GERMAN FEDERAL INSTITUTE FOR RISK ASSESSMENT

Nutritional Quality and Food Safety of Processed Small Indigenous Fish Species from Ghana

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Achieving food and nutrition security for everyone is a challenge sub-Saharan African countries are facing. Malnutrition is a result of limited access sufficient amounts of food and to adequate nutrients which can lead to impairment of health and developmental disorders. Fish is a good source of protein, fatty acids, minerals (e.g. calcium), trace elements (e.g. zinc) and vitamins (e.g. Vitamins A, D, and B_{12}). Fish consumed whole is particularly rich in nutrients, as some of the nutrients are available in the bones, brain and viscera of the fish. Different processing techniques are used to prevent fish from spoiling with smoking being one of the most popular in Ghana. Smoking is one of the leading causes for contamination with polycyclic aromatic hydrocarbons (PAH). Furthermore microbial contamination is possible due to insufficient drying or as recontamination in any step of the value chain.
This study aims to provide data on nutritional quality and food safety in six commercially processed fish from Ghana.

Material and Method

In this study samples of different marine species (*Engraulis encrasicolus* (European anchovy), *Brachydeuterus auritus* (Bigeye grunt), *Sardinella aurita* (Round sardinella), *Selene dorsalis* (African moonfish)) and freshwater species (*Sierrathrissa leonensis* (West African (WA) pygmy herring) and *Tilapia* spp. (tilapia)) were taken from five different markets distributed in Ghana and analysed for nutritional values (protein and fat content, vitamin A and B_{12} content, zinc and selenium content), contamination with PAH4 (sum of benz(a)anthracene, benzo(a)pyrene, bento(b)fluoranthene and chrysene). heavy metals (cadmium, arsenic, lead, mercury) as described by Rekstena et al. (2020). Total colony count was determined on Columbia blood agar incubated at 30°C for 72 h and coliforms and *E. coli* were determined on Brilliance *E. coli*/coliform agar plates (oxoid Deutschland GmbH, Wesel, Germany) incubated at 37°C for 24 h.

Nutritional Quality

Table 1: Mean amounts of different nutrients in processed whole small fish species.

	Unit	Anchovy	Bigeye grunt	Round sardinella	African moonfish	WA pygmy herring	Tilapia
Protein	g/100g	72	64	65	68	68	32
Total fat	g/100g	6	15	14	6	12	7
Vitamin B_{12}	µg/100g	14	9	23	14	16	11
Vitamin A_1	µg/100g	14	323	10	290	39	4
Zinc	mg/100g	6	3	5	5	15	4
Selenium	µg/100g	192	113	242	173	94	33

High protein content in the small fishes can contribute to a more balanced diet, as the Ghanaian diet consists mostly of starchy staples. Vitamin A content in smoked bigeye grunt and smoked African moonfish is high and vitamin B_{12} occurs in animal food sources, especially in the viscera of fish. Compared to other small fish analysed, the concentration of zinc and selenium in the smoked fish samples are notably high. Of all analysed species tilapia was least nutrient dense.

