framework of an extensive consideration concerning mandatory fortification of processed foods with iodine in Australia and New Zealand, **Winger et al. (2005)** determined the stability of iodine in model foods.

Potassium iodide and potassium iodate as well as elemental iodine in a range of 1 to 100 ppm. have been used in the determination of reactivity.

Reasons for that range were the amount of salt and level of iodine often used in food systems and the observation that reactions in foods have not been reported below 12 ppm.

For screening experiments to establish if there is any potential reactivity of iodine in foods 1000 ppm was chosen, based on reported losses of iodine as high as 70% in some food matrices.

As regards the food systems chosen, besides bread as a key food system often using iodized salt, a boiling starch solution at 100degr C and sunflower oil at 180degr C were selected to determine iodine volatility.

The following series of foods were selected to investigate the reactivity of iodine in different food matrices.

- egg white (protein, sulfhydryl groups);
- egg yolk (phospholipids);
- milk (dairy proteins);
- reducing sugars (glucose, lactose, sucrose);
- tomato sauce (used in many food products);
- pigments (anthocyanins and related plant colors).

Authors selected above series since it provided some key components reportedly influenced by iodine in processed foods or theoretically reactive.

The method to prepare samples for the determination of the iodine content, using the ICP –MS method is based on the procedure described by **Fecher et al., (1998)**.

The experimental work showed for iodine concentrations of 1 to 10 ppm no discernable impact on dough production and bread quality.

Higher levels of iodine (100 and 1000 ppm) resulted in significant changes to the dough and bread.

In the above mentioned range of food ingredients treated with 400 ppm iodide or iodate no qualitative changes were observed even after 5 day's storage.

Use of iodine in oil heated for two hours at 180 degr C resulted at 64 ppm iodine in oxidation of the oil.

Some volatility of iodine from food systems upon heating has been observed.

In bread 40% of the iodine as iodate was lost and only 20% of the iodine as iodide.

Approximately 20% of the iodine was lost over two hours from a boiling starch solution at 100degr C and from sunflower oil heated at 180 degr C.

The conclusions authors have drawn are:

- overall there appears to be no observable reactivity of iodine in most food systems provided low iodine fortification levels used. However existing results cannot be extrapolated to all foods.
- the methodology for quantitatively recovering of iodine from food matrices requires further study, no published methods available yet.

4.4 Effect of cooking/heating conditions on iodine stability in foods.

Goindi et al. (1995) assessed in a systematic study with 50 recipes, commonly cooked in Indian families, the iodine losses when using different cooking procedures: boiling, steaming, pressure cooking, shallow and deep frying and roasting.

Samples have been prepared in a hospital kitchen and the iodine content of both raw and cooked samples have been estimated by a colorimetric method (Karmarkar et al. 1986), using cerium and arsenic reaction

. Iodized salt has been used at level of 15 ppm iodine. Iodine source was not indicated.

The means of loss in the different cooking methods ranged from 6 to 37%, the variation in the results of all samples was even much larger (between 3 and 76%).

The loss of iodine due to roasting was found to be the lowest (3-7%), while the maximum loss was found during boiling (28-66%).

Note: In an evaluation of the study, **Winger et al. (2005)** questioned whether the applied level of sampling in the study is of value for complex food materials.

Bhatnager et al. (1997) studied the iodine loss from iodized salt on heating.

The results of the study indicated a gradual but minimal loss of the iodine content of KIO₃ iodized salt (maximum loss 18.5%) subjected to incremental heating up to 350degr.C.

Shi et al. (1998) investigated the effects of various (usual) cooking methods on iodine content in food with iodized salt (no details known).

The different cooking methods had different effects on the iodine retention.

Also the effect of various vegetables on the iodine retention was different.

The retention of iodine after stir frying ranged from 37 to 84% and after stewing of the same **vegetables (fruit bearing, leafy, roots, beans)** from 47 to 66%. Retention of iodine in **meat** after stewing was 43%.

