Enhancing Food Security and Household Nutrition of Women and Children with a Focus on Nutrient Dense Commonly Consumed Fish from Capture Fisheries and Aquaculture in Cambodia, Part I

FOOD AND NUTRITIONAL CONSUMPTION SURVEY: WOMEN AND PRESCHOOL-AGE CHILDREN IN CAMBODIA

Enhanced Trade and Investment for Global Fishery Markets/Study/13HHI02UC

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ABSTRACT

Fish is an integral part of women and preschool children's staple food for their daily consumption and is a main source of protein and other key micronutrients. At the same time, the prevalence of malnutrition among women and preschool children continues to be a major problem in Cambodia. However, data and information on the commonly consumed fish species and the current dietary intake of women and preschoolers in Cambodia are lacking. This study aimed to identify the commonly consumed fish species and Other Aquatic Animals (OAAs); evaluate the food consumption; and dietary energy and nutrient intakes among women and preschool children. 300 women and 342 preschoolers (aged 6 months to 5 years) were randomly selected for study. The 24 hr-food recall questionnaire was used. Microsoft Excel 2013 and SPSS Statistics Version 20.0 were used for data entry and analysis. Forty three (43) fish species and OAAs were consumed by women and 38 fish species and OAAs were consumed by preschoolers. Fish provides 80% of the total animal protein intake. Women consumed fish at 145.3 g/day and preschoolers at 52.9g/day. Women's total average daily per capita food consumption was 861g/day, while for preschoolers it was 489 g/day. Women's total average dietary energy intake was 1976 kcal/day, while for preschoolers it was 844.9 kcal/day.

INTRODUCTION

Fish is an integral part of women and preschool children's staple food for their daily consumption and is a main source of protein and other key micronutrients. At the same time, the prevalence of malnutrition among women and preschool children continues to be a major problem in Cambodia. However, data and information on the commonly consumed fish species and the current dietary intake of women and preschoolers in Cambodia are lacking.

OBJECTIVES

The primary purpose of this activity was to identify the commonly consumed fish species and Other Aquatic Animals (OAAs) of the sample women and preschool-age children. The secondary purpose was to evaluate their current food consumption: energy, and key nutrient intakes of women and preschool children and the relative contribution made by fish and Other Aquatic Animals (OAAs) and its products to total nutrient intake of studied subjects.

METHODS

Study design and scope. Stung Treng province (Upstream Mekong River), Prey Veng province (Downstream Mekong River) and Kampong Thom province (Tonle Sap Area) were selected for study sites. The data collection was conducted in the rainy season from 2 to 26 June 2014. The target subjects of the study subjects are women and preschool children (aged six months to five years). Three hundred (300) eligible women and 343 eligible preschool-age children were selected by using simple randomized sampling from the three provinces. Dietary intake was surveyed through face-to-face interviews by using a single 24-hour food recall to estimate the amount of food that had been eaten in the past 24 hours. Food models were used to identify food items that were eaten by the subjects. All food and beverages consumed were recorded using standard household measurement and an electronic scale (precision to 0.1g). The names of local dishes consumed were also recorded. The amount of each food item consumed was estimated from the real food models. Mothers were asked to show the amount of food consumed by her child, which was then weighed. All food item consumption of women and preschoolers were converted to weight in grams and the nutrient content of the foods consumed were computed by using the ASEAN Food Composition Table (ASEANFCT 2000). Nutrients for evaluation included: energy; macronutrients (protein, carbohydrate and fats); and key micronutrients (iron, zinc, calcium, and vitamin A). The nutrient intakes of women and preschool children were then compared to the Recommended Dietary Allowances harmonization in Southeast Asia (Barba, 2008) to determine the level of nutritional adequacy of the food intake to estimate the amount of food that had been eaten.

Training and survey organization. Data were collected by four trained field enumerators. The training aimed to educate field enumerators on how to conduct dietary assessment by using the 24-hour food recall questionnaire; to educate the interviewers to be familiar with fish species; to reinforce the recall interviewers with exercise practices and pilot testing; and to educate the interviewers to be familiar with the questionnaire before data entry was employed. Pilot pretesting of questionnaires was conducted in order to identify the potential problems encountered in questionnaires, questions, and recall form. A letter of survey objectives was presented to the local authorities informing them of the conduct of the survey before the actual fieldwork was started. Questionnaires were cross-checked by the members of the team for any missing pieces of information followed by data entry. Microsoft Excel 2013 and SPSS Statistics Version 20.0 were used for data entry and analysis. Data coding, cleaning, and cross-checking were conducted. Descriptive statistics were used.

