Concentrations of sodium in, and moisture content of retail bread samples sold in Umuahia metropolis, Nigeria

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Abstract

The bulk of the sodium consumed daily comes from “hidden salt” in processed foods, especially bread. The prevalence of diseases associated with high sodium intake is increasing globally. The aim of this study was therefore to evaluate the concentration of sodium and moisture in one of the most popular foods consumed in Nigeria – bread. The sodium concentrations of 3 different batches of 20 bread brands sold in Umuahia, Nigeria, were therefore determined by flame photometry. Their moisture contents were also determined gravimetrically. Appropriate statistical analyses were carried out on the data generated. The results show that the moisture content of the sliced bread samples ranged from 18.8% – 27.6% while for the unsliced samples it ranged from 18.8% – 21.8%. The mean sodium content [mg/100 g of bread (range)] of sliced bread brands was 716.7 (166.7 – 933.3) while that of unsliced brands was 660.0 (300.0 – 1066.7). Only 6 bread brands (30% of the studied brands) had sodium concentrations that were within the recommended limit. Eating four slices of the studied breads a day could supply 29.0% – 53.6% (for normotensive subjects) and 42.2% – 91.1% (for hypertensive subjects or those at risk of hypertension) of the adult recommended daily allowance for sodium. The sodium contents of the studied bread samples are higher than is acceptable and may be contributing to adverse health outcomes. These results show that salt recommendations are taken with a grain of salt in the studied locality, and calls for urgent public health actions to redress it.

Key words: bread, cardiovascular diseases, health policy, salt, sodium

INTRODUCTION

The daily diets of human ancestors had less than 0.25 g of salt. This changed after the discovery (about 5000 years ago) that salt is an excellent preservative, by the Chinese (He and MacGregor, 2009). Though salt is no longer used chiefly as a preservative, salt consumption has increased in the last century due to large scale industrial production (and concomitant consumption) of highly salted processed foods. Salt consumption (per individual) has now reached a phenomenal 9-12 g/day in many countries (Henderson et al., 2003).
in bread is “hidden” as its quantity is not easily appreciated by taste. Furthermore, the nutrition transition in many developing countries such as Nigeria implies a shift to highly salted processed foods, chief among which is bread.

The consequences of high salt intake include hypertension (He and MaacGregor, 2007), increased cardiovascular disease (CVD) risk (Nagata et al., 2004), renal disease (Ohta et al., 2013), proteinuria (Swift et al., 2005), osteoporosis (Caudarella et al., 2009) and some cancers (Tsugane et al., 2004). Joffres et al. (2007) reported that reducing salt intake by 4.6 g/day would reduce the prevalence of hypertension by as much as 30%, thereby saving approximately $430 million annually. It is estimated that a 15% reduction in salt intake in middle and low income countries would prevent 8.5 million deaths annually (Asaria et al., 2007).

The World Health Organization has therefore set a target of 5 g/day for adult salt intake (that is approximately 2000 mg of sodium/day) (WHO/FAO, 2003) and requires governments to implement strategies to achieve it (Nishida et al., 2004). The United States Department of Agriculture (USDA) recommends a sodium intake of 2300 mg/day for normotensive individuals and 1500 mg/day for hypertensive individuals and those at risk of hypertension (those < 51 years and those of any age who are African-American or have diabetes, or chronic kidney disease), but advices that the general population should strive towards 1500 mg/day ultimately (USDA/DHHS, 2010). Nigeria and South Africa are reportedly the only countries in sub-Saharan Africa to have developed dietary guidelines for salt intake (WHO, 2007). The extent to which these guidelines are implemented and enforced in Nigeria is however debatable.

Bread is one of the oldest foods consumed by humans and is used till date, figuratively, to refer to nourishment. Though bread recipes have remained essentially the same over the millennia, the salt content of bread has increased in recent years. Apart from the improvement of taste, salt plays other roles in bread manufacturing. These include improvement of shelf life, increase in bread volume, strengthening gluten networks thereby improving resistance, extensibility and elasticity, modulation of fermentation rate, and improving certain sensory characteristics (Belz et al., 2012). This implies that there is a limit to how much salt manufacturers will be willing to cut from their recipes. Girgis et al. (2003) however reported that a reduction of up to 25% in the salt content of bread did not affect bread quality and therefore acceptability.

