The Role of Fish in Food-Based Strategies to Combat Vitamin A and Mineral Deficiencies in Developing Countries\textsuperscript{1,2} 

Nanna Roos\textsuperscript{3}, Md. Abdul Wahab\textsuperscript{4}, Chhoun Chamnan\textsuperscript{5}, and Shakuntala H. Thilsted\textsuperscript{3*}

\textsuperscript{3}Department of Human Nutrition, The Royal Veterinary and Agricultural University, 1958 Frederiksberg, Denmark; \textsuperscript{4}Faculty of Fisheries, Bangladesh Agricultural University, 2202 Mymensingh, Bangladesh; and \textsuperscript{5}Inland Fisheries Research and Development Institute, PO Box 582 Phnom Penh, Cambodia

Abstract

Fish is important in the diets and livelihoods of many poor people suffering from vitamin and mineral deficiencies. In this article, fish intake in rural Bangladesh and Cambodia and the vitamin A, calcium, iron, and zinc contents and nutrient bioavailability of commonly consumed species are presented. The contribution of these species to nutrient intakes as well as their potential to meet dietary recommendations are presented and discussed. Data from consumption surveys were analyzed to obtain fish intake by species. Commonly consumed species were analyzed for nutrient contents, and studies on nutrient bioavailability were conducted. In poor, rural, Bangladeshi households, mean fish intake was 13–83 g raw, whole fish per person/d. Frequency of intake of small fish was high, and small fish made up 50–80% of all fish eaten during the fish production season in rural Bangladesh and Cambodia. Many small fish are eaten whole and therefore are a rich calcium source; some are also rich in vitamin A, iron, and zinc. Even small production of the vitamin A–rich fish mola in ponds in Bangladesh can meet the annual vitamin A recommendation of 2 million children, and a traditional daily meal with the iron-rich fish trey changwa plieng can meet 45% of the daily median iron requirement of Cambodian women. Fish consumption data on the species level, nutrient analyses, awareness of the nutritional value of fish, as well as promotion of the production and accessibility of nutrient-dense species can lead to the use of fish in food-based strategies to combat nutrient deficiencies in poor people in Asia and Africa. J. Nutr. 137: 1106–1109, 2007.

Introduction

In riparian and coastal areas with rich fish resources in developing countries, fish and fisheries play an important role in the diets, livelihoods, and income of many poor population groups who suffer from vitamin and mineral deficiencies. As official data on fish catch, production, and consumption often exclude fish caught, consumed, and traded within these groups, the benefits derived from fish are not well documented and can be grossly underestimated (1). It is well accepted that fish are a good source of animal protein; however, their role as a source of vitamins and minerals in developing countries is often overlooked. Thus, quantification of the nutritional contribution from fish in poor, rural households is necessary to assess the role fish can play in food-based strategies to combat vitamin A and mineral deficiencies in developing countries. This article describes results from research and capacity-building projects focusing on fish intake in rural Bangladesh and Cambodia. The vitamin A, calcium, iron, and zinc contents of commonly consumed fish species, nutrient bioavailability, and the contribution of these fish to the intakes of these essential, limiting nutrients are described. In addition, the potential of these fish to meet dietary recommendations of these nutrients is discussed.

Materials and Methods

Data on fish consumption in rural Bangladesh and Cambodia. Data on intake of fish species in selected rural areas of Bangladesh in different seasons were obtained from food consumption surveys conducted in 1991–1992, 1995, 1996–1997, and 1997–1998 (2–7). The methods used were 24-h food weighing and 24-h recall at the individual level of all foods consumed and 5 d recall at the household level of fish species consumed. Data on the intake of small indigenous fish species (SIS), with a length <25 cm at maximum size (8), were also...
collected. In rural Cambodia, a small study on the catch and consumption of fish and other aquatic animals based on biweekly household interviews was conducted in Svag Rieng province in 1997–1998 (9). In addition, a small survey conducted in 30 poor rural households in Kandal province in October–December 2004 used observations and interviews to estimate the amount of the common, small fish, trey changwa plieng (Esomus longimanus), consumed by women in a traditional sour soup dish (10).

**Vitamin A and mineral content in fish species.** Samples of selected, commonly consumed fish species were collected fresh from landing sites, local markets, fishermen, and farmers for nutrient analyses. Subsamples of raw, cleaned parts were obtained by having village women clean the fish according to their traditional practices. Vitamin A compounds (all-trans retinol, 13-cis retinol, all-trans 3,4-dehydroretinol, 13-cis 3,4-dehydroretinol, and β-carotene) in fish samples were analyzed using high-performance liquid chromatography (11,12). Calcium, iron, and zinc were determined by atomic absorption spectrometry (13,14). The content of nonheme iron was determined by the widely used ferrozine colorimetric method (15). This fraction does not, however, include a high-molecular-weight subpool of complex-bound nonheme iron, such as ferritin or ferritin-like compounds and is termed inorganic iron (14).

