Monitoring and impact evaluation of iodized salt intervention in Cameroon

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ABSTRACT

This study was carried out to monitor current iodization and its impact on iodine excess. The results show medians values increasing gradually from 62 μg/L to 283 μg/L then dropping to 169 μg/L for acceptable significance to above toxicity significant values of 300 μg/L as from 2006, exaggerated in 2018 at 1145 μg/L. Salt iodine contents, compared to the 20 – 40 ppm range recommended by WHO, show coarse grain as lowest with average 26.9 ppm while fine grain for human consumption average was 57.3 ppm. The extra fine grain variety has the highest iodine content at 248.8 ppm. Imported cerebos salt from France contained iodine at an average of 45.5 ppm while the Senegal salt contained iodine at an average of 182.2 ppm. The F-ratio (62.9) indicates great variation in iodine content of the salt involved while the p-value (p = 0.0002) indicates significant differences in iodine content of the salt of different refineries. By implication, there are still lapses on iodization.

1. Introduction

It has been diagnosed that approximately two billion individuals worldwide have insufficient iodine intake, with those in south Asia and sub-Saharan Africa particularly affected (WHO, 2007). To salvage the situation, World Health Organization (WHO) and United Nations Children’s Fund (UNICEF) recommended universal salt iodization (USI) as the main strategy to achieve elimination of iodine-deficiency disorders (IDD) (WHO/NHD/01.1, 2001). Universal salt iodization (USI) has been adopted in nearly all countries and has become the best strategy to control iodine deficiency as one of the most cost-effective ways to contribute to economic and social development (WHO/NHD/01.1, 2001). Iodine is an essential component of the thyroid hormones, thyroxine (T4) and triiodothyronine (T3), necessary for normal growth, development, and metabolism during pregnancy, infancy and throughout life (Hetzel, 1991). When the physiological requirements for iodine are not met, a series of functional and developmental abnormalities occur, including thyroid function abnormalities termed IDD (Hetzel, 1991).

In the light of these facts, production, supply and use of iodized salt for humans and animals should become the behavioural norm. Monitoring the process of salt iodization and its impact on the iodine nutrition is of major importance to ensure the efficiency and efficacy of USI in any given population (Aburto et al., 2014). Since production and importation of only iodized edible salt obviously are the main pillars of USI efforts, monitoring at production and importation should be more regular. It is much easier to do this since production plants and importer warehouses are not always many, and they usually serve wide regional consumer populations. In reviewing the data of monitoring at production from several countries WHO/UNICEF/ICCIDD Consultation of 1996 (WHO/NHD/01.1, 2001) revised the norms (of 100 ppm) for iodized salt production and recommended 20–40 ppm of iodine or 34–66 ppm of Potassium Iodate. Also, urinary iodine survey and iodized salt consumption need careful monitoring because both iodine deficiency and iodine excess have adverse effects on health. While lack of iodine results to IDD, iodine excess brings about hyperthyroidism (an overactive thyroid gland), a condition in which excess thyroid hormone is produced. Patients with hyperthyroidism have increased risks of various cardiovascular problems, such as atrial fibrillation, hypertension, coronary artery disease, stroke and heart failure (Ertek and Cicero, 2013). Treatment of hyperthyroidism with either antithyroid medications or radioactive iodine is known to decrease these risks, but the risks are still higher than average when compared to a person without hyperthyroidism (Martin et al., 2007). The aim of this study is to advocate prevention through control.

The two commonly used indicators for assessing excess iodine are the iodine content and household coverage of iodized salt and the median urinary iodine concentration (UIC) value for the sampled population...
the goitre prevalence rate (at 95% confidence level) after the method of Coindet, 1821). Though this situation is presently well-tolerated in most people, nobody has researched to confirm or infirm a similar scenario in Cameroon, especially in a major city with high iodine intake like Yaounde. Also, infants with congenital heart disease exposed to excess iodine are more susceptible to thyroid disorders and impaired renal function (Thaker et al., 2017). These precarious situations have either been occurring and merit further investigations or may soon start happening in Cameroon, due to high median values as seen in Fig. 1. Similar situations occurred in Poland, Greece, Australia, Sweden etc (Angela and Lewis, 2014) but were mitigated with adequate intervention measures.