RESULTS

Socio-economic characteristics. The socio-economic survey provided a summary of the demographic and socio-economic characteristics of the women. Data collected included type of dwelling unit; household possessions; water supply and sanitation; and characteristics of the women such as age, education attainment, and occupation. The socio-economic variables were vital in the analysis of the relationships between the nutrition and health variables, and very useful in targeting and locating specific population groups who are nutritionally vulnerable to socio-economic fluctuations and environmental degradation.

Nearly one-third (30.7%) of the sample women belonged to the adult age category (25 - 29 years old), followed by 26.7% belonging to the age category (30-34 years old). Only 1% was in the age group more than 50 years old. The average age of sample women was 29.6 years old. Regarding marriage, 86.7% of women belonged to age category (20-24 years old) when first married, followed by about 5% belonging to age group (25-29 years old) with an average age of 21.7 years when first married. Women had an average of 2.1 children. More than 70% of the women had 1-2 children, whereas only 5% had more than 5 children (Table 2).

The Cambodian educational system, grade one to six is classify as primary level, grades seven to nine is classified as secondary level, while grades 10 to 12 is classified as high school. Forty-five percent (45%) of sampled women had completed secondary school and 29% more had completed the primary level. Only about 12 % and 3% reached high school and college/university, respectively. The literacy rate was 69% (Table 2). 62.8% of the respondents derived income from agriculture, followed by labor force, fishing and animal husbandry, which accounted for about 42.5%, 41.5% and 40%, respectively. Up to 21.7% generated income from 28 other different job items. Almost half of respondents had two different jobs and only 12% had one job (Table 3).

Information on ownership of durable goods and other possessions is presented in Table 3. Among the appliances that are most acquired by women, mobile telephones rank highest (77%), followed by televisions (56%) and other appliances such as CD/DVD, refrigerator, generator, fans, rice harvesting machine, water pump machine, air-condition, wood cutting machine, electric cooker owned more than 15%. More than half of all respondents own a motorcycle, followed by bicycle ownership of more than 43%. The percentage owning a boat was only 1%. The type of the material used for the house is one of indicators for the impression of the wealth at the first glance. Nearly all (95.4%), of the sample women owned wooden houses (Table 4) and the remainder owned a concrete house. More than half of the sample women (56%) owned land for agriculture.

The source of drinking water is an indicator of whether it is suitable for drinking. Nearly 79% of household of the women sampled consumed drinking water from rainwater and more than half of the women sampled utilized water from a river for drinking water. Nearly one-fourth of women sampled consumed drinking water from a pipe or running water (Table 5). Almost half of the sample women's household had no access to toilet hygiene facility and made use of fields or bush areas. Thirteen percent reported sharing their toilet facility.

Early initiation of breastfeeding is encouraged for a number of reasons. Mothers benefit from early suckling because it stimulates breast milk and facilitates the release of oxytocin, which helps the uterus contract and reduces postpartum blood loss. The first breast milk contains colostrum, which is highly nutritious and has antibodies that protect newborns from disease. UNICEF and WHO recommend that children be exclusively breastfed during the first 6 months of file and that children be given solid or semisolid complementary food in addition to continued breastfeeding from six months to 24 months. Exclusive breastfeeding is recommended because breast milk is uncontaminated and contains all of the nutrients necessary for children in the first few months of life. The proportion of sample children ever breastfed was almost all (98%) and those breastfed only 2.3% (Table 6). More than three-fourths of sample children under six months of age were exclusively breastfed. Forty-three percent of women sampled reported their children get sick a few times a month and more than one-fourth (22%) get sick once a month (Table 5).

Food consumption by women. Food consumption in different areas of the country may be influenced by topography; religious customs; cultural relationships; trades and price (food affordability); agricultural products (local food availability); family size; household food distribution. These factors influence food consumption patterns of individuals, especially women and children. The majority of foods that made up the sample women's diet comes from plants at 76%, while 23% comes from animal source, and 1% comes from food groups such as condiments and spices (Figure 1).

