Effect of smoking on the iodine content of some Ghanaian sea fish

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ABSTRACT

The iodine content of some smoked Ghanaian sea fish has been examined to recommend rich dietary sources of iodine to the public. Fresh fish samples were analyzed for moisture and iodine. Samples of the same species (Kankama-*Sardinella auritus*, Mmornkor-*Penaeus notialis*, Boboe-*Brachydeuterus auritus*, Saman-*Scomber japonicus*, Antele-*Chloroscombus chrysurus*, and Antebo-*Sardinella eba*) from the same catch were then smoked and analyzed for moisture and iodine. In all, except Kankama, significant losses of iodine ($P<0.05$) resulted from smoking. Iodine losses from smoking ranged from 54 to 86 per cent. Enough iodine was, however, left in all cases to make the smoked fish good sources of dietary iodine. Consumption of, as little as, 100 g smoked fish would, in all cases, satisfy the recommended dietary allowance of 150 µg iodine/day for an adult.

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RÉSUMÉ

ASIBEY-BERKO, E., LOKKO, P. & NERQUAYE-TETTEH, G.: *Effet de fumage sur le contenu d'iode de quelques poissons de mer du Ghana.* Le contenu d'iode de quelques poissons de mer fumés du Ghana a été étudié afin de recommander les sources diététiques riches d'iode au grand public. Les échantillons de poisson frais étaient analysés pour l'humidité et l'iode. Les échantillons des mêmes espèces (Kankama-*Sardinella auritus*, Mmornkor-*Penaeus notialis*, Boboe-*Brachydeuterus auritus*, Saman-*Scomber japonicus*, Antele-*Chloroscombus chrysurus* et Antebo-*Sardinella eba*) de la même pêche étaient fumées et analysées pour l'humidité et l'iode. En tout, à l'exception de Kankama, des pertes considérables d'iode ($P< 0.05$) provenaient de fumage. Les pertes d'iode de fumage varient entre 54 et 86 pour cent. Assez d'iode était, toutefois, laissé dans tous les cas pour rendre les poissons fumés des bonnes sources d'iode diététique. La consommation d'aussi peu que 100 g de poisson fumé, dans tous les cas satisfait la ration diététique recommandée de 150 m g d'iode/jour pour une adulte.

Introduction

Iodine is a trace element that is essential in the diet. Without it, thyroid hormones, for example thyroxine and tri-iodothronine, cannot be synthesized by the body. Normal physiological and mental development are hampered, causing iodine deficiency disorders (IDD) such as spontaneous abortions, stillbirths, brain damage leading to cretinism with mental retardation, goitre, retarded physical development, and loss of energy (Hetzel & Pandau, 1994). A normal adult's dietary requirement of iodine is 150 µg/day.

Studies in Ghana, a few years ago, found at least 33 per cent of the districts in Ghana having serious levels of IDD (Asibey-Berko & Orraca-Tetteh, 1994). Iodine capsules were distributed in the hardest-hit areas, pending the iodization and marketing of salt in Ghana. Iodized salt has been produced and marketed in Ghana since 1996.

It is important, however, that the public be educated about local foods which are rich in iodine. Theodosia (1996) reported the iodine contents of some common Ghanaian foods (vegetables, cereals, legumes, tubers, fruits, and sea-fish) and confirmed sea fish as the richest source of iodine. Sea fish are known to contain about 30 times more iodine than fresh-water fish (Börgstrom, 1962). Others followed with a study

of the concentrations of iodine in several commonly consumed fresh Ghanaian sea fish (Asibey-Berko, Lokko & Nerquaye-Tetteh, 1996) to be able to recommend to the general public which local fish are high in iodine. Fishing localities are known to have considerable influence on iodine content of fish (Börgstrom, 1962). The first person to determine the iodine content of many sea and fresh water fish was the French scientist Bourcet (Börgstrom, 1962). Chatin later analyzed food and water samples and showed that iodine is relatively deficient in foods and water in areas where goitre is endemic (Davidson & Passmore, 1986).

Since most Ghanaian fish are usually smoked before marketing, it was considered useful to investigate the effect of smoking on the iodine content of local fish. A similar study was conducted on Ghanaian fish by Aye & Esh (1976) who looked at the effect of smoking on thiamine, riboflavine, niacin, and iodine concentrations. Using a traditional method for small-scale fish smoking, they reported 34 to 46 per cent iodine losses and recommended standardization of the methods of smoking to reduce nutrient losses.