Wang et al. (1999) investigated the effects of storage and cooking on the iodine content in iodized salt. Retention of the iodine varied with the kind of foods and was also influenced by the water content of the cooked food. Retention of iodine after stewing or steaming was usually higher than after frying. Range of retention varied from 37 to 86 %. The applied analysis method was an alkaline method (Li, 1987) modified by own laboratory.

Chavasit et al. (2002) investigated the stability of iodine in iodated salt at different cooking model conditions, i.e. use of 20% salt brine as the model, different utensils, pH levels and food additives

Determination of iodine contents by titration and spectrophotometry showed that cooking methods: boiling, frying, steaming, baking and canning and pHs (3, 6, 9) showed no significant effect on iodine (as iodate) loss.

High iodine losses have been estimated on addition of certain additives, even before cooking, with the use of brass utensils and in the presence of spices like garlic, fresh chili, pepper and green curry paste.

4.5 Nutritional aspects of iodized salt in processed foods

As regards iodine nutrition through (processed) foods **Winger et al. (2005)** reviewed the associated aspect of iodine bioavailability.

They concluded that there are no recent data on the bioavailability of iodine from the diet. All present data are based on limited studies from some decades ago, using radioiodine in very small samples and specific foods.

Further they stated that the various studies on the use of iodate for salt iodization which suggest extreme high bioavailability of iodate do not include interactions with the food matrix, or *in vivo* changes during digestion and absorption.

Therefore they recommended introduction of a national iodine monitoring program with any fortification strategy to ensure the effectiveness of the intervention measures.

In the following limited number of studies emphasize the food technological and nutritional aspects of iodized salt have been emphasized, in particular in cheese processing. Apparently the studies, conducted in Germany, were initiated by the changes in the legislation on the use of iodized salt in processed foods in that period.

Wiechen and Hoffman (1994) investigated the iodization of **semi hard (Edamer) cheese** and concluded that homogeneous iodization of cheese from a salt bath does not occur.

Iodate is reduced and bound to proteins and thus cannot diffuse into cheese during ripening. Homogeneous iodization can be achieved by adding iodide to the culture with about 10% of added iodine found in the cheese. A very low amount of iodine leached by the salt bath indicated that the iodine was tightly bound to the proteins.

However iodization via the culture has not been recommended as iodine transfer depends on each culture and single process parameters.

In a next study on the subject using brine iodized with potassium iodate, **Hoffman et al. (1997)** showed that most of iodine has accumulated in the peripheral layers (thickness 1cm) of the cheese.

About 150 g of that layer would contribute more than half of the RDI of iodine.

The applied iodine analysis method was based on the Sandell –Kolthoff technique, using cerium and arsenium.

Sieber (1998) discusses in his article the possibilities for increasing the iodine content in cheese by adding iodine to the starter culture, to milk, to salt baths, to curd or by injecting salt solutions in the cheese.

Author argued that as from a nutritional point it is desirable to reduce the salt content of cheese, which consequently reduces the iodine content, it is better to increase the iodine content of table salt.

Wagner (2006) investigated the contribution of (iodated) meat products to the iodine supply of the German population, with reference to inductively coupled plasma mass spectrometry (ICP-MS) analytical method for the determination of iodine in meat products.

Examination of the ICP-MS based analytical techniques showed that especially the alkaline disintegration of samples with high fat content proved to require more stringent conditions due to carbon bound iodine.

The analytical results of the iodine content of the common types of meat products provided the base for an estimation of the current frequency of the use of iodated salt in the production of meat products, which amounts to 60-80%.

Author stated that at present meat products can be assumed to contribute about 15% of the recommended daily iodine supply. Moreover he stated that the contribution of the natural iodine content of meat to the iodine supply is small, even if with iodine fortified feed is applied.

Rasmussen et al. (2007) investigated the effect of the mandatory iodine fortification of household salt and bread in Denmark on the iodine nutrition of the population.

The increase in the iodine intake from bread fortification and the increase of the after fortification were measured estimated, based on dietary total iodine intake data from 4124 randomly selected Danish subjects.

Approximately 98% of the rye bread and 90 % of the wheat bread were iodized.