The overall sampled women's diet is basically a rice-vegetable-fish combination (Figure 2). In terms of weight, the total mean one day per capita food consumption is 861g/d, in as-purchased raw form. The most highly consumed food was cereal and cereal products at 369.4 g/d (43% of the total food intake). Vegetables were the second top food group commonly consumed by sample women at around 150 g/d (18 % of the total food intake). Intake of fish, OAA, and their products were the third largest consumption at 145.3 g/d (17% of the total food intake). Consumption of fruits and beverages was 54 g/d (6%). The rest of the major food groups consumed in small amounts were fats and oils; egg, sugar and syrups; legumes, nuts, seeds; and starch roots and tubers.

Among the studied provinces, the Prey Veng province, located in Cambodian Lower Mekong part, showed highest food intake at 884 g/d, followed by Kampong Thom Province, Tonle Sap area, at around 855 g/d, while Stung Treng province, located in Cambodian Upper Mekong part, was lowest at around 843 g/d (Table 7). Intake of cereals and cereal products, predominantly rice, was high Prey Veng province at around 377 g/d followed by Kampong Thom province at 365.2 g/d. Stung Treng consumed 366 g/d. Kampong Thom province consumed vegetables at around 152 g/d followed by Prey Veng province at around 151 g/d and Stung Treng was around 148.6 g/d. Fish, OAA and their products were generally eaten more than meat or poultry or eggs in all sample provinces. Higher consumption of fish was observed in Prey Veng province at around 155g/d, followed by Stung Treng province at around 141g/d and Kampong Thom province at 140g/d. The other different food groups: fats and oils; egg, sugar and syrups; legumes, nuts, seeds; and starch roots and tubers were also consumed, by sample women, across the studied provinces.

Food consumption by preschool children. Diets of sampled pre-school children came from plant sources (75%), animal sources (24%), and condiments and spices (1%) (Figure 3). The mean one-day total food intake of children aged six months to five years old weighed 499 g, in as- purchased form (Figure 4), consisting largely of 256 g (51%) of cereal and cereal products of which rice and rice products were the predominant forms, of 55g (11%) of milk and milk products, of 53g (11%) of fish and Other Aquatic Animals, and a combination of vegetables and fruits around 50g (10%). Energy-giving foods such as rice and body building foods such as milk, fish, meat, poultry, and egg are food items that are needed most importantly in preschool children's diet to support the fast rate of growth and development. Rice contributed more than half of the total food intake. This age group's intake of fish and fish products was about 11% while meat and meat products were 2.4%, and poultry and eggs was 1.5%. Milk and milk products were at 11% of the total food intake. Fruits and vegetables amounted to 29.3 and 20.5 g, respectively, which shared about 5.9% and 4% of total food intake, respectively. The intake of fats and oils, at 0.8 g or 0.17% of the total food intake, although low, is important for the transport of fat-soluble vitamins, especially vitamin A found in animal tissues or beta-carotene, the precursor of vitamin A from the plant tissues.

Table 8 shows that The mean one-day food intake of children aged six months to five years by province was: Prey Veng province highest at 547 g, followed by Stung Treng province at 467 g, whereas lowest food intake was observed in Kampong Thom at 458 g per day. Intake of cereals and cereal products, predominantly rice, was high in Prey Veng province at 300 g followed by mountainous Stung Treng province around 250.5 g per day, while lowest intake was observed in Kampong Thom at around 221 g/d. Fish and beverages were the second largest items consumed across the studied provinces with the combination of both items accounting for nearly one-fourth of total food intake by pre-school children. Milk and milk products ranked third across the studied provinces, with Prey Veng at 49.5 g (9%), followed by Kampong Thom province at 46.5 g (10%) and Stung Treng the lowest consumption at 38 g (8%). Food groups such as fruits, vegetables, eggs, sugar and syrup, starchy roots and tubers, legumes, nuts and seed, and beverages were also consumed by this age group.

Women consume 43 fish and OAA species with an average consumption of 145.3 g/d. The 10 most consumed fish species in terms of weight and percent contribution to women consuming fish species per day were: Trey Riel (*Cirrhinus sp.*), 31g (21%) of total fish intake per day; Trey Ros (*Channa striata)*, 19 g (13%); and Trey Chhpin (*Hypsibarbus pierrei*), 15 g (10.1%) (Table 8). Other fish species, aquaculture fish, and OAA are listed in Table 9.

