Food Chemistry Advances 6 (2025) 100901

Contents lists available at ScienceDirect

Food Chemistry Advances

journal homepage: www.elsevier.com/locate/focha

Potential role of aquaculture fish to the recommended nutritional intake (RNI) of children, adults, pregnant and lactating women in Asuogyaman Municipality, Ghana

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ARTICLE INFO

Keywords:
Ghana
Cultured fish
Proximate composition
RNI
micronutrients
Minerals

ABSTRACT

This study examined the nutritional composition of farmed fish in Ghana to evaluate their potential contribution to recommended nutrient intakes (RNI) for adults, pregnant and lactating women (PLW), and children. The study used standard methods to analyse the micronutrient and proximate composition of twenty-four samples of three fish species—*Heterotitis niloticus, Clarias gariepinus,* and *Oreochromis niloticus*. The protein compositions of *Oreochromis niloticus, Clarias gariepinus,* and *Heterotis niloticus* were 17.96 g/100 g, 14.00 g/100 g, and 13.25 g/100 g, respectively. Their lipid values were 0.56 g/100 g, 5.01 g/100 g, and 1.76 g/100 g; ash content was 6.77 g/100 g, 1.90 g/100 g, and 2.94 g/100 g; carbohydrate content was 4.00 g/100 g, 5.02 g/100 g, and 17.20 g/100 g; and moisture content was 70.71 %, 74.07 %, and 64.84 %, respectively. The mineral values ranged from 4.05 to 11.96 mg/100 g (iron), 15.10 to 23.23 mg/100 g (calcium), 1.02 to 8.26 mg/100 g (zinc), 16.52 to 28.42 mg/100 g (potassium), and 10.25 to 19.67 mg/100 g (sodium). The fish species contributed ≥25 % of the zinc and iron RNIs for adults, PLW, and children but were inadequate in providing the recommended daily intake of calcium for the vulnerable groups. Therefore, government interventions are needed to enhance the supply and affordability of farmed fish, to make it more accessible to vulnerable communities.

1. Introduction

Fish is a crucial animal food source, providing essential nutrients that contribute significantly to food security and combat malnutrition, especially in developing countries (Adeniyi et al., 2012). In many regions, fish offers an affordable and accessible way to diversify diets, with rural populations obtaining about 60 % of their protein from fish (Adekoya & Miller, 2004).

Ghana is a leading aquaculture producer and one of the fastest-growing in Sub-Saharan Africa (SSA) (Ragasa et al., 2018). According to the FAO (2017), Ghana was the 13th largest producer of tilapia in the world in 2015 and the second largest in Sub-Saharan Africa, after Uganda. About 95 % of all domestic aquaculture production reported to the Food and Agriculture Organization (FAO) of the United Nations consists of Nile tilapia, with the remainder largely being African catfish, which are farmed in tanks or ponds as polyculture with tilapia (Frimpong, 2014). The demand for high-value goods, including tilapia, is rising in this lower-middle-income nation, supported by a growing middle-class population. Ghana has one of the highest fish consumption rates in SSA and the world, at over 28 kg per capita per year. In Ghana, 60 percent of the country's animal protein intake comes from fish (Rurangwa et al., 2015), which is around four times higher than the

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https://doi.org/10.1016/j.focha.2025.100901
Received 25 July 2024; Received in revised form 6 January 2025; Accepted 22 January 2025
Available online 23 January 2025

global average (Hishamunda et al., 2009). This high consumption rate is attributed to taste, cultural acceptance, and affordability (Onumah et al., 2020). Despite abundant freshwater resources and a per capita fish consumption of 28 kg (Asiedu et al., 2023), malnutrition persists, particularly among preschool children, due to insufficient intake of vital micronutrients. This issue affects a significant proportion of children under five, with 19 % stunted, 5 % wasted, and 11 % underweight (USAID, 2018).

The nutritional composition of fish includes fat, moisture, protein, carbohydrates, ash, and minerals (Ahmed et al.., 2022). Variations in fish composition between species, influenced by diet, sex, and age, result in different nutritional profiles (Egun & Oboh, 2022). Understanding fish's nutritional content is crucial for assessing fisheries resources, nutrient availability, and guiding policy (Maulu et al., 2021). Fish consumption increases the bioavailability of nutrients, such as iron and zinc, which are typically missing in grain- and tuber-based diets (Reksten et al., 2020).