Microbial contamination

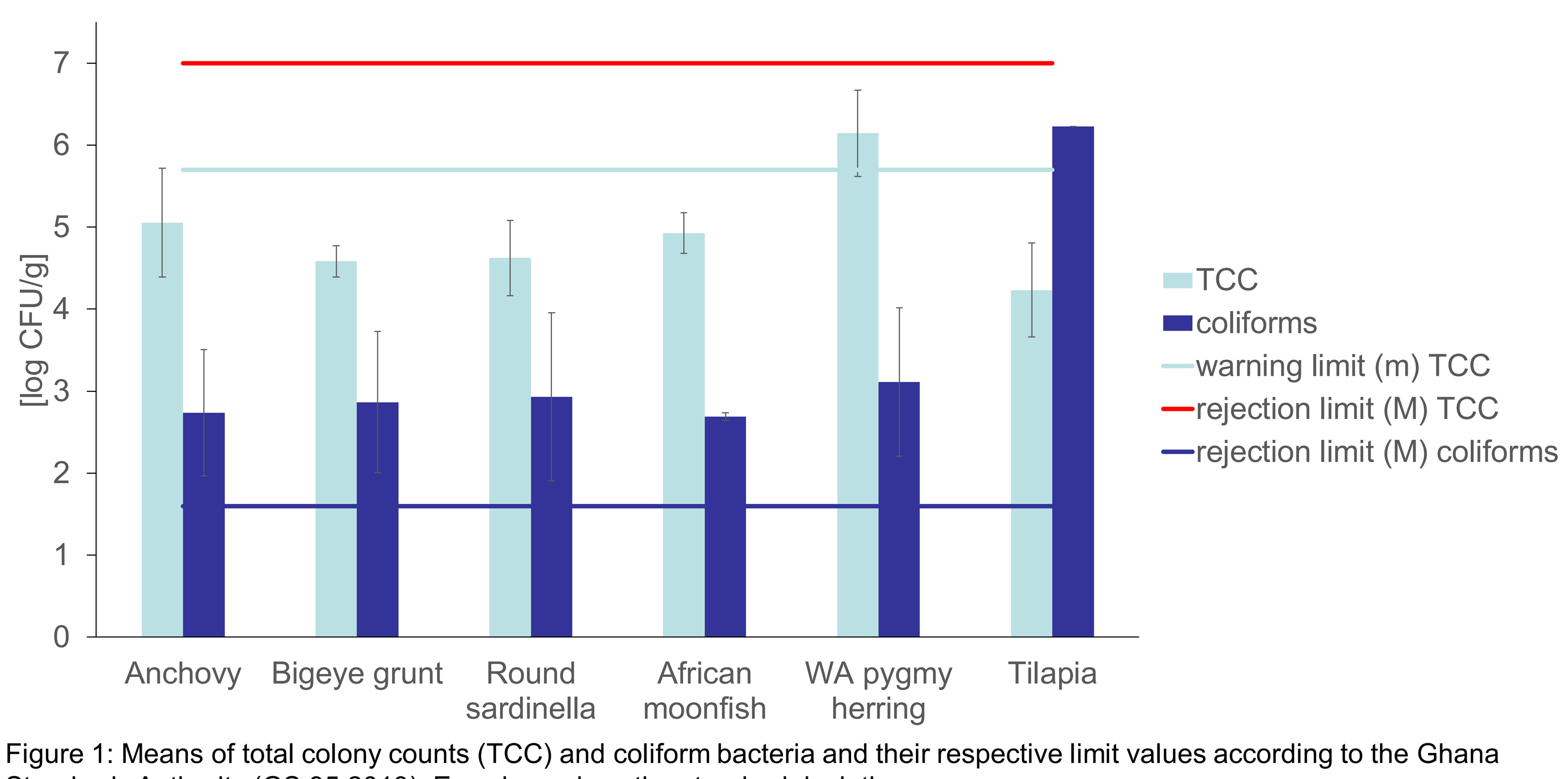

Figure 1: Means of total colony counts (TCC) and coliform bacteria and their respective limit values according to the Ghana Standards Authority (GS 95:2013). Error bars show the standard deviation

The limit of rejection for total colony count by the Ghana Standards Authority is 7 log CFU/g (GS 95:2013) and all samples were below this limit. Only WA pygmy herring was above the warning limit of 5.7 log CFU/g. Only one sample was positive for *E. coli* (WA pygmy herring from Techiman).