Preschoolers consumed 38 fish and OAA species with an average consumption of 53 g/d. The most consumed fish species in term of weight and percentage contribution to children were: Trey Riel (*Cirrhinus sp.*), 12.9 g/d (24.3%); Trey Ros (*Channa striata*), 9.6 g/d (17.8%) and Trey Kanhchus (*Mystus sp.*), 5.09 g (9.6%) (Table 10). Other fish species, aquaculture fish, and OAAs are also listed in Table 10.

Nutrient intake by women. All major food groups contribute to the caloric intake of individuals, especially women and children; therefore, adequacy in the caloric and protein intakes measured against the recommended daily allowance is a good indicator of food adequacy. An intake of one g of carbohydrate-rich foods such as cereal and its products, starchy tubers and roots, sugar and syrups, fruits and vegetables will generate four Kcal. An intake of one g of protein-rich foods such as fish, meat, milk, poultry, eggs, dried beans, nuts and seeds and their products will also generate four Kcal. An intake of one g of fats and oils, including butter or margarine will give nine Kcal. The sources of calories in a diet, namely carbohydrates, proteins and fats are an indicator of the quality of the diet. The diet of women sampled in this study has a total energy of 1976 Kcal, the largest amount of which comes from carbohydrates at 71%, with desirable contribution from proteins at 13% and very low from fats and oils (16%) (Figure 5).

The total energy and nutrient intake among three provinces ranked from 1813.3 Kcal (Kampong Thom) to 2082.6 Kcal (Prey Veng) (Table 11). The sampled women's daily protein intake ranged from 61.9 to 67.8 g, carbohydrate intake from 346.7 to 271.4 g, while lipid intake ranged from 28.9 to 44 g. Iron intake ranged from 11.7 to 13.9 mg, zinc from 3.1 to 4.1 mg, calcium intake from 478.4 to 619.4 g and vitamin A from 404.9 to 531.4 mcg RE. In terms of energy and nutrient adequacy, half of the sampled women met at least 100 % of their recommended intake for energy. About 71% of the sample women met at least 80% of the recommended intake of protein. Less than one-fifth of the sample women met at least 80% of the recommended intake for iron. More than 1/3 of sampled women met at least 80% of the recommended intake for zinc. Close to one-fourth of sampled women met the recommended intake for calcium and more than one-fourth of sampled women met the recommended intakes for vitamin A.

Nutrient intake by preschoolers. The total energy intake of sampled pre-school children among three provinces ranked from a low of 775.9 Kcal (Kampong Thom) to a high of 922.9 Kcal (Prey Veng) (Table 12). The sampled preschool children's daily protein intake ranged from 26.7 g to 32.9 g, carbohydrate intake from 119.5 g to 152.9 g, and lipid intake from 13.08 g to18.9 g. Iron intake ranged from 4.75 to 5.56 mg, zinc intake from 1.26 to 2.14 mg, calcium intake from 207.5 to 332.7 g and vitamin A intake from 221.5 to 268 mcg RE. Among the preschool children, only about 30% met the recommended dietary intake for energy; more than half met at least 80% of protein requirements; and close to one-fourth of the preschool children met at least 80% of recommended intake for iron. Less than1/10 of the preschool children met at least 80% of recommended intake for zinc; about 24% met the recommended intake for calcium and more than 18% met the recommended intake for Vitamin A.

The contribution of particular food groups to total energy and nutrients intake (Table 13) indicates that cereal and cereal products are top energy contributors in the sampled women diet contributing 60.9 %. Because of the large bulk of this food group, it is also the major contributor of carbohydrates at more than 77%. It is also the second contributor of protein at 31%, fats at 14.8%, iron at 43%, calcium at 22% and vitamin A at 7.8%. Fish and fish products are the major contributors of protein at 48.9%, fats at 28.4 %, iron at 25.8 %. Meat and meat products follow fish and fish products in their contribution to the total nutrient intake. Vegetables, on the other hand, are the second largest contributor of carbohydrate at 12.5%, and the major contributors of iron, zinc, calcium, and vitamin A. Fruits were the top contributor to total vitamin A intake, while beverage was the second largest contributor to total energy intake by the sample women.