Fish may be smoked in, at least, three different ways. Depending upon the type of fish to smoke, what it will be used for, and the length of time it may have to be stored, an appropriate smoking method may be chosen. The smoking process can take any time from 1h to 3 days. For "cold smoking", fish is smoked for a short period without getting cooked. This is not practised in the tropics. For small to medium-sized oily fish (e.g. *Sardinella ethnalosa)*, the "hot-smoking" process is used at over 80 °C for 2 to 5 h. This yields a moist, versatile product which can keep for about 1 to 2 weeks (UNICEF, NCWD & FRI, 1984). Products of this type are found in both tropical and temperate countries. They can be consumed without any further cooking, although they may be cooked again before consumption.

The third method, "smoked-drying", involves 10 to 18 h smoking, mainly at lower temperatures, and may take about 3 days if smoking very slowly." Smoke-drying" is the most widely practised fish-smoking method in developing countries, especially, Africa. The process begins with hot-smoking for about 2 to 5 h, after which it is continued over moderate fire (below 60 °C) for about 2 to 3 days, producing a very dry (10-15 % moisture) product with a potential shelf-life of 6 to 9 months (UNICEF, NCWD & FRI, 1984).

A little over 20 years after the study by Aye & Esh (1976), this paper looks at the effect of smoking on the iodine content of selected sea fish. The Chorkor Smoker, a new and improved method of fish smoking (UNICEF, NCWD & FRI, 1984) in the West African sub-region, was used in the study.

Materials and methods

Fish selection for the study

Based on the concentrations of iodine identified in the commonly consumed fresh Ghanaian sea fish in an earlier study (Asibey-Berko *et al.*, 1996), this study focussed on a selection of fish species analyzed in the earlier study. In a decreasing order of iodine content, these were Kankama or Amane (Round sardinella or *Sardinella auritus*), Mmornkor (Pink shrimp or *Penaeus notialis*), Boboe (Burrito or *Brachydeuterus auritus*), Saman (Spanish mackerel or *Scomber japonicus*), Antele (Atlantic bumper or *Chloroscombus chrysurus*), and Antebo which is also called Amane (Flat sardinella or *Sardinella eba*).

Fish storage

Fish freshly landed on the beach were packed into sealable polyethylene bags. They were placed in boxes containing ice packs on the beach and subsequently stored frozen at -20 °C until analysis.

Fish smoking

The hot-smoking procedure was used. Starting from an ambient temperature of about 30.6 °C, the smoking temperature increased steadily, reaching a maximum of 108 °C occasionally. Kane-May Ltd KM 1242 temperature recorder was used to record the temperature at 15-min intervals for 3 h 56 min.

The product was stored frozen in sealed polyethylene bags, on cooling, until analyzed.

Laboratory analysis for moisture and iodine

Fresh fish were analyzed for moisture and iodine. Samples of the same species of fish from the same batch were then smoked and analyzed for moisture and iodine. For the analyses, fish (fresh or smoked) were cut up and blended (without the addition of extra water) at medium speed for about 20 sec. Moisture was determined with an AOAC (1970) method and iodine with the method of Fisher & L'Abbe (1981). Moisture was determined on triplicate samples of blended fish and digestion for iodine determined on duplicate samples of blended fish. Each of the duplicate digests for the iodine determination was also analyzed spectrophotometrically on several replicates. Where samples of the same fish were collected from different regional beaches (Volta, Greater Accra, Central and Western) of the Ghanaian shore-line, these different beaches were analyzed, yielding more replicate data.

Results and discussion

Table 1 shows the moisture and iodine contents before and after smoking for six species of fish. Moisture ranged from 70.9 to 75.8 per cent, and from 19.4 to 58.2 per cent for fresh and smoked fish, respectively. Iodine contents ranged from 5.9 to 17.5 µg/g, and 1.8 to 6.9 µg/g for the fresh and smoked fish, respectively. Except for Kankama in which no iodine loss was recorded, iodine content significantly ($P<0.05$) decreased in all the remaining fish after smoking. Decreases in iodine in the remaining fish ranged from 54.2 to 86.2 per cent. The highest loss of 86.2 per cent was observed in Saman (*Scomber japonicus*). The iodine concentrations in the fish, after smoking, ranged from 202 to 693 µg/100 g by dry weight. The lowest concentration was in Antebo (*Sardinella eba*) and the highest in Kankama (*Sardinella auritus*). These post-smoking iodine concentrations per 100 g fish represent 130 to 460