PAH4 loads

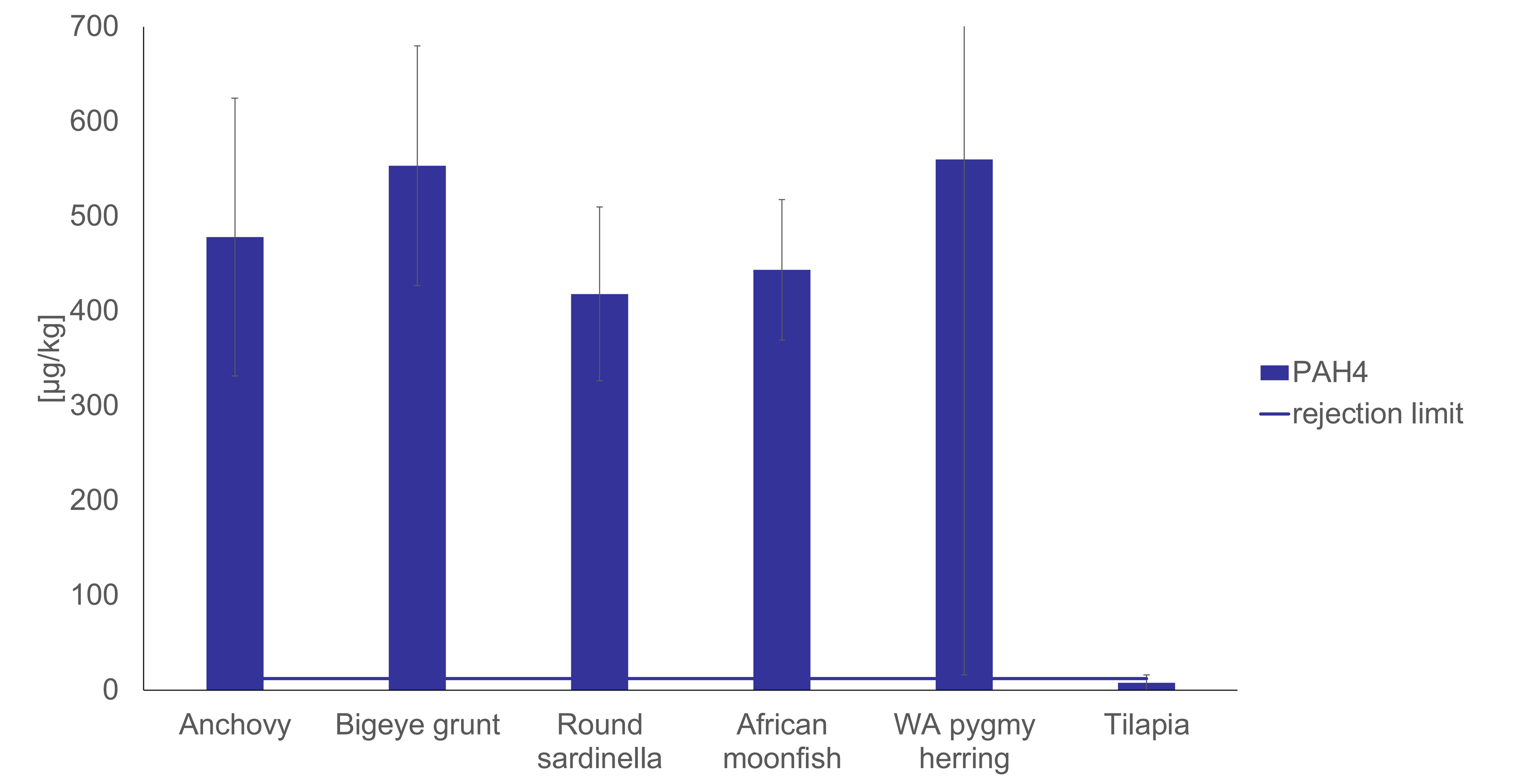

Figure 2: Means of PAH4 in processed small fish and the rejection limit for PAH4 by the European Commission of 12 µg/kg (EC No 837/2011). Error bars show standard deviation.

PAH4 concentrations were high in all smoked samples. Only tilapia, as the only non-smoked sample, was below the rejection limit of 12 µg/kg by the EU. The use of metal drum kiln and chorkor ovens increases the production of PAH4 (Figure 3).

Figure 3: Fish is being processed using traditional drum kiln ovens. Area for fish processing (left) and freshly smoked fish packed for transport and fish in a traditional drum kiln (right). Fotos taken by Amy Atter (left) and Johannes Pucher (right)

Heavy metal concentrations

Table 2: Concentrations of different heavy metals in processed fish. Measured concentrations are given in mg/kg fish product.

	Anchovy	Bigeye grunt	Round sardinella	African moonfish	WA pygmy herring	Tilapia
Cd	0.31	0.12	0.19	0.06	0.02	<LOQ
Pb	0.13	0.16	0.10	0.24	0.64	<LOQ
Hg	0.04	0.06	0.03	0.05	0.22	<LOQ
As	7.80	4.90	9.76	5.67	0.95	0.10

<LOQ: Below level of quatitification

The European Commission established maximum permissible level for cadmium (0.05 mg/kg wet weight (w.w.) and 0.25 mg/kg w.w. in *Engraulis* species). mercury (0.5 mg/kg w.w.), and lead (0.3 mg/kg w.w.) in raw fish (EC 2006). All of the limit values are given for fresh fish and a water reduction due to processing needs to be taken into account. After normalization to a 75% water content, as in fresh fish, only the concentration of lead in WA pygmy herring exceeded the maximum limits. Heavy metals in food can be of various sources, but one explanation might be the result of anthropogenic contamination from illegal mining or e-waste recycling sites.

Conclusion

→ Processed small fish provide proteins and essential micronutrients
→ Tilapia, which is the only species that might be farmed, was less nutrient dense compared to wild caught fish
→ Concentrations of PAH4 are high and the use of improved smoking practices and ovens (e.g. FTT-kiln or Ahonto oven) should be promoted
→ Overall microbial quality was acceptable, but sources of elevated coliform counts need to be determined

Rekstena A, Bøkevolla A, Frantzena S, Lundebyea A, Kögel T, Kolåsa K, Aakrea I, Kjellevold M. Sampling protocol for the determination of nutrients and contaminants in seafood – The EAF-Nansen Programme. MethodsX. accepted.
Commission E. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Off J Eur Union. 2006;364.