The contribution of different food groups to total energy and nutrients intake (Table 14) indicates that cereal and cereal products are the largest contributors in the sampled pre-school children's diet to energy, carbohydrates, iron at about 57.4%, 73.4%, and 44.4%, respectively. It is also the second contributor to protein and fats at about 34.5% and 21.5%, respectively. Fish and fish products are top contributors to protein and fats with 40.8% and 28.4%, respectively. Milk and milk products were the largest contributors to zinc and calcium at around 39.7% and 36.3%, respectively. Fruits and vegetables, on the other hand, were the major contributor to vitamin A, while the other food groups such as starchy roots and tubers; legumes, nuts and seed; sugars and syrup; beverages; condiments; and spices were lesser contributors to energy and nutrient intake by preschool children.

Role of fish in nutrition security in women and preschool children. Fish plays a great role in meeting dietary energy needs. When energy needs of the body cannot be supplied by rice and other carbohydrate-rich foods, the body metabolizes the protein from fish to sustain the caloric need of the body for the proper functioning of various physiological and biochemical processes such as digestion and metabolism of foods to sustain life. Fish is also a source of fats. The fats and the protein contributed by fish significantly mitigate caloric deficiency in women's and preschool childrens diets and perhaps the protein-energy malnutrition which is the form of malnutrition that exists in developing countries like Cambodia.

Fish contribute some fat but overall intake of fat was low; it is far lower than the desirable contribution of fats to total dietary energy recommended at 30%–40% for infants and 20%–30% for all others. The low fat intake is one reason for low calorie intake. Fish provides protein, which the body uses for optimal growth, but in the context of low calorie intake the body must turn to protein to satisfy energy needs. This is the form of protein-calories malnutrition (Marasmus) and the major reason for stunted growth and development in Cambodia. Another form of protein-calorie malnutrition (Kwashiorkor) is simple protein deficiency. This type is not common in Cambodia and rarity can be attributed to availability of protein from fish. It can be noted that the contribution of dietary energy from fish at 13% (Figure 5) and 15% (Figure 6) to total dietary energy per capita is the level of protein recommended at 10%–15%.

Fish, OAAs and their products were the major contributors of energy and nutrients of animal origin to women, providing 80% of the total animal protein intake (Table 15). Meat/poultry and eggs contributed less than one-fourth to the total animal protein intake accounting for about 18 % and 2 %, respectively. Fish, OAAs and their products were also the major contributors of energy, fats, carbohydrate, iron, zinc, calcium, and vitamin A at 69.7%, 54%, 99%, 74.5%, 44.6%, 83% and 87.4%, respectively.

Again fish, OAAs and their products were the largest contributors to the total daily energy and nutrient intake from animal sources for preschool children, around 80% of the total animal protein intake (Table 16). Meat/poultry and eggs contributed to the total animal protein intake at about 14.5 and 7.3%, respectively. Fish, OAAs and their products were also the major contributor to energy, fats, carbohydrates, iron, zinc, calcium, and vitamin A at 72.1%, 60%, 93%, 57.2%, 44.1%, 92.8% and 56.4%, respectively.

DISCUSSION

Cambodian women's and preschool children's diets are basically a rice-vegetable-fish combination and have similar proportions: 76% from plant sources, 23% from animal sources, and 1% from food groups such as condiments and spices. The Philippine Food Consumption Survey in 2008 indicated that the Filipino diet comes 70% from plant sources, 29% from animal sources and 1% from condiments and prices. Our study shows that Cambodian women's and preschool children's consumption of plant-source foods was higher than that of Filipinos, whereas consumption of animal-source foods was lower. Animal- source food in Cambodia is mainly from fish. Other animal sources like beef, chicken, and pork are relatively expensive in Cambodia compared to fish which is available and affordable for rural households.