An accurate scientific review of food composition data is essential for nutrition-related purposes, including assessing nutrient requirements, conducting epidemiological studies, and formulating policies (Greenfield & Southgate, 2003). There is a specific need for an Africa-specific food composition database (FCDB) to assess dietary habits and their health impacts (Ene-Obong et al., 2019).

In Ghana, three fish species are predominantly farmed: African bony-tongued fish (*Heterotitis niloticus*), African catfish (*Clarias gariepinus*), and Nile tilapia (*Oreochromis niloticus*). These fish are versatile in preparation, often consumed fresh, fried, grilled, salted, dried, or smoked (Magna et al., 2024).

Among these, the African catfish stands out for its high protein content, which ranges from 28 to 32 % of its weight, along with essential amino acids and vital minerals such as iron and zinc (Langi et al., 2024). This protein supports muscle development and repair, while iron plays a crucial role in preventing anaemia, a common health issue in many communities. Additionally, the catfish's rapid growth rate and adaptability to various farming conditions make it a key component of aquaculture, providing a reliable source of nutrition and income for local populations.

The African bony-tongued fish is also noteworthy, being rich in essential fatty acids, vitamins (particularly B vitamins), and minerals like calcium and phosphorus. Its high omega-3 fatty acid content contributes to cardiovascular health, while the vitamins support metabolic functions and bolster immune health (Mozaffarian & Wu, 2011). The African bony-tongued fish is frequently featured in traditional dishes, carrying cultural significance and playing a vital role in local diets, thereby enriching food diversity.

Nile tilapia, on the other hand, is valued for its role in weight management and its provision of essential nutrients that enhance overall health and wellness. Furthermore, tilapia farming practices tend to be more sustainable, helping to alleviate pressure on wild fish stocks and ensuring a consistent food supply.

Despite the advancements in aquaculture and its contributions to meeting nutritional needs, there remains uncertainty regarding the impact of aquaculture expansion on food diversity and micronutrient intake.

The Ghanaian fish composition table was published in 2009 (Obodai et al., 2009), with most studies using data from raw fish sourced from Japan, the US, and Europe (Hellberg et al., 2012). Limited updates since then have failed to capture the diverse range of culturally significant fish species in Ghana (Hasselberg et al., 2020).

A study in rural Ghana reported 21.4 % zinc deficiency among children under five (Greffeuille et al., 2023). A nationwide survey found that 66 % of children under five and 42 % of pregnant women suffer from anaemia due to iron deficiency (Spring, 2016). Iron deficiency during pregnancy can lead to adverse outcomes like preterm birth and impaired cognitive development (Georgieff, 2020). Another study found nearly 100 % of pregnant women had inadequate calcium intake, and 90.2 % had inadequate zinc intake (Ayensu et al., 2020). Targeted interventions, such as supplementing diets with fish, are recommended to improve health in Ghana.

Assessing the nutritional needs of farmed fish species is critical to determining their capacity to meet human food needs, aligning with the Sustainable Development Goals to end hunger and improve human health. This study aims to investigate the mineral and proximal composition of fish species raised in Ghana and determine their contribution to fulfilling the recommended daily intake (RNI) for adults, pregnant and lactating women (PLWs), and children in Ghana.

2. Materials and methods

2.1. Sample collection

Twenty-four samples of African catfish (*Clarias gariepinus*), Nile tilapia (*Oreochromis niloticus*), and African bony-tongued fish (*Heterotis niloticus*) were collected from earthen pond systems at the Aquaculture Research and Development Centre (ARDEC) in Akosombo, Asuogyaman Municipality, Ghana. ARDEC was chosen for its optimized strains of fingerlings and broodstock to support fish farming development. The weights of the fish samples varied as follows: African catfish (250–400 g), Nile tilapia (200–350 g), and African bony-tongued fish (150–300 g). Samples were preserved in aluminium foil, placed in an insulated ice chest with ice packs, and transported to the Ghana Standard Authority laboratory for further analysis.