2.1. Statistical analyses

Raw data obtained were analyzed in a statistical package of Statgraphic 5.0, in one-way Analysis of Variance (ANOVA) according to the procedure of Steel and Torrie (1980). Significantly different means or averages were separated using the methods of Duncan (1955). The values obtained were presented as Least Significance Differences (LSD) of means at (p < 0.05) compared to those which did not differ significantly (p > 0.05) from the value of Duncan. Sigmaplot 11.0 was used for plotting of graphs.

3. Results and discussions

3.1. Median urinary iodine values and implications

Iodine levels in contrast vary with iodine intake and cannot be reliably measured at individual levels (Rasmussen et al., 1999), but median urinary iodine concentrations (UIC) are recommended and have been widely used as a biomarker of population iodine intake. Levels >300 μg/l are considered excessive in children and adults while levels >500 μg/l are considered excessive in pregnant women (WHO/UNICEF/ICCIDD, 2007). From the baseline value of 62.5 μg/L (Fig. 1), the median values are observed to increase gradually to 283 μg/L in 1999, dropping to 169 μg/L for acceptable significance to above the toxicity significant values as from 2006, being exaggerated in 2011 at 1145 μg/L.

An auto-regulatory phenomenon in which excess uptake of iodine by the thyroid inhibits thyroid hormone synthesis is called Wolff-Chaikoff effect (Kirstie and Symonds, 2017). This might have happened in Yaounde where iodine intake is very high. This phenomenon that occurs in some susceptible patients, with excess iodine furnishing rich ingredients for increased production of thyroid hormones might be transient or permanent (DeGroot, 2016). This iodine-induced hyperthyroidism that is also called the Jod-Basedow phenomenon was first described in the early 1800’s in patients with endemic goiter treated with iodine supplementation (Coidet, 1821). Though this situation is generally well-tolerated in most people, nobody has researched to confirm or infirm a similar scenario in Cameroon, especially in a major city with high iodine intake like Yaounde. Also, infants with congenital heart disease exposed to excess iodine are more susceptible to thyroid disorders and impaired renal function (Thaker et al., 2017). These precarious situations have either been occurring and merit further investigations or may soon start happening in Cameroon, due to high median values as seen in Fig. 1. Similar situations occurred in Poland, Greece, Australia, Sweden etc (Angela and Lewis, 2014) but were mitigated with adequate intervention measures.

3.2. Results on iodized salt and its implication

The salt producers studied were: Société de Transformation du Sel (SOTRASEL), Société de Purification du Sel (SOCAPURSEL), African Salt Company (Société de Rafﬁnage du Sel) producing AIGLE-brand, and Sel du CAMEROUN (SELCAM). The fifth dealer was a major importer (SOR-EPCO Sarl) of the brand Sel de Sine Saloum (SSS), and the sixth dealer was an importer marketing CEREBOS which is table salt from France. Table 1 shows that in the crude imported for reﬁning, there is some natural iodine, if it is marine salt; with an average iodine content of 2.9 ppm, range 1.1–8.5 ppm. Cattle or coarse grain has an average of 26.9 ppm with range 9–751.5 ppm. The F-ratio (62.9) indicates great variation in iodine content of all salt varieties involved while the p-value (p = 0.0002) indicates signiﬁcant differences in the salt of different reﬁneries.
From Table 1, there was the tendency for most salt producers to iodize fine and extra fine varieties more than the recommended range of 20–40 ppm iodine by (ICCIDD/UNICEF/WHO, 1996). However, apart from SOCAPURSEL that iodized coarse grain at 11.2 ppm most refineries tended to respect this recommendation for the cattle or coarse grain variety according to 26.9 ppm iodine value obtained. This coarse-grain or cattle salt is marketed in standard 18 kg sacks and is effectively largely used for animal consumption. This is by far the commonest variety in the popular markets of the countries of the Central African Sub-region, as it is also consumed by humans.