Preparation of the bread extracts prior to the iodine assessments as well as the analysis of iodine, its accuracy and repeatability have extensively been described.

Iodine content of bread extracts was determined by ICP-MS.

The median intake of iodine from bread increased by 25 mug/day and the total median intake by 63 mug/day. Authors concluded that the fortification of bread and household salt has resulted in a desirable increase in iodine intake and that the current fortification level of salt (13 ppm) seems reasonable.

4.6 Discussion

The limited number of reported adverse reactions has been observed at high iodine concentrations in the product; in canned tomatoes at > 100ppm (El Wakeil, 1955) and in milk at >20 ppm iodine (Skudder, 1981) or only observed with iodate as iodine source: emulsion type luncheon meat.

Also some of the studies dealing with pickled vegetables reported changes in product characteristics (color, texture) when iodization was conducted with iodate (Amr and Jabay, 2004 and Mencinicopschi et al. 2005).

Therefore it has been suggested that in an iodine fortification program where pickled vegetables should be considered as a tool to increase iodine nutrition of the population, potassium iodide would probably be the preferred iodine source for that product.

However when fortification programs are designed also other aspects should be taken into consideration, such as effectiveness of the proposed iodine vehicle in terms of increasing the iodine nutrition in the general population, in terms of cost to the (salt) industry and of the legislation being in force.

Studies that (also) have included assessment of iodine stability, reported that considerable loss of iodine during processing is possible, sometimes up to 70%.

Analysis of the relevant studies showed that different analytical methods have been used to assess the iodine content in foods.

In the report of **Winger et al. (2005)** for the New Zealand Food Safety Authority authors, who also investigated iodine stability, stated that the methods for iodine measurement in the studies they reviewed, being part of the studies reviewed in this report lacked sufficient controls and would not be appropriate today.

5. Successful examples of and barriers to incorporation of iodized salt in processed foods.

5.1 Success examples.

In the review on the current use of iodized salt in processed foods per country examples of successful incorporation have been mentioned with the circumstances that have led to success and where relevant the threats for successful application achieved thus far.

Obviously the role of the health and food authorities is crucial.

As reviewed in paragraph 3, the compulsory use of iodized salt in processed foods in all of selected food segments has been enacted in 4 of the 27 EU member states and in 13 countries of the UN CEE/CIS region, so contributing to successful elimination of iodine deficiency. Introduction of compulsory use of iodized salt for households and in processed foods does not automatically mean that optimal iodine nutrition can be achieved on short term.

The **WHO report “Iodine status world wide”** (2004) indicates that, based on surveys in the period 1994-2001, in 9 of the 17 “compulsory” countries iodine nutrition is (still) insufficient.

Since most of the compulsory iodine fortification programs in these countries have been introduced in 2001 and beyond it would be advisable to conduct surveys on short term to assess the impact of the fortification program on the iodine status.

Awareness at highest political level on the effect of iodine deficiency on the country’s population and the political will to introduce, to enforce but more particular to maintain appropriate legislation for use of iodized salt in (selected) processed foods have been the key conditions for adequate and sustainable iodine nutrition.

Obviously regular monitoring of iodine nutrition and of changes in diet pattern and consequently adaptation of the current legislation is also a major condition for sustainability.

A good example of above mentioned “vigilance” of the authorities is the situation in The Netherlands.

Use of iodized salt in a selected basic food product (bread), initially on mandatory base and prolonged on that basis for many years could survive a legislative change to voluntary use.

Presently almost all bakeries continue the use of iodized salt despite voluntary use and an existing price difference of about 10% between iodized and non iodized salt.

This practice also represents a kind of historical “gentlemen’s agreement” between the government and the bakery sector.

Furthermore all bakers recognize the designation “bread salt”, exclusively used in bread and bread replacers. **(C.T.F. Grit, Dutch Association of Bakeries, 2005).**

The role of the salt industry, particularly in providing adequately iodized salt to the food processors, is basically simple: satisfy the need of her customers, in this case food producers.