2.2. Sample preparation

Each sample of the fish species was thoroughly cleaned with distilled water and dried using filter paper. Subsequently, the fish was carefully dissected using a sterile stainless-steel knife. The edible portions, comprising the muscle and skin (fillets), were then chopped and crushed into small pieces to represent the parts typically consumed. The samples were rinsed with distilled water, wrapped in aluminium foil, and stored in a freezer at −18 °C. The detailed materials and methods for the proximate composition analysis of selected species are as follows

2.3. Proximate analytical methods

2.3.1. Moisture content

Moisture content was determined following AOAC (2000) guidelines. Samples were dried in an air furnace at 101 °C for 24 h until a stable weight was achieved, then cooled in a desiccator and re-weighed. The moisture content was calculated as the percentage difference between the initial and final weights.

2.3.2. Ash content

Ash content was determined according to AOAC (2000) guidelines. Dried samples were heated at 550 °C in a muffle furnace for four hours. The ash content was calculated by subtracting the final weight from the initial weight and expressing the difference as a percentage.

2.3.3. Fat content

Crude fat was extracted using a Soxhlet apparatus with petroleum ether (boiling point 40–60 °C) as the solvent, following AOAC (2000) guidelines. Approximately 5 g of the sample was wrapped in filter paper and extracted for four hours, repeated four times.

2.3.4. Crude protein content

Crude protein content was determined using the method by Sumi et al. (2023). About 0.5 g of the sample, 1.1 g of digestion mixture, and 10 mL of concentrated sulfuric acid were placed in a Kjeldahl flask and digested for 45 min. The digested solution was distilled with 40 % sodium hydroxide and 4 % boric acid, and the total nitrogen content was determined by titrating with 0.2 N HCl. Crude protein was calculated by multiplying the total nitrogen content by a conversion factor of 6.25.

2.3.5. Total carbohydrate content (%) analysis

The total carbohydrate content (%) was estimated by subtracting the protein, lipid, ash, and moisture content from 100 (Onyeike et al., 2000). The equation is total carbohydrate content (%) = [100- (moisture + ash + crude protein + crude fibre + crude lipid)]

2.3.6. Minerals content

Defatted fish meal was burned at 550 °C to obtain ash, which was combined with 10 mL of 20 % hydrochloric acid. The mixture was filtered and transferred to a 100 mL standard flask for mineral analysis. Sodium (Na), calcium (Ca), iron (Fe), potassium (K), and zinc (Zn) concentrations were analysed using a Varian AA 240FS atomic absorption spectrometer. Quality control was ensured using routine laboratory reference samples and certified reference material 1570a from the US National Institute of Standards and Technology. Standardisation techniques were applied, and samples were analysed three times for accuracy using calibration curves.

2.4. Statistical analysis

Statistical analysis for the nutritional contents' standard deviation, range, and mean values was conducted using Microsoft® Office Excel 2013. Graphical representations of the data were also created using this software. SPSS version 20 was utilised to analyse the statistical differences between the variables, with a significance level set at $p < 0.05$. The mean ± standard deviation per 100 g for each fish species was presented for the three composite samples, with data expressed in standard units.

2.5. Estimation of the potential contribution to recommended nutrient intakes (RNIs)

The study evaluated the potential contribution of each fish species to the daily recommended nutrient intake (RNI) for children aged 1 to 3 years and adults aged 8 years and above, as recommended by WHO/FAO (2004). This was assessed using the following equations:

$$N_{ps} = \frac{S_s \times N_A}{100} \tag{1}$$

$$\%\ RNI_i = \frac{N_{ps}}{RNI_i} \times 100 \tag{2}$$

Where N_A is the level of nutrients (mg/100) in the fish; S_s is the daily expected standard portion of a food source; RNI_i is the recommended quantity of nutrients i that should be consumed (Table 1) and % RNI_i represents the daily RNI's percentage contribution from an assumed standard portion.

In Ghana, the average fish consumption is 28 kg per year per person, equating to a daily intake of about 76.71 g (Asiedu et al., 2023). However, a dietary survey conducted in the study area revealed that households consumed an average of 300 g of fish per day for children, 800 g for pregnant and lactating women, and 700 g for adults. These amounts were used to calculate the contribution of fish consumption to adherence to the RNI for each group. The study assumed 100 % bioavailability of nutrients in fish species. Following other research (FAO/WHO/UNU, 1985; Kingsley et al., 2022), the study considered that the average consumption of each nutrient for certain groups was ≥ 25 % of the recommended nutrient intake (RNI).