TABLE 1

Changes in Moisture and Iodine Content of Fish after Smoking

Fish	*Fresh fish*		*Smoked fish*		*% change in iodine content after smoking*	*µg I/100 g smoked fish [b](% RDA)*
	% moisture (Mean ± SEM)	*Iodine concentration dry basis (µg/g) (Mean ± SEM)*	*% moisture (Mean ± SEM)*	*Iodine concentration dry basis (µg/g) (Mean ± SEM)*		
Kankama	70.9 ± 0.5	6.9 ± 0.3	49.5 ± 0.2	6.9 ± 0.3	0.0	693
(Round sardinella)	[a](n = 3)	(3)	(3)	(4)		(460)
Mmornkor	74.8 ± 1.0	17.5 ± 1.2	19.4 ± 1.3	4.3 ± 0.3	-75.2	434
(Shrimps)	(n = 9)	(8)	(9)	(9)		(290)
Boboe	72.6 ± 0.6	9.1 ± 0.6	37.4 ± 4.6	4.2 ± 0.2	-54.2	419
(Burrito)	(9)	(8)	(9)	(9)		(280)
Saman	71.1 ± 0.6	13.0 ± 0.1	58.2 ± 0.08	1.8 ± 0.3	-86.2	179
(Spanish mackerel)	(8)	(8)	(9)	(8)		(120)
Antele	71.1 ± 0.6	7.2 ± 0.2	34.5 ± 5.8	2.9 ± 0.2	-59.6	290
(Atlantic bumper)	(8)	(8)	(9)	(8)		(190)
Antebo	72.1 ± 0.9	5.9 ± 0.2	33.3 ± 6.2	2.0 ± 0.3	-65.9	202
(Flat sardinella)	(6)	(4)	(6)	(4)		(130)

[a]n = Number of samples [b]RDA = Recommended daily allowance = 150 µg iodine/day for adults

per cent of the recommended daily allowance (RDA) of iodine for adults.

The variation in the concentrations of iodine in the different species of fish before smoking is expected. Of all the minerals in fish, iodine has been reported to show the greatest variation in concentration (Börgstrom, 1962). Even within the same species of fish, the locality of catch can lead to great differences in iodine concentration, possibly because of great differences in iodine concentration in plankton in different localities (Börgstrom, 1962). Analyses of iodine contents in canned tuna in the USA, for instance, showed concentrations ranging from 0.34 to 1.90 µg/g, underscoring the large variation of iodine concentration even within the same species (Heckman, 1979).

While this study found iodine losses of 54.2 to 86.2 per cent with smoking, Aye & Esh (1976) found losses of 36 to 46 per cent. This may be explained by differences in smoking methods. This study used hot-smoking, in a Chorkor Smoker, involving the use of fire with flame and smoke. Aye & Esh (1976) used a traditional method for small-scale smoking, involving the use of smouldering fire without flame, but producing enough heat and smoke to cook and give the fish a smoky colour. The Chorkor Smoker (improved oven) used in this study and currently being widely adopted, smokes more fish for commercial purposes, insulates the user from smoke, and is healthier. It is more economical in the conservation of heat and fuel-wood, producing a product considered of high quality and uniform hue (UNICEF, NCWD & FRI, 1984).

One possible source of iodine loss during fish smoking could be the leaching and evaporation of body fluids (Börgstrom, 1961). Iodine occurs in every single cell in the form of the hormone thyroxine, and perhaps other thyroid hormones (Davidson *et al.*, 1979). There would also be inorganic iodides in the fish that are absorbed from water and digested foods. At high temperatures and high relative humidities, inorganic iodides are oxidized to molecular iodine which evaporates (sublimes) and disappears (Hetzel, 1988). This would cause iodine loss during smoking.

Each fish species in the study represents a slightly different biological system in body density, size (ranging from an average of 17-40 cm for this study) (Wolfgang, 1990), toughness of flesh and musculature, differences in heat penetrability, and ease of fluid loss during smoking. All these factors could influence the rate of iodine loss, leading to different degrees of iodine loss in the different fish during smoking. Despite these losses of iodine from smoking, the smoked sea fish remained adequate sources of iodine for the diet. Their iodine content, after smoking, ranged from 202 to 693 µg/100 g by dry matter. Given that the recommended daily allowance (RDA) for iodine for adults is only 150 µg/day, consumption of only 100 g of any of the smoked fish studied provides more than the entire RDA for iodine in all cases.

Conclusion

Fish smoking significantly ($P<0.05$) decreased the iodine content of most of the sea fish in this study. Enough iodine was, however, retained to adequately satisfy human nutritional requirement for iodine. This indicates that smoked sea fish is a good source of dietary iodine.

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