To meet the need of their customers, who basically always want to pay the least amount possible for the product they want, the challenge for salt producers is to distinguish their product on basis of price, quality and security of supply.

Authorities should co-operate and communicate with the salt industry on (technological) feasibility of suggested measures.

In The Netherlands the salt industry has been involved and consulted by the authorities on the changes in legislation as earlier described.

Obviously the role of the food industry is pivotal.

Ideally the industry, the sector of a relevant segment, should be involved in all considerations for introduction of either mandatory or voluntary use of iodized salt.

Based on communications with some food processors, the impression is that they consider their role as a passive one.

Observations of the current situation in the countries confirm that impression.

Food processors will basically only introduce iodized salt when enforced by relevant legislation.

At voluntary use, substantial market shares of iodized salt in the sector have only be realized in countries with a long history of (compulsory) iodization.

In a personal communication with a major global food processor, author experienced low interest in the subject. The company’s spokesman indicated that introduction of iodized salt by the company should only be the result of (national) iodine fortification programs.

A complicating factor is that food producers and so indirectly salt producers are confronted with the effects of the WHO strategy to reduce the overall salt consumption.

Since the focus of salt reduction programs is on processed foods, special attention is needed to safeguard adequate iodine nutrition through processed foods currently being a vehicle for iodine and affected by such reduction programs.

In The Netherlands the authorities have recently adopted the WHO recommendation to reduce the salt consumption and started challenging the processed food industry.

Simultaneously they announced to consult with the relevant food sectors currently using iodized salt, in particular the bread segment on measures in order not to jeopardize the adequate iodine nutrition in the country.

In Unicef reports on recent study tours for countries in the CEE/CIS region, organized to deal with the resistance of food producers to use iodized salt and to transfer experience and knowledge on the use of iodized salt, successes of application in different food segments were shown.

The tours were: a Turkish Study Tour to Bulgaria (2005), the Latvian Study Tour to The Netherlands (2005) and the recent Moldovan Study Tour to Switzerland (2006).

5.2 Barriers for introduction

Published and analyzed studies do not justify hard evidence for a (significant) impact of iodine on the sensory properties or other qualities and characteristics of the food products.

However as mentioned in paragraph 1, the perception of food producers that iodine in the salt will adversely affect the quality and characteristics of their food products should be used as a major barrier for introduction of iodized salt in their products.

This perception is in particular observed in several countries in the CEE/CIS region and in parts of China.

Therefore Unicef's CEE/CIS office has in her on-going study on the subject compiled in total 25 testimonials on the current use in dairy, bread, meat and pickles segments from food producers and institutions in Belarus, Bosnia and Herzegovina, Bulgaria, Georgia and Serbia and Montenegro.

Only one bread producer in Belarus expressed his concern on iodine stability in bread and one cheese manufacturer in Georgia continued to use non-iodized salt based on his conviction that iodine in salt should affect the smell of the product.

In a report of **Sivuha and Lyashkevich (2005)** on the situation in Belarus, authors indicated that none of the cheese factories in the country use iodized salt.

The reason is a negative recommendation from countries' relevant Meat and Dairy Research Institute, in turn based on publications of the Russian Research Institute for Cheese and Butter. Common believe is that iodization changes both taste and color of cheese.

In the review on the situation in China besides the cost and awareness aspects affecting the use of iodized salt, also dietary customs and habits are important aspects influencing use of iodized salt.

Many people, in particular in western China are getting use to crude salt; they believe crude salt is saltier and tastier than refined iodized salt. In Xingjian and Qinghai provinces, people believe the meat will be tastier when cooked with crude salt. Pickled vegetables are an important part of the diet and people believe that vegetables pickled by use of crude salt will be better colored and tastier than by use of refined iodized salt.

A second potential barrier for use of iodized salt in processed foods is cost related.

Besides the costs to governments of administering and enforcing relevant fortification programs both salt producers and food manufacturers are confronted with costs resulting from introduction of such programs.

Costs incurred by the salt industry could be related to upgrading of equipment to meet increased demand and processing conditions when iodization of salt for the food segment is different from that for the retail segment.

