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Iodine content in bread, milk and the retention of inherent iodine in commonly used Indian recipes

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ABSTRACT

Iodine deficiency disorders (IDD) is still a major public health problem and iodized salt remains the most effective means to control IDD in India. Few reports indicate that vegans have inadequate iodine intake while at the same time concerns are being raised on the implementation of universal salt iodization in the country. Therefore, we investigated the iodine content in bread, milk and commonly used Indian recipes prepared without iodized salt and the retention of inherent iodine therein. Results showed considerable iodine content in bread (25 μg/100 g) and milk (303 μg/L) as a positive fallout of universal salt iodization. Iodine content in 38 vegetarian recipes prepared without iodized salt was very low (2.9 ± 2.4 μg/100 g). Retention of inherent iodine (65.6 ± 15.4%) and iodine from iodized salt (76.7 ± 10.3%) in the same recipes was comparable. Thus, universal salt iodization programme remains the single most important source of dietary iodine for the Indian population.

1. Introduction

Food is the major source of total iodine intake by mankind, with water and beverages contributing small amounts. Database on iodine content in foods and diets prepared from results available in the literature by Fordyce (2003) showed that the geometric mean of iodine content was highest in marine fish (1456 μg/kg) followed by freshwater fish (106 μg/kg), leafy vegetables (89 μg/kg), dairy (84 μg/kg), other vegetables (80 μg/kg), meat (68 μg/kg), cereals (56 μg/kg), fresh fruit (31 μg/kg) and bread (17 μg/kg). The results show that in general grain crops are poorer sources of iodine than vegetables and that there is some equivocal evidence to suggest that leafy vegetables contain higher iodine concentrations than other vegetables. The iodine content of foods also varies with different geographic location, ranging widely from 30 to 800 μg/100 g (EGVM, 2000; FAO/WHO, 2002; Haldimann, Alt, Blanc, & Blondeau, 2005; Longvah & Deosthale, 1998). Hence, the average iodine content of food from one country cannot be universally used for estimating the iodine intake for another population.

Iodine occurs in food mainly as inorganic iodide which is readily and almost completely absorbed from the gastro intestinal tract. Iodine is required for the synthesis of thyroid hormones, thyroxine (T4) and tri-iodothyronine (T3) which are iodinated molecules of the amino acid tyrosine. The thyroid hormones regulate a wide range of physiological processes including the cellular oxidation. Thus deficiency of iodine leads to endemic goitre and cretinism, retarded physical growth and intellectual development as well as a variety of other conditions commonly termed as iodine deficiency disorders (IDD) (Hetzel, 1983).

The current recommended dietary allowance of iodine is 90 mg/d for 1–8 years old, 120 mg/d for 9–13 years, 150 mg/d for 14 years and older, and 250 mg/d for pregnant and lactating women (UNICEF, 2007). Failure to meet this requirement will result in IDD. Worldwide, iodine deficiency remains the single greatest cause of preventable brain damage and mental retardation. Elimination of IDD is therefore of both national and international interest and the only way to eliminate IDD is to make iodine available to the deficient population.

Salt iodization has been the preferred strategy that is economical, convenient and effective means to control and prevent IDD in many parts of the world (WHO, 1994). However, iodine in iodized salt may be volatile and lost through cooking processes (Winger, Koenig, & House, 2008). A systematic study carried out on the loss of iodine from iodized salt through cooking processes showed mean iodine retention of 60 ± 21% in 139 commonly consumed Indian recipes (Longvah et al., 2012). Other sporadic studies in different food preparations using iodized salt showed a very wide variation in the retention of iodine ranging from 14% to 94% (Amr & Jabay, 2004; Azanza et al., 1998; Szymandera-Buszka & Waszkowiak, 2004). In all these studies, the retention of iodine from iodized salt have been shown to be affected by many factors

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such as the food variety, type of cooking utensil, the recipe method employed and the time of addition of iodized salt to the food preparation.

Recent reports have shown that vegans not consuming iodine supplements, seaweeds and/or related products have inadequate dietary intakes of iodine (Draper, Lewis, Malhotra, & Wheeler, 1993; Krajcovicova-kudlackova, Buckova, Klimes, & Sebokova, 2001; Lightowler & Davies, 1998; Rauma, Tormala, Nenonen, & Hanninen, 1994). The majority of the Indian populations are vegetarian, some by choice while most others do not consume fish, meat and their products due to economic reasons. Iodized salt remains the single most effective means of eradicating IDD in India but concerns are also being raised at some quarters on the implementation of universal salt iodization in the country. Therefore, we investigated the content and retention of inherent iodine in commonly used Indian recipes prepared without iodized salt and the importance of bread and milk as a source of iodine for the Indian population.