Studies have identified deficiencies in key micronutrients such as zinc, iron, and calcium in both rural and urban communities in Ghana (Greffeuille et al., 2023; UNICEF, 2017; Wiafe et al., 2023). Therefore, these trace elements were selected to estimate the recommended nutrient intake (RNI) for each group.

Table 1
Daily Recommended Intake (mg) of Nutrients as Advised by the Food and Nutrition Board.

	Sub-group of the Population		
Average Daily RN	Children	PLW	Adults
Zinc	10	20	15
Calcium	700	1200	1000
Iron	10	18	16

Source: Kingsley et al., 2022.

3. Results and discussions

3.1. Proximate composition

The moisture, carbohydrates, energy, lipids, ash and protein, compositions of *Heterotis niloticus, Clarias gariepinus*, and *Oreochromis niloticus* are presented in Table 2. The total energy and carbohydrate contents varied from 92.83 to 137.70 kJ and 4.00 to 17.20 g/100 g, respectively. In the tissues of fish, water exists in two forms: freely dispersed and chemically bound to proteins within the tissue structure. The characteristics of fish, such as their weight, texture, flavour, appearance, and shelf life, are all influenced by their moisture content. Primarily, the moisture content constitutes about 60 to 80 % of their total weight (Aberoumand, 2014; Nihan, 2003; Kingsley et al., 2022). One of the main factors influencing the varying characteristics and attributes of different kinds of fish is their high moisture content. Accordingly, the moisture contents for this study varied from 64.85 % to 74.07 % and fell within the permissible range of 60–80 % indicated for fish by Nihan (2003). From a nutritional standpoint, protein is the most crucial component of fish. It is the primary factor that determines the overall wholesomeness and quality of fish as a food item (Aberoumand, 2014). Quantitatively, protein ranks as the second most prevalent substance in fish muscles (Vikaspedia, 2021). Accordingly, the cultured fish species contain animal-derived protein, and the total protein content ranges from 13.25 to 17.96 g/100 g. This protein content is considered to be of excellent nutritional quality, as per the guidelines established by the World Health Organisation (WHO) in 2007. Fish lipids are one of the best forms of polyunsaturated fatty acids, primarily omega-3 fatty acids, which are crucial for human health (Reksten et al., 2020). Fish are a rich source of omega-3 fatty acids, which are vital for brain development and function, particularly in children and during pregnancy, and regular consumption of fish is linked to a reduced risk of chronic diseases such as cardiovascular diseases, obesity, and certain cancers (Kingsley et al., 2022). Therefore, incorporating fish into diets can enhance dietary diversity, which is crucial for overall health and well-being. Fish are divided into four classifications based on their lipid content: high fat (more than 8 %), lean fish (less than 2 %), medium fat (4–8 %), and low fat (2–4 %), according to the Ackman (1989) classification system. Based on these categorizations, the Nile tilapia (*O. niloticus*) and the *Heterotis niloticus* have low-fat content, at 0.56 % and 1.76 %, respectively, placing them in the lean fish category. This implies that these foods are

Table 2
Proximate composition of the cultured fish species.

Proximate	O. niloticus	Clarias gariepinus	Heterotis niloticus
Protein (g/100 g)	17.96 ±0.02^{c}	14.00 ±0.01^{a}	13.25 ±0.01^{a}
Moisture (%)	70.71 ±0.02^{c}	74.07 ±0.03^{b}	64.85 ±0.01^{a}
Total fats (g/100 g)	0.56 ±0.01^{c}	5.01 ±0.04^{a}	1.76 ± 0.01^{b}
Total Ash (g/100 g)	6.77 ± 0.03^{a}	1.90 ± 0.01^{b}	2.94 ± 0.02^{b}
Carbohydrates (g/100 g)	4.00 ± 0.02^{c}	5.02 ± 0.03^{c}	17.20 ± 0.02^{a}
Energy (kcal)	92.83 ± 0.05^{b}	121.22 ± 0.10^{c}	137.70 ± 0.30^{a}

Values are mean ± SD, Values within the same rows with different superscripts are statistically significant.

not a suitable source of fatty acids for human nutritional therapy. In contrast, the African catfish (*Clarias gariepinus*), with a fat content of 5.01 %, corresponds to the medium-fat (4–8 %) group. This indicates that the African catfish could be a good source of fish oil. Fish lipid content varies significantly more than other proximate constituents due to species variation, size, life cycle, and age (Bogard et al., 2015; Nihan, 2003).