Processing conditions might include the change from coarse salt to salt with smaller particle size to meet optimal iodization conditions.

Other costs are related to labeling, to purchasing of additional iodine and to analytical or compliance testing and storage.

Costs will also be incurred by food producers. Their costs are related to additional cost for salt then iodized, for change of labeling by replacing salt with iodized salt analytical or compliance testing.

A rough estimate for the cost difference between iodized and non-iodized (bread) salt is 10 % (Personal communication Eu Salt member, Access Economics Pty Ltd, 2007).

Within the framework of the consideration of mandatory fortification of bread and bread products with iodine in Australia and New Zealand, costs of the proposed fortification program have been assessed very recently (**Access Economics Pty Ltd for FSANZ, 2007**).

Upfront and ongoing costs have been estimated and when these costs may be passed on to consumers the price of bread should increase by less than \$0.01 per loaf.

Differences in legislation concerning iodized salt affect export opportunities for both salt producers and food processors.

In member states of the European Union salt producers consider the prevailing chaos on legislation of iodized salt in the region as a relevant obstacle for improving the iodine nutrition. Most countries do not have mandatory iodization of edible salt. Where salt is iodized, the levels vary from place to place and many are not consistent with WHO/UNICEF recommended standard.

That will also apply to food producers as indicated before on the situation in Switzerland where export oriented food producers are reluctant to use iodized salt because it limits their market due to meeting regulations in export countries.

In the same light FSANZ decided in her final consideration for the mandatory introduction of iodized salt in bread to remove biscuits from a previous proposal.

All imported biscuits would need to use iodized salt requiring overseas manufacturers to set up separate production lines.

Domestic biscuit producers who export to Japan would also need to have separate production lines as Japan does not allow the import of iodized foods.

6. Considerations and discussion.

Universal Salt iodization (USI), i.e. iodization of **all** salt used for human and animal consumption is the recommended global strategy to control iodine deficiency.

However as the review in paragraph 3 has shown, in the focus area for this study USI has been adopted through mandatory use of iodized salt in a limited number of countries, most in the CEE/CIS region.

Current practice has shown that practical application and enforcement of the relevant regulation, often enacted within the last ten years, is a challenge.

In the more developed economies USI, as defined above, has not been adopted.

In countries as USA, Canada, Germany, Austria, Netherlands and Switzerland legislation permits and in some cases mandates iodization of salt for households and /or salt for some processed foods.

In general in these countries use of iodized salt in processed foods is voluntary and application is often very limited to moderate.

When focused on Europe, the 2004 WHO report on the worldwide iodine status indicates that optimal iodine nutrition is also realized in those countries where the voluntary use of iodized salt in processed food(s) is more than marginal.

Netherlands is a good example of how the observed re-emergence of iodine deficiency in the 1980's and 1990's has been addressed in spite of use of iodized salt for households and for a few food products only on voluntary base.

That example and others show that in fact the goal of optimal iodine nutrition can be realized even if not the formal definition of USI is applied.

The pending proposal to mandatory fortification of bread with iodine in Australia and New Zealand is another recent example how an observed re-emergence of iodine deficiency in (parts of) the population has been addressed.

In 2004 an extensive investigation was started on the most effective public health strategy for addressing the re-emerged iodine deficiency.

Food and Health authorities at ministerial level, advised by health experts, asked the Food Standards Australia New Zealand (FSANZ) to assess whether mandatory fortification with iodine could be achieved taking into account safety and cost effectiveness.

Issues which were taken into account in the subsequent extensive consideration and consultation processes and procedures were a/o:

- assessment of the health benefits and risks of increased dietary intakes of iodine the populations;
 - identification of a preferred food vehicle and level of iodine concentration to achieve the desired health outcome;
 - effectiveness and technological feasibility of proposed intervention;
 - cost-benefit analysis;
 - associated communication and education;
 - monitoring and implementation issues and presentation of a preferred regulatory approach.
- The preferred solution should also be consistent with international guidance and experience.

