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Original Article

Depreciation of the iodine rate in the food salts sold on the markets in Côte d’Ivoire

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Abstract

In this study, the survey of salt iodization was performed in 21 cities and towns spread over three sectors to assess the rate of iodine salt in accordance with the standards. To this end, 397 salt samples were collected and the rate of iodine was assayed. Also, some physicochemical parameters such as moisture, impurities, particle size and color of the salts were analyzed. The results give an average of 37.5 ppm iodine (± 22.8 ppm), iodine levels ranging from 0 to 98.4 ppm. In terms of actors, 28%, 42.5% and 28.6% of salt samples collected respectively at retailers, wholesalers and semi-wholesalers have iodine levels below 30 ppm. Also, 10.5% of salt samples collected from retailers, 23.4% for semi-wholesalers and 11.8 among wholesalers have iodine levels zero. The mean levels of moisture and impurities, respectively 2.372% (± 1.75%) and 0.24% (± 0.24%), are beyond the standards and contribute significantly to the drop of iodine level. Parameters such as color and size also have an impact on the drop of iodine level. Indeed, the risk of having a depreciated salt iodine levels is 2 times higher in color salt than in the white color salt. Similarly, fine salts are more iodized than coarse salt. Moreover, surveys show that the drop of iodine in salt is confirmed by the failure of iodine, its existence in the salt and its potential consequences which its deficiency in the body by actors in the sector. The establishment of a system of quality control of salt and a suitable education policy actor in the sector are needed to overcome the dysfunctions.

Key words: Iodine, salt, IDD, moisture, impurities.

1. INTRODUCTION

Iodine is an essential trace element, present in very small quantities in our body, the order of 15-20 mg in adults [1]. Iodine enters the thyroid synthesis. Iodine deficiency results in a slowdown of cellular metabolic functions. The recommended daily intakes are calculated accurately according to age and sex. A billion and half people around, or nearly a third of the world population live in areas endemic for iodine deficiency [2]. This leads to iodine deficiency disorders in metabolic functions. Among the possible consequences of disorders of iodine deficiency (IDD), it is important to mention cretinism, goiter, the failure of reproductive function, infant mortality…The public health planners and international agencies are becoming more and more aware that the elimination of iodine deficiency is a goal we can achieve. Also they recommend among other measures, the enrichment of foodstuffs of which the universal iodations of salt [3]. Salt is an ideal vehicle for the transport of iodine, in addition, it is universally used by all strata of society in quantity almost daily. The government of Côte d’Ivoire, like other countries has opted for the fortification of salt with iodine. However, the Ivorian government has not ratified the low on iodine fortification of salt food on its territory, but advocates that the imported salts are first enriched by the original producers. Today, with the diversity of suppliers and open borders because of war, markets are flooded with various salts which do not always respect the standard. The national nutrition program (NNP) has noted a sharp decrease in the rate of iodine in salt sold in supermarkets and as trade in markets [4]. It is therefore necessary to set levels of wastage in the distribution chain to control the levels of these losses to improve the quality of salt consumption. Thus, the overall objective of this study is to identify areas of high losses of iodine levels in the chain of distribution of dietary salt. The specific objectives assigned to it are to
determine the factors responsible for the loss rate of iodine in edible salt and assess the level of knowledge of industry players on salt iodization and IDD.

2. MATERIALS AND METHODS

2.1 Collection and treatment of samples

The study material consists of salt sold in the Ivorian territory. These salts have been collected from wholesalers (industrial importers), semi-wholesalers (second link in chain) and retailers who are in direct contact with consumers.