The iron fractions not quantified by the above method; heme iron and complex-bound nonheme iron, were calculated as the difference between total iron and inorganic iron. In some samples of trey changwa plieng, heme iron was measured (14).

**Bioavailability of nutrients from fish and nutritional contribution of fish.** The bioavailability of calcium in the Bangladeshi SIS mola (Amblypharyngodon mola) was determined in both humans and rats (16,17). An efficacy study of the effect of mola on vitamin A status in Bangladeshi children has been completed (Shakuntala H. Thilsted, Department of Human Nutrition, The Royal Veterinary and Agricultural University, Frederiksberg, Denmark, personal communication). Estimations of the contribution of mola to vitamin A recommendation of Bangladeshi children and trey changwa plieng to iron requirements of Cambodian women and children were made.

**Results and Discussion**

**Fish intake in Bangladesh and Cambodia.** Consumption surveys conducted in selected areas of rural Bangladesh showed that the amount of fish consumed varies with location and household socioeconomic status and is highly seasonal. In poor households with small landholdings, the mean fish intake ranged from 13 to 83 g/d raw, whole fish per person (7). The fish consumption survey conducted in 84 rural households in Kishoreganj, Bangladesh in 3 rounds, July 1997, October 1997, and February 1998 showed that the total fish intake was highest (median ± SD: 82 ± 65 g/d raw, edible parts per capita) in October, with SIS making up a much greater proportion, 84% of the total fish intake, than large fish. The frequency of fish intake, in particular SIS, was high. All households consumed SIS at least 1 of the 5 d, except 1 household in July and 2 in October, whereas one-third of the households did not consume large fish (5,18).

There are very few data on fish intake in Cambodia. In the small study conducted in 66 poor, rural households in the Svag Rieng province in 1997–1998, an average intake of 70 g/d raw, edible parts of fish per person as well as 9 g/d of other aquatic animals (for example frog, snail, and snake) per person were recorded (9). Based on a survey of fish consumption in fishing communities around the Tonle Sap lake in 1998, using structured interviews, it was estimated that the average fish consumption was 67 kg/y raw, whole fish per person (19), corresponding to a average intake of 128 g/d raw, cleaned parts per person, adjusting for cleaning loss (30% weight of raw, whole fish) (9).

These studies showed that small fish made up 50–80% of all fish eaten during the fish production season in rural Bangladesh and Cambodia. In Bangladesh, with decreased freshwater capture fisheries and reduced access to open-water fisheries for poor, rural households, the total fish intake of the poor, as well as the proportion of SIS of the total fish intake, have declined. At the same time, aquaculture has become highly successful, and the production of carp, especially silver carp (Hypophthalmichthys molitrix), in ponds has increased. The intake of silver carp by the poor has increased because of its accessibility and low price, one-half of that of other large fish species, even though it is less preferred than other cultured carp species (5,7). This changing pattern of fish consumption has resulted in a decreased contribution of vitamin A and minerals from fish. The edible parts of many SIS, whole fish with bones, have high contents of these essential, limiting nutrients; however, the edible parts of large fish, including silver carp, mainly the muscles, contain low contents of these nutrients.

**Nutrient contents of commonly consumed fish.** The vitamin A, calcium, iron, and zinc contents of selected, commonly consumed fish in Bangladesh and Cambodia are shown in Table 1. Some common SIS have high contents of preformed vitamin A, mainly as retinoids (vitamin A-1) and dehydroretinoids (vitamin A-2), found predominantly in the eyes and viscera. The proportions of vitamin A-1 and vitamin A-2 vary considerably between species. For example, in chanda (Parambassis bucailis), vitamin A-1 accounts for 90% of the total vitamin A content, expressed as retinol activity equivalent (RAE), and 20% in darkina (Esomus damicus). Many SIS are eaten whole, including the bones, and are, therefore, a rich calcium source. Large fish do not contribute to calcium intake because their bones are discarded as plate waste and not eaten (4). The 2 species from the genus Esomus, darkina from Bangladesh and trey changwa plieng from Cambodia, have significantly higher iron content than the other analyzed species. Iron in fish is present in the forms of heme iron, a high-molecular subpool of complex-bound nonheme iron, and inorganic iron, the proportions varying with fish species (14). Trey changwa plieng also has higher zinc content than the other analyzed Cambodian species. The interspecies variations in the contents of iron and zinc seem to be less than that for vitamin A.