This is supported by the findings of Ferrante et al. (2011). Reduction in the salt content of bread (and other processed foods) is therefore feasible and will reduce population level exposure to salt considerably and have positive public health impacts (Belz et al., 2012). The relationship between salt intake and cardiovascular derangements is still controversial, and how the potential benefits of salt reduction are likely to affect populations is still debated (Hooper et al., 2002; Ejike and Ugwu, 2012; Heerspink and Ritz, 2012). The evidence in favour of salt reduction is nonetheless monumental and compelling. This study therefore assesses the concentration of sodium in, and moisture content of, retail samples of bread sold in Umuahia metropolis, Nigeria; the probable contributions of bread in population level exposure to salt; and draws attention to the need to develop effective strategies to ensure that reduction in salt consumption is achieved.

MATERIALS AND METHODS

Bread samples

Three batches of 20 bread brands (10 sliced and 10 unsliced bread brands) per batch, sold regularly in Umuahia metropolis were purchased at weekly intervals from retail outlets in Umuahia, Abia State, Nigeria. For each batch, three different samples of the 20 brands were purchased. The bread samples were appropriately labelled using codes derived from their brand names and the details of their manufacturers. A total of 180 bread samples were purchased and analysed.

Moisture content determination

The moisture contents of the bread samples were determined, in duplicates, gravimetrically for all the bread samples. The means of the duplicate determinations per sample, per batch were recorded and used in computing the mean moisture contents and standard deviations of the 20 brands of bread studied.

Sodium determination

The dried bread samples were ashed with 25% HNO₃ at 450°C, and the ashes used to determine the sodium content by flame photometry (Chen et al., 2005). The limit of detection was 0.2 µg/g while the precision was > 96%. The average weight of the slices of bread for each brand of the sliced breads were determined and used in determining the sodium content per slice of bread. For the unsliced bread samples, the pooled average weight of the slices from the bread samples was used. The sodium chloride equivalent was calculated from the relationship: 1 g of sodium chloride ≡ 393.4 mg of sodium.

The recommended daily allowance (RDA) for adult sodium intake was taken as 2300 mg/day for normotensive individuals and 1500 mg/day for hypertensive individuals and those at risk of hypertension...
(USDA/DHHS, 2010). From a convenient sampling of opinions from one hundred adults living in Umuahia, four slices of bread was taken as the average quantity consumed by an adult per meal.

Based on the above, the contributions of bread to the RDA were calculated for normal subjects and for those who are hypertensive or at risk of hypertension. The design of the study and ethical matters relating to it were approved by the Board of the Department of Biochemistry, MOUAU.

**Data analysis**

Descriptive statistics was carried out on the data generated, and where necessary, One Way ANOVA was used to test differences between means for significance. In order to assess the relationship between moisture content and sodium concentration of the bread samples, the Pearson’s correlation coefficients were calculated. A significant threshold of $P < 0.05$ was employed for all analyses. Data analysis was done using the IBM-SPSS Statistics 20 software package (IBM Corp., Armonk, NY).

**RESULTS**

The mean moisture content of the sliced bread samples was 23.2% (range: 18.8% – 27.6%) while for the unsliced samples it was 20.4% (range: 18.8% – 21.8%) (Figure 1). Sliced bread samples had significantly ($P = 0.011$) more moisture content, compared to the unsliced samples.

Sliced bread samples had a mean sodium content of 716.7 mg/100g of bread (range: 166.7 – 933.3 mg/100g). For the unsliced bread samples, the mean sodium content was 660.0 mg/100g (range: 300.0 – 1066.7 mg/100g) (Figure 2). The differences in the sodium content of the sliced and unsliced bread samples were however, statistically insignificant ($P = 0.387$). The concentration of sodium in four slices of sliced bread ranged from 833.3 ± 146.6 to 1223.3 ± 215.5 mg; while that for unsliced bread ranged from 633.3 ± 152.8 to 1366.7 ± 305.5 mg (Table 1).

All but 6 bread brands (2 sliced and 4 unsliced), that is 70% of the studied brands, had considerably more sodium than the recommended 440 mg/100g of bread. There was no significant correlation between the moisture content and the sodium content of the studied brands of bread ($r = -0.174; P = 0.184$) (Figure 3).