When considering improving the iodine nutrition status of the population through use of iodized salt in processed foods, either voluntary or mandatory, the following aspects need to be considered.

- the food product(s) should be consumed uniformly by the majority of the population and preferably not being affected by trade concerns, i.e. produced domestically for the local market;
- the food product should have a rather constant salt content, hence iodine content;
- preferably iodization should be done with food products based on simple manufacturing and on minimal number of ingredients, and iodization should also require simple processing;
- iodization should not affect the quality and acceptance of the food products as well as of products using the iodized food stuff like cheese in pizza's;
- minimum loss of iodine and at storage;
- efficacy of iodized food product as well as effectiveness in providing iodine adequately to the population through introduction of this product must be proven.

7. Conclusion and recommendations

Above review and considerations show that there is no simple blueprint for realizing optimal iodine nutrition through iodized salt.

Optimal nutrition can also be achieved through different sub-strategies of USI:

- Mandatory use in households and in processing of some or all food products, as applied and successfully enforced in a number of CEE/CIS countries, in Bulgaria and Slovakia.

Impact of recent enacted and introduced iodine fortification programs in relevant countries should be assessed by conducting UI surveys.

Though China should have virtually achieved the goal on country level, still 14 provinces have not (yet).

- Mandatory use in households and voluntary use in (part of) processed foods (Austria, Czech Republic);

- Voluntary use both in households and in processed food segments with varying market shares (Germany, Netherlands, Switzerland, USA and Spain)

The review shows that only in countries with (a history of) strong centralized governmental authority, in most cases also being developing economies, the fortification programs are based on the strict USI interpretation of using iodized salt and enacted accordingly..

Nevertheless often implementation and enforcement turn out to be a challenge.

In the developed economies iodine fortification programs are more "tailor made" designed, taking into account all relevant aspects for such programs, as described above.

The recent FSANZ work on consideration mandatory fortification with iodine shows that such designing can be a long a winding route.

In that case is shown that in the considerations, under final governmental responsibility, all relevant parties such as public health and nutrition experts, producers of food products tentatively selected and salt industry have been involved and consulted.

The FSNZA case shows how (a segment of) the food sector acts when confronted with a fortification program possibly affecting their product(s) and their business.

The scope of the initially proposed fortification program has been modified as a result of technological and business related concerns of the food producers regarding the first proposal.

If fortification is on voluntary base, the review shows that it is an exception when use of iodized salt is widely applied in a country.

Basically producers will only initiate fortification of their products when the incurred costs of using iodized salt will be returned.

The necessary awareness-raising activities i.e. communication of the added value (health claim) of the product with iodized salt is in general a heavy burden for an individual food producer and will in practice not be done.

Such communication activities might be affordable on food segment/ sector level or for the really large producers (multi nationals).

Consequently, if in a country the iodine fortification program for food products is based on voluntary base, it is expected that only implementation on segment/sector level is most likely.

Based on these considerations it is recommended to work on engagement of a relevant sector of the food processing industry on country level, in a country/countries to be defined and on involvement of the very large food producers.

Selection of country should be based on the actual iodine nutrition status, the iodine fortification program enacted and on the share of salt consumption through processed foods in the daily menu.

Criteria for the selection of the food segment(s) to be approached are indicated in the previous paragraph.

Relating to the effect on quality and acceptability of the product, the review of the literature shows in most cases no effect of use of iodized salt, using either iodide or iodate and at the low iodine levels commonly applied in the food products.

Some adverse effects reported were related to pickled vegetables when using iodate as iodine source. The relevant studies recommended further investigations or in this application the use of iodide.

As regards the retention of iodine, i.e. the stability of iodine during processing, storage and heating of food products with iodized salt, the reviewed studies reported for nearly all products processed with iodized salt a loss of iodine.

Dependent on the product and the processing, heating and storage condition losses up to 100% have been reported.

However different analytical methods have been used in the various studies.

A recent report judged that used methods for iodine measurement from earlier reports would not be appropriate today.