Fish ash content, which varies from 1.2 to 1.5 % of the fish's body weight according to FAO, indicates the kind and quantity of minerals in the fish's tissue (Adewumi et al., 2014). The observed mean ash levels (g/100 g) for *O. niloticus, C. gariepinus,* and *H. niloticus* were 6.77, 1.90, and 2.94, respectively. These levels indicate each fish species' total mineral (sodium, potassium, magnesium, iron, and calcium) content (Aberoumand, 2014).

3.2. Mineral composition and potential contribution to RNI

Fish are a rich source of highly bioavailable key minerals, with variations in mineral content across different species (Jim et al., 2017). These minerals support various bodily functions and are particularly important for vulnerable populations The exclusion and inclusion of different fish parts (skin, head and bones) in the assays under analysis might be linked to the concentration of many significant minerals in fish (Bogard et al., 2015). Table 3 illustrates the mineral levels of *Heterotis niloticus, Clarias gariepinus*, and *Oreochromis niloticus*.

When comparing the mean levels of these minerals across the three species, some differences were noted: *Clarias gariepinus* had mean levels of potassium (19.40 mg/100 g), calcium (18.35 mg/100 g), sodium (14.56 mg/100 g), zinc (5.17 mg/100 g); and iron (6.02 mg/100 g); *Oreochromis niloticus* had mean levels of calcium (17.47 mg/100 g), potassium (24.21 mg/100 g), sodium (17.42 mg/100 g), iron (9.82mg/100 g), and zinc (2.60 mg/100 g) and *Heterotis niloticus* had mean levels of calcium (18.28 mg/100 g), potassium (21.24 mg/100 g), sodium (16.54 mg/100 g), iron (8.91 mg/100 g), and zinc (3.62 mg/100 g).

The results of this investigation corroborated those of Njinkoue et al. (2016), who suggested that fish with higher K values and lower Na levels were beneficial to human health, especially in preventing cardiovascular disorders. The findings of this study suggest that the fish species examined have Na/K ratios smaller than 1. This suggests that it is safe for adults, children, and PLW to consume *Clarias gariepinus, Oreochromis niloticus,* and *Heterotis niloticus*. This is supported by the assertion made by Bu et al. (2012) that any food material with a Na/K ratio > 1 may be hazardous to human health. Therefore, the low Na/K ratios observed in the fish studied indicate that they are suitable for safe human consumption.

The iron content in the studied fish species varied significantly. *O. niloticus* had iron levels ranging from 7.98 to 11.55 mg/100 g, *H. niloticus* had 5.42 to 11.96 mg/100 g and *C. gariepinus* had 4.05 to 9.15 mg/100 g, The iron levels observed in this sample exceeded the benchmark levels for fish and shellfish recorded in the FAO/INFOODS global database. Importantly, all the cultured fish species examined provided at least 25 % of the recommended daily iron intake (RNI) for adults, children, and pregnant/lactating women, as shown in Table 4 and Fig. 1. One of the main causes of anaemia in adults, children, pregnant women, and nursing mothers in Ghana is iron deficiency. According to studies, iron deficiency accounts for almost 50 % of anaemia cases in Ghana (Anlaakuu & Anto, 2017). Unfavourable outcomes for both mothers and foetuses have been associated with a high reported incidence of iron deficiency anaemia (IDA) in pregnant and nursing women, particularly in rural areas (Kingsley et al., 2022). The findings of this study indicate that the iron content in the cultured fish species is substantial. This suggests that incorporating these fish into the diets of adults, pregnant and lactating women, as well as children, in the Asuogyaman Municipality of Ghana could help address the issue of iron deficiency anaemia in these vulnerable populations.