An adult who eats four slices of sliced bread a day, gets 29.0% – 53.6% (for normotensive subjects) and 44.4% – 82.2% (for hypertensive subjects or those at risk of hypertension) of their RDA for sodium from just bread (Table 1).

**DISCUSSION**

The course of evolution has resulted in only small genetic changes or variations since the dawn of agriculture in the Neolithic period. It appears that humans evolved to suit the diet and lifestyle of hunters and gatherers (Lindeberg, 2009). Unfortunately, human diet and lifestyle have considerably changed. It has been argued that the huge changes in diet over the millennia are responsible for the many metabolic derangements that plague mankind today (Eaton and Eaton III, 2000). In that direction, it is thought that the large amounts of salt consumed daily today, places a lot of burden on the excretory systems of the body and results in renal and cardiovascular diseases.

As a result of the rising burden of cardiovascular diseases globally (and more so in developing countries) and the economic burden it places on healthcare systems, the place of prevention has been highlighted in recent years. In recognition of the contributions of salt to the CVD burden, and that the bulk of the salt consumed in the diet comes from processed foods, attempts have been made to reduce the salt content of processed foods by legislation, public education and collaboration with relevant stake-holders. Bread is one of the most salty foods eaten globally, and has been the subject of many regulations. In Nigeria, bread is arguably the only processed food that is accessible to, and consumed regularly by, both the poor and the rich. Unfortunately, the degrees to which salt reduction programs are initiated and implemented, and targets met vary from country to country.

The sodium content of 70% of the studied brands of bread were higher than is recommended. A salt concentration of 440 mg/100 g of bread (equivalent to 1.1 g per 100 g) is the widely recommended concentration in most parts of the world. In some countries, lower targets have been set. For example, the UK Food Standards Agency recently set a target of <400 mg/100 g of bread for bakers to meet (FSA, 2011).

The high sodium content of the bread samples is very worrisome, especially given that an adult (consuming say 4 slices of bread a day) could get 29.0% – 53.6% (for normotensive subjects) and 44.4% – 82.2% (for hypertensive subjects or those at risk of hypertension) of their RDA for sodium from bread alone. Such high sodium content from only one food source (often eaten as a meal or as a snack) clearly predisposes the consumers to renal and cardiovascular diseases, and could exacerbate existing pathologies. It is also worrisome that there were high degrees of variation in the salt and moisture contents of individual brands of bread,
Figure 1. Moisture content of sliced and unsliced bread samples sold in Umuahia metropolis. Points represent means and SD of eighteen determinations (duplicate determinations for each of three samples per batch, for three different batches bought over a three-week period) for each brand of bread.

Figure 2. Sodium content of sliced and unsliced bread samples sold in Umuahia metropolis. Points represent means and SD of eighteen determinations (duplicate determinations for each of three samples per batch, for three different batches bought over a three-week period) for each brand of bread.
Table 1. Concentrations of sodium and sodium chloride per ready-for-consumption slice of bread sold in Umuahia metropolis

<table>
<thead>
<tr>
<th>Code</th>
<th>Conc. of sodium per 4 slices of bread (mg/slice)</th>
<th>Conc. of sodium chloride per 4 slices of bread (g/slices)</th>
<th>% of RDA [NS (HT or at risk of HT)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sliced Bread</td>
<td>Unsliced Bread</td>
<td>Sliced Bread</td>
</tr>
<tr>
<td>1</td>
<td>1033.3 ± 208.2</td>
<td>766.7 ± 146.3</td>
<td>2.6 ± 0.5</td>
</tr>
<tr>
<td>2</td>
<td>1200.0 ± 158.4</td>
<td>933.3 ± 192.0</td>
<td>3.1 ± 0.4</td>
</tr>
<tr>
<td>3</td>
<td>833.3 ± 146.6</td>
<td>1200.0 ± 216.5</td>
<td>2.1 ± 0.4</td>
</tr>
<tr>
<td>4</td>
<td>933.3 ± 177.6</td>
<td>733.3 ± 146.2</td>
<td>2.4 ± 0.5</td>
</tr>
<tr>
<td>5</td>
<td>1233.3 ± 115.4</td>
<td>933.3 ± 188.6</td>
<td>3.1 ± 0.3</td>
</tr>
<tr>
<td>6</td>
<td>1200.0 ± 204.8</td>
<td>1366.7 ± 305.5</td>
<td>3.1 ± 0.5</td>
</tr>
<tr>
<td>7</td>
<td>666.7 ± 151.1</td>
<td>633.3 ± 152.8</td>
<td>1.7 ± 0.4</td>
</tr>
<tr>
<td>8</td>
<td>1223.3 ± 215.5</td>
<td>800.0 ± 258.9</td>
<td>3.1 ± 0.5</td>
</tr>
<tr>
<td>9</td>
<td>966.7 ± 152.8</td>
<td>933.3 ± 250.5</td>
<td>2.5 ± 0.4</td>
</tr>
<tr>
<td>10</td>
<td>833.3 ± 155.1</td>
<td>1200.0 ± 357.4</td>
<td>2.1 ± 0.4</td>
</tr>
</tbody>
</table>