As far as “fine Table Salt” is concerned, destined almost exclusively for human consumption, the average iodation levels of 57.3 ppm is above the limits of 20–40 ppm iodine recommended by ICCIDD/UNICEF/WHO in 1996. The same is true for the very high average values of 248.8 ppm of industrial extra fine salt for specific uses. The consumption of these fine grain varieties that are iodized with no conformity to any regulation will result in excess iodine intake. The fact that local industries producing common popular food commodities like NESTLE and CHOCOCAM used it amongst the ingredients for their final products which children of urban centres consume very much, is a great reason for iodine excess especially in the major cities like Yaounde as observed above in median UIC values.

Table 1
Means, averages and ranges of iodine in salt refineries varieties.

| Salt variety               | Refinery | Count | Mean iodine (ppm) | Average (ppm) | Range       |
|----------------------------|----------|-------|-------------------|---------------|-------------|
| Crude                      | SELCAM   | 8     | 1.4 ± 23.2a       | 2.9a          | 1.1–8.5     |
|                            | SOTRASEL | 18    | 4.7 ± 15.5a       | 15.5a         | 2.3–23.3a   |
|                            | SOCAPURSEL | 24  | 2.4 ± 13.4a       | 2.4 ± 13.4a   | 13.4a       |
|                            | EAGLE    | 8     | 2.3 ± 23.3a       | 2.3 ± 23.3a   | 26.9ab      |
| Crude or Coarse grain      | SELCAM   | 4     | 22.6 ± 32.9b      | 22.6 ± 32.9b  | 26.9ab      |
|                            | SOTRASEL | 18    | 36.8 ± 15.9b      | 36.8 ± 15.9b  | 32.5 ± 23.3b|
|                            | SOCAPURSEL | 13 | 11.2 ± 18.3b      | 11.2 ± 18.3b  | 31.7–751.5 |
|                            | EAGLE    | 8     | 32.5 ± 23.3b      | 32.5 ± 23.3b  | 31.7–751.5  |
| Fine grain                 | SOCAPURSEL | 17 | 62.6 ± 16b        | 62.6 ± 16b    | 57.3b       |
|                            | EAGLE    | 8     | 49.6 ± 23.3b      | 49.6 ± 23.3b  | 49.6 ± 23.3b|
| Extra fine grain           | SOTRASEL | 12    | 356.4 ± 19.0d     | 356.4 ± 19.0d | 248.8c      |
|                            | SOCAPURSEL | 13 | 149.5 ± 18.3f     | 149.5 ± 18.3f | 31.7–751.5  |
| P value                    |          |       |                   | 0.0002        |             |
| F ratio                    |          |       |                   | 62.9          |             |

Values in the same column having the same superscripts are not significantly different from each other (p > 0.05).

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Here, the children of urbanizing African cities are beginning to follow the nutrition path of children in some industrialized Countries. Though the latter supply iodine to the masses through common and popular food commodities (biscuits, milk, sweets, chocolates, condiments etc), they also ensure that everything is meted with adequate control. This control that checks iodine excess is yet to fully happen in our context.

From the technical point of view, it is quite praise-worthy that the major salt dealers are working hard to respect the iodized salt norms although they still suffer from some mechanical and technological lapses which call for external vigilance through periodic external quality assurance and control by competent inspection teams. It is believed that these lapses are being objectively identified through this manuscript for correction.