**The nutritional value of fish.** In the above-mentioned fish consumption survey in Kishoreganj, Bangladesh, it was estimated that SIS contributed 40% and 31% of the total recommended intakes of vitamin A and calcium, respectively, at household level in the peak fish production season. In Bangladesh, we have conducted studies that show that the nutrient-dense SIS mola can be successfully integrated into carp polyculture in small, seasonal ponds belonging to poor, rural households without negatively affecting carp production. At the same time total fish production increased, and the nutritional value of the total production significantly increased (4). A production of only 10 kg/y of mola in each of the estimated 1.3 million ponds in Bangladesh meets the annual recommended intake of vitamin A of >2 million children (5).

To quantify the nutritional value of a fish species, it is important that cleaning practices be recorded, that analysis of...
nutrient composition be carried out on samples of raw, cleaned fish parts, ready for cooking, and that plate waste be measured. In the above-mentioned study in Kandal province, Cambodia, it was recorded that the majority (80%) of the households cooked the commonly consumed fish, trey changwa plieng, with the head intact. The contents of calcium, iron, and zinc were considerably higher (58, 25, and 53%, respectively) in raw, cleaned samples, with the head than in samples in which the head was discarded during cleaning (10).

The biological activity of preformed vitamin A and bioavailability of minerals in fish are determining factors for its nutritional value. A biological activity of 40% in relation to all-trans retinol was used to calculate RAE from vitamin A-2 in fish samples, based on the growth response of vitamin A-2 in rats (21). The results from the efficacy study with mola fed to Bangladeshi children will shed light on the effect of vitamin A-2 on vitamin A status. The calcium in SIS has been shown to have the same high bioavailability as that from milk in both humans and rats (16,17).

Analysis of 16 common Cambodian fish species showed that, on average, 30% of the iron in these fish was present as inorganic iron, the remainder being heme iron and complex-bound nonheme iron. The bioavailability of heme iron is estimated as 25%, 25% for complex-bound nonheme iron, and 10% for inorganic iron (14). Our study in poor, rural households in Cambodia on the preparation and the consumption by women of a traditional meal, consisting of a sour soup dish, prepared with trey changwa plieng and boiled rice, indicated that the sour soup dish contributed a significant fraction of the daily iron requirement for women weighing 50 kg (1.35 mg/d iron per woman) (22), the above 2 iron fractions supplied 36% of the daily median iron requirement for women. In addition, the fraction of inorganic iron in the meal supplied 0.12 mg absorbable iron per woman per meal. With the daily median iron requirement for women of 0.49 mg absorbable iron per woman per meal, equivalent to 0.12 mg absorbable iron per woman per meal. Based on the measured iron contents of the meal components, it was estimated that the fractions of heme iron and complex nonheme iron supplied 1.94 mg iron per woman per meal, equivalent to 0.49 mg absorbable iron per woman per meal. With the daily median iron requirement for women weighing 50 kg (1.35 mg/d iron per woman) (22), the above 2 iron fractions supplied 36% of the daily median iron requirement for women. In addition, the fraction of inorganic iron in the meal supplied 0.12 mg absorbable iron per woman per meal, 9% of the daily median iron requirement.

Thus, a traditional meal of a sour soup dish prepared with trey changwa plieng and boiled rice has the potential to meet 45% of the daily median iron requirement of Cambodian women of childbearing age (14). Assuming an intake of 100 g sour soup dish (containing 25 g trey changwa plieng) in a meal in children,
the contribution to the daily median iron requirement (0.45 mg/d iron per child) (22) is 42%.

In quantifying the contribution of fish species to recommended amounts of vitamin A and minerals, factors other than the cleaning practices and plate waste, such as processing and cooking methods, are important. It has been shown that sun drying of mola destroyed nearly all of the vitamin A (12). In addition, a dish prepared by boiling trey changwa plieng, compared with one fried at a higher temperature had a higher content of heme iron (14).

Our studies show that in Bangladesh and Cambodia, SIS with low market value are commonly consumed and make up a large part of the everyday diet of the poor. SIS are an important source of calcium. Some are rich in vitamin A and/or iron and zinc. Data on fish consumption at the species level and analyses of nutrients in commonly consumed fish species and fish dishes are needed to quantify the present and potential contribution of fish to vitamin A and mineral requirements. Awareness of the importance of nutrient-dense fish species to combat vitamin A and mineral deficiencies should be raised at the household level as well as all levels in the agriculture, health, and nutrition sectors. The inclusion of suitable nutrient-dense fish species in aquaculture in Bangladesh should be promoted (23). Access to these fish, through management of fisheries resources, including open-water fisheries should be protected and enhanced. These steps can lead to nutrient-dense fish being used in food-based strategies to combat vitamin A and mineral deficiencies. The work we have done in Bangladesh and Cambodia also has relevance for addressing nutrient deficiencies in poor population groups in Africa, for example those living in the Lake Victoria region.

Literature Cited

2. Hels O. Dietary intake of nutrients from fish and rice in rural Bangladesh [MSc thesis]. Copenhagen, Denmark: Research Department of Human Nutrition, the Royal Veterinary and Agricultural University; 1995.