Concentration of sodium chloride is calculated based on the relationship: 1 g sodium chloride ≡ 393.4 mg of sodium. RDA stands for recommended daily allowance. RDA for sodium (for adults) used above are 2300 mg/day for normal subjects (NS) and 1500 mg/day for hypertensives (HT) or those at risk of hypertension.

Figure 3. Correlations between moisture content and sodium content of bread samples sold in Umuahia metropolis ($r = -0.174; P = 0.184$) Points represent means of six determinations (duplicate determinations for each of three samples per batch per brand of bread). Each brand is represented by three points, one for each batch.

suggesting that the manufacturers may have followed their recipes (if they in fact did) with questionable fidelity.

The finding of high concentration of sodium in bread in this study is not an isolated case. The salt content of bread from different European countries has been reported and many of the countries have values similar to what is reported here (Quilez and Salas-Salvado, 2012). Ferrante et al. (2011) reported that bread sold in Argentina had salt contents of up to 2 g/100 g of bread. In Nigeria, Nwanguma and Okorie (2013) recently found that the salt content of retail bread samples sold in Enugu State, Nigeria (which is different from the site of this study) ranged from 0.5 g to 1.8 g per 100 g of bread (that is approximately 201 mg to 708 mg of sodium/100 g of...
bread). Otemuyiwa and Adewusi (2012) reported that adult Nigerians in Lagos State (also different from the site of this study) got as much as 3078 mg (males) and 2991 mg (females) of sodium daily from fast foods. It is therefore plausible that the salt content of the diets of Nigerians may be playing a major role in the rising prevalence of cardiovascular and renal diseases in both adults and children (Ejike et al., 2009; Ejike et al., 2010; Ijeh et al., 2010). This underscores the need for action aimed at reducing the salt content of processed foods, chiefly bread.

Historically salt was of high value and often in short supply, thereby ensuring that despite its sought-after taste, it was not over-consumed. Currently, it is inexpensive, found virtually everywhere, and is "hidden" in most processed foods; hence it’s probable abuse (Legowski and Legetic, 2011). Sodium in salt is thought to affect cardiovascular events by increasing plasma sodium content, thereby causing fluid retention and an increase in blood volume; and altering the functions of endothelial cells and production of nitric oxide (Dickinson et al., 2011).

It places a burden on the kidneys which strain to excrete the excess sodium. A reduction in the quantity of salt consumed is known to reverse the side effects of high plasma sodium. Given the fact that as much as 75-85% of the total salt intake comes from salty processed foods (James et al., 1987; Sharp, 2004) the health benefits of a deliberate national and global strategy to reduce the salt content of popular and widely eaten foods such as bread cannot be over-stated. Developing countries such as Nigeria, cannot afford the extra healthcare expenditure that the burden of CVDs (if unchecked) portends, and must therefore borrow a leaf from other countries in engaging this salt challenge. This is more so since lowering the sodium content of bread is both medically and economically a wise thing to do.