2. Materials and methods

2.1. Study area and sample collection

The study was carried out in the states of Bihar, Haryana, Himachal Pradesh, Sikkim, Nagaland, Manipur, Meghalaya, Punjab, Uttar Pradesh and Uttarakhand covering 26 districts. In each selected district two households were selected randomly for preparation of the most commonly used recipes. Recipes were prepared by the house lady without the use of iodized salt. Every detail of the recipe was documented including weight of each ingredient used. Samples of all ingredients used as well as the cooked recipes were collected and transported by air to the laboratory in Hyderabad.

All industrially manufactured bread available in Hyderabad as well as bread from retail shops consisting mainly milk, sandwich and whole wheat bread were collected from different parts of the city. Half liter packs of whole, low fat and very low fat milk was collected from the major regional milk distributors during the winter months.

2.2. Analytical methods

Iodine was determined by the method of Moxon and Dixon (1980). The principle involves alkaline incineration of the sample at 600 °C to remove all organic material, followed by determination of iodine by measuring the rate of catalytic destruction of iron thiocyanate by nitrite in the presence of iodine.

2.3. Quality control (QC)

The method was validated with the use of Certified Reference Material (CRM) NIST 1549. The concentration of iodine obtained from CRM NIST 1549 was 0.31 ± 0.008 μg/g which is in agreement with the certified value of 0.32 ± 0.02 μg/g for iodine. Casein was used as in house quality control material with every batch of analysis. While casein does not have a certified value, it develops an expected value through repeated analysis. The results for this QC are monitored to check for consistency of results from batch to batch. Recovery analysis was also performed with samples spiked with iodide equivalent to 1 mg/kg with every batch of analysis. Spiked recovery ranged from 93% to 101% with limit of detection of 8 μg/kg. The coefficient of variation (relative standard deviation) for iodine analysis carried out in this study was 12.5%.

2.4. Calculation of iodine retention in commonly consumed recipes

Iodine retention is a measure of the proportion of iodine remaining in the cooked food in relation to the amount of iodine originally present in the given food before cooking. Iodine retention in per cent, of recipe was calculated following the formula of Murphy, Criner, and Gray (1975) as given below:

$$\%\ \text{Iodine retention} = \frac{(\text{iodine content per g of cooked food} \times \text{total weight (g) of food after cooking})}{(\text{iodine content per g of raw food} \times \text{total weight (g) of food before cooking})} \times 100$$

2.5. Statistical analyses

Descriptive statistics viz. Mean, Range and Standard Deviation were calculated. Student's *t*-test was used to determine significance.

3. Results and discussions

3.1. Iodine content in bread samples

The use of non-iodized salt in bread making resulted in low iodine content hereafter, referred to as non-iodized bread while the use of iodized salt resulted in substantial iodine content referred to as iodized bread. Of the total 64 bread samples collected for iodine analysis, 18 bread was found to be non-iodized defined as bread with iodine content below 4.5 μg/100 g while the rest were iodized (>20 μg/100 g). Of the total bread sampled, retail shop bread constituted 20% milk, 18% sandwich and 5% whole wheat bread with majority of the samples being industrially manufactured. Iodine content of retail bread and industrially manufactured bread was comparable among the bread types. Bread samples were segregated as iodized and non-iodized according to bread types and presented in Table 1. Iodine content of iodized bread samples ($n = 46$) was 25.0 ± 3.1 μg/100 g significantly higher than 3.8 ± 0.5 μg/100 g found in non-iodized bread ($n = 18$). The iodine content in iodized bread from Bern, Switzerland (Haldimann et al., 2005) was reported to be 39.3 μg/100 g which is slightly higher than the present study. Non-iodized bread from Norway was reported to contain 3 μg/100 g iodine (Dahl, Johansson, Julshamn, & Meltzer, 2003) comparable to the iodine content of non-iodized bread in the present study. Data available in the literature has shown that the geometric mean of iodine content in cereals was 5.6 μg/100 g and without external source of iodine, cereal product such as bread had low content of 1.7 μg/100 g (Fordyce, 2003).

All types of bread whether milk, sandwich or whole wheat showed stark differences in iodine content between iodized and non-iodized bread. One slice of iodized bread contained 6.25 ± 1.6 μg iodine whereas it was <1 μg in non-iodized bread. There are reports that iodated conditioners added to bread to maintain freshness and prolong shelf life resulted in high iodine content of 150 μg/slice in the UK (London, Vought, & Brown, 1965) and as high as 587 μg/slice of bread in the US which was of concern (Pearce et al., 2004). However, this was not the case in the present study with all iodized bread having iodine content between 3.3 and 8.9 μg/slice. Of the total bread samples in the present study, 72% was iodized whereas in developed countries like Denmark, 90–98% were iodized (Rasmussen et al., 2007). In India, it appears that non-iodized salt is still being used in the food industry as there is no legislation on mandatory iodization in processed food, however, majority of the bread samples were iodized as a direct fallout of the implementation of universal salt iodization in the country.

3.2. Iodine content in milk samples

The iodine content in milk samples from Hyderabad is given in Table 2. The Mean ± SD iodine concentration in 47 milk samples