Table 3
Mineral composition of the cultured fish species.

Minerals	O. niloticus (mg/100 g)	C. gariepinus ((mg/100 g)	H. niloticus (mg/100 g)
Ca	17.47 ± 0.21^{a}	18.35 ± 0.13^{c}	18.28 ± 0.05^{c}
Fe	9.82 ± 0.32^{b}	6.02 ± 0.42^{a}	8.91 ± 0.24^{b}
Zn	2.60 ± 0.02^{a}	5.17 ± 0.02^{c}	3.62 ± 0.12^{a}
K	24.21 ± 1.02^{c}	19.40 ± 1.52^{b}	21.24 ± 2.20^{b}
Na	17.42 ± 3.14^{a}	14.56 ± 1.32^{b}	16.54 ± 2.05^{a}
Na/K	**0.72**	**0.75**	**0.78**

Values are mean ± SD, Values within the same rows with different superscripts are statistically significant.

The calcium content in the examined fish species ranged from 15.10 mg/100 g in *O. niloticus* to 23.23 mg/100 g in *H. niloticus,* which falls within the typical calcium range found in fish and shellfish (FAO/INFOODS 2016). However, according to the data in Table 4 and Fig. 2, none of the cultured fish were able to provide more than 25 % of the Recommended Nutrient Intake (RNI) for calcium for pregnant and lactating women, adults, or children. During pregnancy and infancy, the mother's calcium homeostasis plays a critical role in providing sufficient calcium for the developing foetus's bone mineralization, primarily through breast milk (Ettinger et al., 2014). Notably, the prevalence of hypocalcaemia (low blood calcium levels) in pregnant women in sub-Saharan Africa has been strongly correlated with documented elevated systolic blood pressure in this population (Ajong et al., 2019). According to a study conducted by Saaka (2020), approximately 91.5 % of pregnant women in northern Ghana were found to have inadequate calcium intake, based on an assessment of the nutrient adequacy ratio (NAR) for various nutrients. For this study, the Asuogyaman District's low dietary diversity suggests that adults, PLW, and children who depend on these fish species as dietary calcium sources are more vulnerable to calcium insufficiency and its associated side effects. Consequently, to fulfil the RNI for calcium for the groups in question, it is imperative to include other rich sources of calcium in their diet, including milk.

Studies conducted in Ghana have reported low zinc levels among children. Specifically, a study by Egbi (2012) found that children in both southern and northern regions of Ghana had low serum and hair zinc concentrations. Furthermore, a more recent study on the dietary diversity and nutritional status of adolescents in rural Ghana revealed that approximately 86.9 % of the participants had inadequate zinc intake (Wiafe et al., 2023). Clinical research has revealed a high incidence of maternal zinc insufficiency in Nigeria, especially among adults and pregnant and lactating women from socioeconomically impoverished communities (Kingsley et al., 2022). Maternal zinc deficiency has been linked to impaired foetal growth and foetal malnutrition, which are prevalent issues in developing countries (Bolaji et al., 2016). Meanwhile, zinc plays a crucial role in regulating the growth hormone and insulin-like growth factor-I (IGF-I) systems, which directly influence bone metabolism (Eckhardt, 2006). Zinc deficiency can lead to anorexia, causing decreased intake of various nutrients, and ultimately limiting growth (Clausen & Dorup, 1998).

The zinc content in the fish species examined in the present study, *O. niloticus* (1.02 - 3.84 mg/100 g), *C. gariepinus* (4.28 - 8.26 mg/100 g), and *H. niloticus* (1.45 - 5.88 mg/100 g), falls within the range of zinc levels typically found in fish and shellfish, as reported in the literature (FAO/INFOODSFAO/INFOODS, 2016). Moreover, the data presented in Fig. 3 and Table 4 indicate that the cultured fish species can provide at least 25 % of the RNI of zinc for PLW, children and adults. This suggests that zinc deficiency (hypozincaemia) is unlikely to be a significant concern for children, adults, or PLWs living in the Asuogyaman municipality. Additionally, the findings imply that fish can be relied upon to meet the recommended daily intake of zinc, provided that a sufficient quantity is consumed, even in cases where zinc deficiency may arise.