Therefore it is recommended that earlier reported methods for determination of the iodine content in food products are compared with the more recently used method ICP-MS in order to get consensus on the methodology used in studies on the subject.

8. Acknowledgements

The author would like to thank the members of Eu Salt, the Salt Institute, the ICCIDD Regional Coordinators and Unicef Regional Officers who participated in this study for their collaboration. In particular he would like to thank Mr. Arnold Timmer of Unicef CEE/CIS office for providing detailed information on the subject from the region.

9. References

Access Economics Pty Limited. *Costs of fortifying bread and bread products with iodine*. Report for Food standards Australia New Zealand, May 2007

Aghini-Lombardi F., Antonangeli I., Pinchera A. *Iodine deficiency in Europe. National reports on iodine status in West- Central European countries*. Journal of Endocrinological Investigation **26**, Suppl. to no.9 VI-VII (2003)

Amr A., Jabay O.A. *Effect of salt iodization on the quality of pickled vegetables* Journal of Food, Agriculture & Environment Vol **2**(2):151-156 (2004)

Amr A., Jabay O. *Quality and residual iodine content of some foods prepared with iodized salt* Journal of Food, Agriculture & Environment Vol. **2** (3&4): 21-24 (2004)

Azanza P., Cariaso K., dela Cerna M.C., de Ocampo C., Galvez F., Moises M., Pulanes K. *Use of iodized salt in processed Philippine food products* Asia Pacific J Clin Nutr **7**(2): 123-127

Badran O., Quaraqash W., Gamah S. *Possible effects of iodized salt on the taste , colour and consistency of traditional pickles*. Eastern Mediterranean Health Journal Vol **2**. 2, 219-223 (1996)

Bhatnagar A., Maharda N.S., Amardar V.K., Dham D.N., Magdum M. Sankar R. *Iodine loss from iodized salt on heating* Indian J Pediatr. **64**(6): 883-5 (1997)

Bürgi H. *Iodized salt and the curing of meat* IDD Newsletter August 2003, 47-48

Capanzana M. V., Molano B.T., Saiase M.C., Garcia R.G., Trinidad II T.E., Lapis T.J., Zarate,jr. R.U., Guavarra M.C.P. *Effects of iodized salt on the quality of processed food products.* Fnri.dost.gov.ph (?)

Chavasit V., Malaivongse P., Judprasong K. *Study on the stability of iodine in iodated salt by use of different cooking model conditions* Journal of food composition and analysis **15(3)** 265-76 (2002)

CNSIC (N.N) *A study of iodized salt used in preserved Szechuan pickles.* (2004)

CNSIC (N.N) *A study of iodized salt used in soy sauce processing.* (2004)

CNSIC (N.N) *A study of iodized salt used in bottled potherb mustard.* (2004)

De Benoist B., Andersson M., Egli I., Takkouche B., Allen H. *WHO Report Iodine status world wide WHO Global Database on Iodine Deficiency* (2004)

Doman M., Korsak D., Lekowska- Kochaniak A., Popowski J. *The effect of potassium iodide on cabbage fermentation and growth of chosen microorganisms- short report* Polish J. Food Nutr. Sci., **8/49(2)** 201-208 (1999)

EI Wakeil F.A.E.S. *Effects of iodized salt and other iodine compounds on the quality of processed vegetables* Dissertation, Ohio State University Columbus, OH 1958

Fecher P.A., Goldman I., Nagenast A. *Determination of iodine in food samples by inductively coupled plasma mass spectrometry after alkaline extraction.* Journal of Analytical Atomic Spectrometry, **13**:977-982

Food Standards Australia New Zealand. *Proposal 230 Consideration of mandatory fortification with iodine. Draft assessment report* August 2006. *Key issues for consideration at Final assessment.* May 2007

Gerasimov G. *Progress of IDD elimination through Universal Salt Iodization in the Czech Republic, Slovakia, Hungary and Poland.* Unicef Report, March 2002.