2.2 Methods

Given the diversity of targets and the desire to gather reliable data, the methodology uses two (2) forms of approach: a qualitative approach and a quantitative approach. The sample used is a plan to rational choice. Côte d’Ivoire has been split into three (3) sectors (port cities, main towns, bordering cities). In each market, the sampling method used is “Method of routes [5], as the number of sellers per market reach six (6) and the top six (6) were identified. After, three (3) following vendors are ignored and the fourth become the number one (1). After, three (3) following vendors are ignored and the fourth become the number two (2). And so on until the 18 vendors identified by scanning in the direction of clockwise. The six (6) top sellers with a record of qualitative and quantitative survey, the remainder received only a quantitative form. Wholesalers and semi-wholesalers receive two cards. At the end of the interview a sample of 200 g is taken from a sealed and cleaned container and an identification label comprising the area / department / vendor number / date is displayed. The sample size is twenty three (23) by city, or eighteen (18) samples from retailers and five (5) samples for semi-wholesalers or wholesalers. The size of the overall sample is four hundred sixty (450). Thus, twenty one (21) cities in thirteen (13) departments were surveyed and three hundred ninety seven (397) samples were collected.

2.3 Chemical analysis

The determination of the iodine content of salt samples was carried out by titrimetric method [6] which is the standard method of FAO. The iodine content in salt was freed using concentrated acetic acid in the presence of an excess of potassium iodide. The free iodine was titrated with sodium thiosulfate to 0,002 N, using 1% starch as indicator. The moisture in the salts was measured by the method described by the collection of the Inter-Professional Analytical Study [7]. The determination of the impurities was made by the method described by the collection AOAC [8]. Granulometry was given on the basis of theoretical law of distribution in size of the particles [9]. The size of salt is assessed using a vibrating sieve (D470-020) equipped with a column of sixteen (16) screens of various sizes AFNOR standard type and electronic scale SARTORIUS type of accuracy 0.1 mg. The color is determined by visual observation using color chart.

3. Statistical method

The statistical software SPSS 11.5 was used to determine the significance of variations in iodine levels between the cities with the Duncan test. The influence of physical-chemical changes in the rate of iodine was analyzed with Student tests and Khi2 at the significance level of 5%.

4. RESULTS

The packaging is mainly constituted of “the bag of rice” that is a permeable polyethylene. In fact, 88% of players say they receive their salt conditioned in this material, while 5% and 7% respectively receive the jute bags and plastic bags (Fig. 1). The average rate of iodine salt samples analyzed (37.5 ppm) is in the range of the standard point of sale which is 30-50 ppm. The average moisture content is 2.37% and is well above the norm is between 1 and 1.5%. The rate of impurity average is 0.24%, it is also well above the norm (0.03 to 0.05%) (Table 1). At the city level, the rate of iodine salt samples collected in the town of Abobo, in the towns of Boua, Odienne, Touba and Danane are below standard at the point of sale, by one of the salt samples collected in Port-Bouet exceeds the standard (Table 2). Apart from these common salt samples collected in other cities and municipalities have iodine levels in the range (30-50 ppm). These iodine levels tend to approach the upper bound of the standard, which demonstrates the phenomenon of hyper iodization of salt taken in this area. Generally, the moisture and impurities are relatively high compared to standards (Table 2). The salt samples collected from semi-wholesalers in the western area have iodine levels below the norm, while the salt samples taken from semi wholesalers in other areas have rates in the range of the standard. The rate of iodine salt samples collected from the wholesaler 2 is below the standard with high moisture content (Table 3). In terms of particle size analysis reveals three (3) types of grains of salt. The “coarse” with a high density at large mesh sieves, followed by a decrease to below the mesh. Salts "medium
Table 2: Distribution of the rates (iodine, moisture and impurities) of the cities concerned with the study

<table>
<thead>
<tr>
<th>Location</th>
<th>Semi-Wholesalers</th>
<th>Wholesalers (Importing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone portuair</td>
<td>Zone centre</td>
</tr>
<tr>
<td>Iodine (ppm)</td>
<td>34.7 ± 22.9</td>
<td>31.0 ± 20.4</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>48.6 ± 21.8</td>
<td>15.5 ± 22.4</td>
</tr>
<tr>
<td>Impurities (%)</td>
<td>0.29 ± 0.17</td>
<td>0.36 ± 0.27</td>
</tr>
</tbody>
</table>

N = 18, the values of the same line being affected same letter are not significantly different according to the multiple test of comparison of Duncan to the threshold of 5 %.