Food is deemed a relevant source of minerals if it contributes 15 % of the RNI, and a major source if it provides 30 % of the RNI, according to

Table 4
Potential contribution of cultured fish species in assumed portion to average daily recommended nutritional intake (RNI) (%).

	Calcium (mg)			Iron (mg)			Zinc (mg)		
AD RNI	Children 700	PLW 1200	Adults 1000	Children 10	PLW 18	Adults 16	Children 10	PLW 20	Adults 15
O. niloticus	52.41 (7.49 %)	139..76 (11.65 %)	122.29 (12.23 %)	29.46 (294.60 %)	78.56 (436.44 %)	68.74 (429.63 %)	7.80 (78.00 %)	20.80 (104.00 %)	18.20 (121.33 %)
C. gariepinus	55.05 (7.86 %)	146.80 (12.23 %)	128.45 (12.85)	18.06 (180.60 %)	48.16 (267.56 %)	42.14 (263.38 %)	15.50 (155.10 %)	41.36 (206.80 %)	36.19 (241.27 %)
H. niloticus	54.84 (7.83 %)	146.24 (12.19 %)	127.96 (12.80 %)	26.73 (267.30 %)	71.28 (396.00 %)	62.37 (389.81 %)	10.86 (108.60 %)	28.96 (144.80 %)	25.34 (168.93 %)

RNI- Recommended nutritional intake; PLW-Pregnant and lactating women, AD RNI-Average daily Recommended nutritional intake.

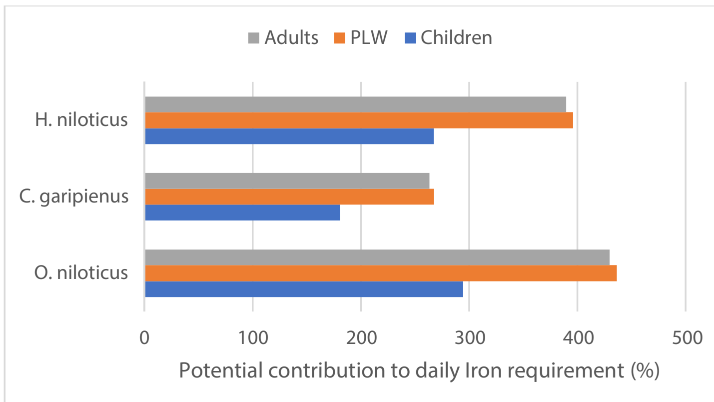

Fig. 1. Potential contribution to the daily iron nutrient requirement of cultured fish species.

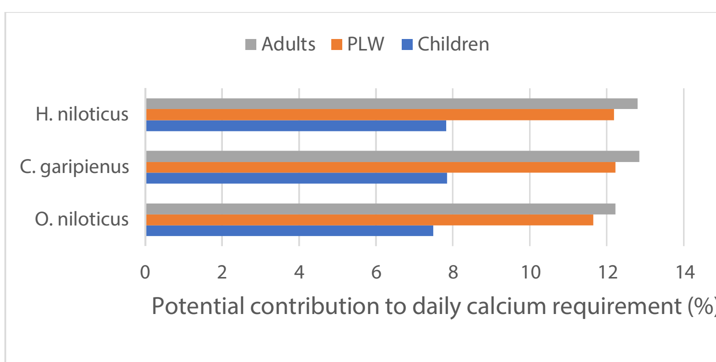

Fig. 2. Potential contribution to the daily calcium nutrient requirement of cultured fish species.

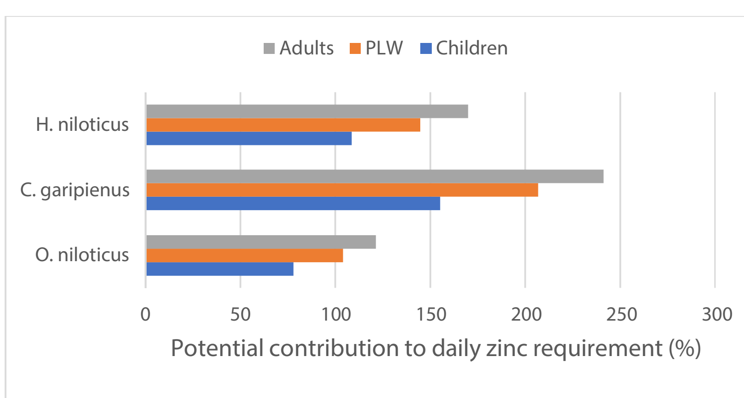

Fig. 3. Potential contribution to the daily zinc nutrient requirement of cultured fish species.