In developing countries where access to refrigeration may be limited, the extension of shelf life of processed food such as bread is often an excuse for the high salt content in such foods. Data from the correlation studies presented here however show that the reason for the high sodium content of the studied bread samples could not have been the extension of shelf life. Since the water activity of any food substance is inversely proportional to its shelf life (in the absence of preservatives), one would expect that the sodium content of the bread samples would have a significant, positive, linear relationship with the moisture content if preservation was the goal.

Though salt plays other important roles in bread manufacture (Belz et al., 2012), there is evidence that its role in sensory improvement, increase in bread volume, improving resistance, extensibility and elasticity, and modulation of fermentation rate can be overcome.

The technical feasibility of producing bread that is low in salt content has been established. All that is required is making appropriate changes to the bread-making process and the new product remains essentially the same (Noort et al., 2012; Belz et al., 2012). In fact, a report from Janssen and Koeman (2010) shows that a stepwise reduction in the salt content of bread could not be detected by as much as 85% of Dutch subjects. This is likely because the taste for salt is malleable and decreases with lesser salt consumption. Ferrante et al. (2011) reported that a reduction from 2% to 1.4% (a 30% reduction) in the salt content of bread was largely undetected by a panel of testers. Earlier, Girgis et al. (2003) reported that a reduction of up to 25% in the salt content of bread did not affect bread quality and therefore its acceptability. Aside the feasibility of reducing the salt content of bread, such an action is reportedly cost-effective and beneficial to all stake holders.

Globally, campaigns to regulate the salt content of bread have been predicted to prevent 8.5 million deaths, mostly from CVDs (Asaria et al., 2007). A 15% reduction in dietary salt between 2006 and 2015 is estimated to be capable of saving about 60,000 lives in Argentina alone (Rubinstein et al., 2009). Joffres et al. (2007) have shown that reducing the sodium content of foods can reduce the prevalence of hypertension by 30% and result in healthcare savings of about $430 million annually in Canada. Bibbins-Domingo et al. (2010) suggested that reducing salt intake in the United States by 3 g/day had the potential to decrease new coronary heart disease, stroke and myocardial infarction by as much as 120,000, 66,000 and 99,000 respectively.

Furthermore, Palar and Sturm (2009) reported that $18 billion in healthcare, and $32 billion in quality adjusted life years, could be saved in the United States simply by reducing the salt intake to an average of 5 g/day. In South Africa, a reduction in the salt intake by 0.85 g/person/day will reportedly result in 7,400 fewer CVD deaths and 4,300 less non-fatal strokes annually (Betram et al., 2012). Given the above benefits, Nigeria should immediately move to reduce the salt content of bread and thus stave off the impending epidemic. Nigeria’s current policy on salt appears to concentrate on enforcing iodization of salt alone. The success recorded in that drive can also be replicated if the reduction in the salt content of processed foods is given proper attention.

Therefore, the following suggestions are pertinent: (1) that an efficient system be established to monitor the intake of sodium in the diet, especially from processed foods such as bread; (2) that educational campaigns be launched on the health risks of salty diets and how to reduce the intake of salt (this may even warrant modifying primary and secondary school curricula, and may require asking healthcare professionals to provide education in this regard to each patient they attend to); (3) that food processing industries who are willing to reduce the salt content of their products should be offered incentives to encourage compliance; and (4) that
appropriate labelling of the salt content of the product on
the shelf is introduced and enforced. It is important to
note that working with the industry is of critical
importance, given the contributions of salty processed
foods to the daily sodium intake. In fact, Millet et al.,
(2012) noted that public awareness campaign alone
resulted in only small reductions in discretionary use of
salt in the kitchen. Nigeria and the United Kingdom have
historical ties therefore Nigeria should borrow a leaf from
the UK national strategy for salt reduction introduced in
2003 (which has been described as a model by many).

In conclusion, the sodium content of 70% of retail bread
brands sold in Umuahia metropolis exceeds the threshold
for sodium in bread. Consumption of a meal of four slices
of bread with such high sodium concentrations could
contribute more than 50% of the subjects RDA for
sodium. This may be a source of risk for the disorders
associated with over-consumption of sodium. The
present study indicates that salt recommendations are
taken with a grain of salt in Umuahia metropolis, Nigeria.
There is therefore an urgent need for public health action
in Nigeria, targeted at reducing the quantity of sodium in
processed foods, especially bread.

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