In addition, iodine content tends to rise with the fineness of the salt. Since table (fine) salt tends to be over-iodized, city dwellers need to be counseled to stop over-consuming table (fine) salt so as to reduce iodine excess. However, restaurant keepers need to be drafted into the National Coalition and taught the special nutritional value of iodized salt and the brand of choice. They can do a lot to both promote Universal Iodized Salt Consumption and help in reducing iodine excess since regular eating in restaurants is much in fashion for urban workers, many of whom are not
Table 2
Imported salt varieties and iodine content.

| Salt brand | Count | Iodine content Parts per million (ppm) | Average | Range |
|------------|-------|----------------------------------------|---------|-------|
| Cerebos    | 04    | 45.4a                                  | 44.9-46.6|
| SSS        | 26    | 182.2a                                | 42.3-878.1|

P value 0.0994
F ratio 2.91

Values in the same column having the same superscripts are not significantly different from each other (p > 0.05).

Table 3
Household Salt samples and iodine content.

| Year of sample collection | Count | Iodine content Parts per million (ppm) | Average | Range |
|---------------------------|-------|----------------------------------------|---------|-------|
| 1991                      | -     | 0.0b                                   | 0.0-0.0 |
| 2007                      | 185   | 47.3b                                 | 2.1-163.9|
| 2009                      | 150   | 110.9d                                 | 6.3-215.8|
| 2010                      | 118   | 63.7c                                 | 2.1-126.9|
| 2014                      | 182   | 72.6c                                 | 0.0-201.0|
| 2017                      | 151   | 72.4c                                 | 1.1-201.0|

P value 0.0004
F ratio 25.67

Values in the same column having the same superscripts are not significantly different from each other (p > 0.05).

Disorders (ICCIDD), impact was positive as average iodine in local refineries’ salt dropped, remaining virtually low up to 2017. The standard deviations (STDs) also behaved similarly, indicating that local refineries improved relatively in the iodization process. On the contrary, the average for imported salt remained high (though dropping slightly), far above the limits of 20-40 ppm iodine recommended by ICCIDD/UNICEF/WHO in 1996. However, the STDs of the imported salt are observed to drop drastically signifying a positive impact of the inspection team that provided IEC (information, Education and communication) booklets to the importers for knowledge transmission to foreign refineries in Senegal, the source of the imported SSS variety.

Table 3 shows the averages of iodine in salt at household levels. It should be recalled that these samples were kitchen salt collected from children of ages 5–12 years with no information given as to the exact salt brand bought from the market by their mothers. Averages started from

![Fig. 2. Evaluation year vs average iodine ppm in local salt refineries and STDs.](image)
It thus seems reasonable to state that UIC median iodine values are also skyrocketing due to increased consumption of imported salt that brings in more iodine to the household than is necessary. Importers do not have warehouse control units (laboratories) that can check the level of iodine in the tons of salt they import. There is need for collaboration with academia laboratories, the respect of legislation and ensuring continuous inspection at the port to salvage the situation. The current legislation at the ministry of public health that emphasizes 100 ppm for iodine in iodized salt is outdated and needs revision.

4. Conclusion

The study shows that there is adequate household coverage of iodized salt but there are lapses on iodization with consequence being high median urinary iodine concentration (UIC) value for the population.

The excessive iodine exposure cases are not clinically fatal but could be harmful. Hypothyroidism, hyperthyroidism and autoimmune thyroiditis occur in cases with more than adequate or excessive iodine level. The latter is unsafe especially for susceptible populations with recurring thyroid disease, the elderly, fetuses, and neonates and merits further investigation. It appears quite recommendable that inspection teams should perpetuate their current periodic industrial visits to iodized Salt Refineries and warehouses of salt importers ad infinitum besides pursuing the setting up of internal quality control laboratories by all refineries as a practical policy.

Declarations

Author contribution statement

Bonglaisin J.N., Ngondé E.M.C., Tsafack T.J.J., Lantum D.N.: Conceived and designed the experiments.

Ngo Nlend M.: Analyzed and interpreted the data; Wrote the paper.

Mbakop C.D., Wirsiy E., Kimoun M.K., Ekambi M.A.: Performed the experiments.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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