EFSA (EFSA, 2011). The mineral contents in the muscles of three cultured fishes from the Asuogyaman municipality—*Oreochromis niloticus, Clarias gariepinus*, and *Heterotis niloticus*—showed that these kinds of fish are crucial sources of iron and zinc for adults, children, and PLW. These fish species' fillets, however, did not supply up to 15 % of the RNI for calcium in the target demographic groups, and as a result, they cannot be regarded as a relevant calcium source.

3.3. Limitations and strengths of the study

The dietary composition of food, especially fish, is known to vary seasonally due to shifts in the external environment, food availability, and the life stage of the organism. However, the study in question did not account for these seasonal variances, as it was outside the scope of the research. Additionally, the study's use of a small sample size may have limited the representativeness of the results. This was a limitation imposed by the local resource constraints, which made it infeasible to obtain a larger, and more representative sample size. It is crucial to keep in mind that the dietary composition numbers reported represent the overall quantity of nutrients present in the food, not the amount that is assimilated by the body. When using these numbers to calculate potential RNIs, it's important to consider bioavailability factors. A hypothesis of 100 % bioavailability was put out, and only data for fresh, unprocessed fish were employed in the estimations for this study. However, variables such as the actual bioavailability of the nutrients and the impact of regional processing methods like smoking, grilling, salting, frying and drying were not taken into account.

Despite the limitations of the study and the current lack of information on the nutrient composition of Ghanaian cultured fish species, the results are still highly valuable. They provide location- and time-specific forecasts that can be compared to other analyses, offering insights that would otherwise be unavailable.

4. Conclusions

The desire to assess the nutritional value of fish has arisen from its importance as a dietary source of animal-based food, particularly in underprivileged regions where it serves as a readily available meat alternative. This research investigates the nutritional content of fish species cultured in the Asuogyaman municipality and assesses how well these fish species can provide the recommended dietary intakes (RNI) for a range of critical nutrients. The results show that *Heterotis niloticus, Clarias gariepinus,* and *Oreochromis niloticus* are good contributors of protein, iron, zinc, and lipids. The mineral composition analysis of the RNI (recommended nutrient intake) for the fish species indicates that these fish can be a valuable food-based approach to address iron and zinc deficiencies in pregnant and breastfeeding women, as well as children and adults residing in the Asuogyaman municipality. The cultured fish species available are inadequate in providing the vulnerable group's recommended daily intake (RNI) for calcium. To meet their dietary calcium needs, this group should either consume more fish or supplement their diet with calcium-rich alternative foods like milk. The study can inform health professionals and government bodies in designing effective public health initiatives aimed at improving nutrition. Additionally, it can serve as a foundation for further research into the health impacts of aquaculture fish consumption on various populations. Therefore, the government should expand the aquaculture sector through capacity building and introduce program interventions to enhance the availability and accessibility of cultured fish for vulnerable communities.

Funding statement

No funding was received to assist with the preparation of this manuscript.

CRediT authorship contribution statement

Emmanuel Kaboja Magna: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Conceptualization. **Ebenezer Koranteng Appiah:** Visualization, Software, Resources, Conceptualization. **Patrick Senam Kofi Fatsi:** Visualization, Resources, Project administration, Investigation, Data curation. **Emmanuel Delwin Abarike:** Visualization, Supervision, Investigation, Formal analysis, Conceptualization. **Kwadwo Ansong Asante:** Visualization, Supervision, Resources, Formal analysis, Data curation. **Maxwell Kogbe:** Validation, Methodology, Investigation, Data curation. **Felix Ayarika:** Visualization, Project administration, Data curation. **Michael Dabi:** Writing – review & editing, Visualization, Software, Conceptualization. **Joseph Korpone Sakna:** Visualization, Resources, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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