Table 3: Distribution of the rates (iodine, moisture and impurities) of the salt exits samples of the local wholesale dealers and wholesalers

Table 4: Influence of certain characteristics on the fall of the iodine rate.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Samples depreciated</th>
<th>RR</th>
<th>Khi²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Retailers</td>
<td>(n = 397)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Grain</td>
<td>118</td>
<td>279</td>
<td>0.69(0.48-0.99)</td>
<td>3.63</td>
</tr>
<tr>
<td>White Color</td>
<td>88</td>
<td>273</td>
<td>0.27(0.22-0.33)</td>
<td>64.5</td>
</tr>
<tr>
<td>Sector 1</td>
<td>35</td>
<td>126</td>
<td>0.62(0.44-0.87)</td>
<td>0.004</td>
</tr>
<tr>
<td>Sector 2</td>
<td>15</td>
<td>44</td>
<td>-</td>
<td>0.61</td>
</tr>
<tr>
<td>Sector 3</td>
<td>68</td>
<td>109</td>
<td>1.69(1.24-2.30)</td>
<td>11.6</td>
</tr>
</tbody>
</table>

Table 5: Search of bond between the iodine rate and the characteristics of salt (size and color of the grains).

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<table>
<thead>
<tr>
<th>Variables</th>
<th>samples depreciated no</th>
<th>RR</th>
<th>Khi²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Grains</td>
<td>374</td>
<td>38.1</td>
<td>22.3</td>
<td>2.26</td>
</tr>
<tr>
<td>Others</td>
<td>23</td>
<td>27.1</td>
<td>26.4</td>
<td>-</td>
</tr>
<tr>
<td>Difference</td>
<td>11.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White color</td>
<td>364</td>
<td>40.1</td>
<td>21.4</td>
<td>8.06</td>
</tr>
<tr>
<td>Others</td>
<td>33</td>
<td>9.07</td>
<td>17.7</td>
<td>-</td>
</tr>
<tr>
<td>Difference</td>
<td>31.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. DISCUSSION
In this study, the average rate of iodine salt samples that emerges is 37.5 ppm (± 22.8 ppm). Given this rate and compared to the standard point of sale (30-50 ppm), the salt sold in Côte d'Ivoire is adequately iodized. However, many gaps and dysfunction exist among different actors along the distribution chain. At the level of salt samples collected...
from the retailers, those port cities have generally a normal iodine levels except salt samples from the town of Abobo, which are hypo iodized with a value of 26.8 ppm ± 21.4 ppm and those of the town of Port-Bouet who have a hyper rate with 54.5 ppm iodine ± 14 ppm. At the borders, salt samples from the town of Bouna and towns of the western border (Odiènné, Toub, Danané) have iodine levels below the norm. The samples of salt from the town of Danane are characterized by a rate almost zero (2.1 ppm ± 5.4 ppm). Regarding the three gateway cities, samples of salt iodine levels were within the norm. These shortcomings are observed in both strata related depreciation. In stratum 1 (port area), many samples have a zero rate of iodine. These salts are however well packed with moisture and impurities practically correct, and are sold in supermarkets. In general, the iodine levels of salt samples from surrounding areas of Abidjan, and are higher than those in more remote areas of the capital. These high rates are the foundation of iodized salt hyper observed in households in the city of Abidjan [10] and this is explained by the fact that these areas are close to suppliers. Indeed importers of salt being in the port area, the time between its last and the consumer basket is very short. Although iodized salt is thus found among consumers in this area has not lost its iodine in the proportions recommended for consumption. Going deep into the country there would be losses of iodine up to 45% given the remoteness [11]. In terms of players in the sector, the samples collected from the wholesalers have a relatively low rate of iodine. Indeed, 28.6% samples have a wholesale rate below 30 ppm. This could be explained by two hypotheses. In the first case in reliance on the accuracy of the information collected on the ground, some batches of inadequately iodized salt would be imported at the producer level. Wholesalers are the first links in the chain of distribution in Côte d'Ivoire. The problem of inadequate iodization is related to the level of producers to financial issues because they often use potassium iodide (KI) instead of potassium iodated (KIO3) which is more stable in the tropics [2]. Among retailers, 28% of samples have iodine levels below the standard and 10.5% have a zero rate. As for semi-wholesalers 42.5% of samples have a rate below the standard and 23.4% a zero rate. In general, the rate of iodine is higher among retailers and wholesalers and semi wholesalers, which in normal circumstances would be the opposite. Indeed, the semi-wholesalers are the actors who directly supply retailers. On the ground observation is that the bags of salt are stacked on each other. The new bags of salt piled arriving on the old bags. The retailer that arises is automatically supplied with bags lately. The old bags suffer losses of iodine by absorbing moisture. The problem arises from these players is inventory turnover. The management, inventory turnover is defined as the number of times the stock of a trader running in the year [12]. In practice at the time of delivery, the trader should start with the oldest stock to go to the most recent inventory. But the opposite is observed, the iodine content of salt that is found in the retailer is higher in iodine than the semi-wholesaler. Or the second hypothesis that could justify this finding is counterfeiting. Indeed, the borders are porous against counterfeiting of war could explain the dysfunction between the rates of iodine salts collected from various actors. Factors that may explain the loss of the iodine in salt, the moisture are the mean of the study was 2.37% of (± 1.75%). This average, which reflects the moisture content of all samples of salt, exceeding the standard is 1 to 1.5%. Indeed, the salt is a hygroscopic substance which therefore needs to be protected, hence the problem of packaging. The study revealed that 87% of retailers repackage their salts in bags and 11% in basins. However, these 87% before reconditioning bagged, have their salts in trays or other containers not covered to attract the sympathy of the customer. In reality it is therefore 98% of retailers who display their salts. These salts pick up moisture from the air and the phenomenon of seepage, iodine evaporates. Similarly, 88% of retailers say they receive their salts in "rice bags” that are packaging polyethylene semi-permeable. These different materials used by industry players promote wetting of salt. The use