Goindi G., Karmarkar M.G., Kapil U., Jagannathan J. *Estimation of losses of iodine during different cooking procedures.* Asia pacific J of Clin Nutr **4**:225-227 (1995)

Harris M.J., Jooste P.L., Charlton K.E. *The use of iodized salt in the manufacturing of processed foods in South Africa: bread and bread premixes, margarine, and flavourants of salty snacks.* International Journal of Food Sciences and Nutrition **54**, 13-19

Harrison L.J., Cunningham F.E. *Influence of salt on properties of liquid yolk and functionality in mayonnaise* Poultry Science **65** 915-921 (1986)

Hofman W., Anke M., Buchheim W. *The use of iodized brine for iodine enrichment of semi hard cheese* Milchwissenschaft **52(5)** 257-259 (1997)

Hostettler H. *Ueber den Einfluss des jodierten Kochsalzes auf die Kasequalitat,* Schweizerische Milchzeitung **19**, 1-111 (1953)

Kojima N., Brown H.D. *The effects of iodized salt in processed fruits and vegetables.* Food Technology **9**; 103-107 (1955)

Kuhajej. E.J., Fiedelman H.W. *Nutritional iodine in processed foods.* Food Technology **27**; 52-53 (1973)

Marggrander K. *The manufacture of aspic products with iodized salt and iodized nitrite curing salt* Fleischwirtschaft **76** (10) 1010+1013 (1996)

Mencinicopschi G., Zacchia M., Balint, L., Vlassa M., Deleanu M. *Studies and research of the effect of the use of iodized salt in preserving vegetables by pickling and marinating* The

Romanian company for applied research and investments, The department for food research, Romania 2004

Rasmussen L.B/, Ovesen L., Christensen T., Knuthsen P., Larsen E.H., Lyhne N., Okholm B., Saxholt E. *Iodine content in bread and salt in Denmark after iodization and the influence on iodine intake*. International Journal of Food Science and Nutrition **58**(3) 231-239 (2007)

Sevenants M.R., Sanders R.A. *Anatomy of an off-flavor investigation: the "Medicinal" cake mix*. Analytical Chemistry **56** 293A-298A

Sieber R. *Use of iodized salt during cheese manufacture*. Ernährung **22** (5), 196-201 (1998)

Sivuha S., Lyashkevich A. *Program of salt iodization in Belarus: initial outcomes*. No ref. (2005)

Shi L., Zhou R., Wang G. *Effects of cooking methods on iodine content in iodized salt* Wei sheng yan jiu =Journal of hygiene research **27** (6): 412-414 (1998)

Skudder P.J., Thomas E.L., Pavey J.A., Perkin A.G. *Effects of adding potassium iodate to milk before UHT treatment. I. Reduction in the amount of deposit on heated surface*. Journal Dairy Research **48** (1): 99-113 (1981)

Wagner. H., *The contribution of meat products to the iodine supply of the population*. Mitteilungsblatt der Fleischforschung Kulmbach **45**, Nr. 172, 119-123 (2006)

Wang G.Y., Zhou R.H., Wang Z., Shi L. Sun M., *Effect of storage and cooking on the iodine content in iodized salt and study on monitoring iodine content in iodized salt*. Biomedical and Environmental Sciences **12**, 1-9 (1999)

West C.E., Merx R.J.H.M. *Effect of iodized salt on the colour of taste of food*. Unicef (1995)

Wiechen A., Hoffman W. *Studies of the iodization of cheese during cheese making process*. Milchwissenschaft **49**(2) 74-78 (1994)

Winger R.J., Koenig J., Lee S.J., Wham C. House D.A. *Technological issues with iodine fortification of foods*. Final report for New Zealand Food Safety Authority (May 2005)

Wirth F., Kuehne D. *Herstellung von jodierten Fleischerzeugnissen. Manufacture of iodized meat products*. Fleischwirtschaft **71** (12) 1377-1384, 1432

Zimmermann C., Leiterer M., Engler K., Jahreis G., Schone F. *Iodine in Camembert: Effects of iodized salt and milk origin- cow versus goat*. Milchwissenschaft **60** (4) 403-406 (2005)