![Figure 2: Granulometric analysis of the salt samples](image-url)
of glass materials, bag and polyethylene bag waterproof retain more iodine would be encouraged [13]. The wetting of salt is also enhanced by the size of the grains. More grain size, the greater the salt provides a large contact surface with water molecules [13]. The color of the salt also affects the drop of iodine. Indeed, all color samples have a lower rate than the norm. The salt is normally white, or color change is due to an increase of impurities. This promotes an increase in humidity, because in addition to the hygroscopic salt, impurities also trap water molecules [14]. Beyond these factors that can be considered as internal salt, the major problem among actors is ignorance. Levels of knowledge about iodized salt and IDD at retailers, wholesalers and semi-wholesalers are relatively low.

6. CONCLUSION AND RECOMMENDATIONS
The study of the depreciation rate of iodine food salts shows that non-iodized salt and salt iodized inadequately circulated among retailers, wholesalers and semi-wholesalers. This study also shows that areas of endemic goiter as the cities west continue to be supplied inadequately iodized salt or with a zero rate. In areas close to suppliers, the trend is to hyper iodized salt with which can be the basis of certain diseases. Moreover, ignorance of the existence of iodine in salt by the majority of players in the sector and the use of semi-permeable packing as well as exposure to salt air are all practices that promote evaporation of iodine in salt.

- The Ivorian state must become more involved in fight against IDD through preventive actions such as:
  - Strengthen the regulation for trade of salt for better organization of the sector;
  - Establish programs of mass awareness and adapted to the level of industry players but also the location of population;
  - Make checks qualities of all the salts entering the territory of Côte d'Ivoire;
  - Strengthen the operations of National Nutrition Program (NNP) in its fight against IDD in endemic areas;
  - Strengthening the efforts of iodized oil supplementation to mitigate the adverse effects of IDD.
- For industry players
  - Adopt a better inventory management to avoid the phenomenon of hyper or hypo iodization at the consumer level;
  - Avoid exposing the salt to the open air, which increase the impurities and moisture.
- For consumers
  - Focus salts grained and white

7. Acknowledgments
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8. REFERENCES

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