The overall mean daily per capita food consumption of women and preschool children are 861 g and 499 g in raw as-purchased form, respectively. By comparison, Filipino adult women from 13-19 years old consumed 709 g and Filipino preschool children consumed 492g, of which milk and milk product contributed the largest amount at 188g; cereal and cereal products, accounting for 148g; fish and fish products at 36g; and vegetables 16g. Fish and OAAs were the largest consumption by women and preschool children, estimated at 145.3 g and 52.9 g, respectively. Our findings are less than those in the study by Touch Bunthnag et al. (2011) at 172.7 g, perhaps because the surveys were conducted in different seasons. Cambodian women's diet has a total energy of 1976 Kcal, the largest amount of energy (up to 71%) coming from carbohydrates, with a good contribution from proteins at 13%, but low contribution from fats and oils at 16%. Cambodian preschool children's diet has a total energy of 844.9 Kcal, of which carbohydrate generates the largest amount (68%), protein 15% and fats and oils 17%. The study conducted in Cambodia by FAO (2012) found that the contribution of total energy from carbohydrate was 76%, whereas the shares of protein and fat to the overall energy supply were 10% and 14%, respectively. A study by Phuong H Nguyen et al. (2013) in Vietnam showed that energy intake of Vietnamese women was 2196 kcal/day with 65.5%, 14.8%, and 19.5% coming from carbohydrate, protein and fat, respectively.

Our study found that fish and OAAs contributed to energy intake of Cambodian women at 69.7% (Table 14) and of preschool children at 72.1% (Table 15) to the total animal energy intake. Fish is also the source of fats in contributing to the total animal fat intake at 54% (Table 14) and 60% (Table 15) of women and preschool children, respectively. More importantly, fish is a main source of protein, providing up to 80% and 78% of the total animal protein intake and 78% for women and preschool children, respectively.

Another study by United Nation Children's Emergency Fund (UNICEF)/World Food Program (WFP) showed that fish is part of the daily diet of 74%–80% of all children of over 11 months old. Fats and protein contributed from fish significantly mitigated caloric deficiency in women's and preschool children's diets and perhaps the protein-energy that exists in developing countries like Cambodia. Fish contribute some fat but overall intake of fat was low, far lower than the level of fats to total dietary energy recommended at 30%–40% for infants and 20%–30% for adults (RENI 2002). The low fat intake is the reason for low calorie intake. Fish provides protein, which the body uses for optimal growth, but in the context of low calorie intake the body must turn to protein to satisfy energy needs. This form of protein-calorie malnutrition (Marasmus) is the major reason for stunted growth and development in Cambodia. Another form of protein-calorie malnutrition (Kwashiorkor) is simple protein deficiency. This type is not common in Cambodia and its rarity can be attributed to the availability of protein from fish. The contribution of dietary energy from protein, 13% for women and 15% for preschoolers, to total dietary energy per capita is in the recommended range of 10%–15% of total protein intake per individual.

Aside from contributing to the total energy intake, fat of fish contains essential fatty acids namely, linoleic acid (omega 6), the precursor of arachidonic acid (ARA) and linolenic acid (omega 3), the precursor of DHA. These nutrients are not synthesized by the body, but must be obtained from food and are known to benefit health. DHA is a key component of the phospholipids in membranes of the eyes and brain, essential for brain and eye development infants and children. It reduce the risks of heart disease and stroke, prevents blood clots, lowers blood pressure, protects against irregular heartbeats, reduces inflammation, strengthens the immune system, and is essential for normal growth and development for healthy skin, normal growth, and reproduction. A diet that is deficient in DHA is associated with poor growth, skin lesions, reproductive failure, and fatty liver.

Beside its key contribution in meeting primarily protein and energy requirements, fish plays a significant role in meeting iron, zinc, and vitamin A requirements in women and preschool children. Iron functions as part of hemoglobin, which transports oxygen in blood to cells and part of myoglobin in muscles, which makes oxygen available for muscle contraction. Iron is part of an enzyme in the immune system to help protect against infections and is involved in making amino acids, collagen, hormones, or normal brain functions, for synthesis of neurotransmitters and brain growth in humans.

Overall, half of the Cambodian women surveyed met the recommended intake for energy. More than two-thirds (65.7%) of women met at least 80% of the recommended intake for protein, 1/10 of women met at least 80% of the recommended intake of iron intake, nearly one-fourth of women met at least 80% of the recommended intake of calcium, and 28% of women met at least 80% of the recommended intake of vitamin A.

In comparison, the Philippines Food Consumption Survey (2008) of adult Filipino women showed that only 17.9% met the recommended dietary energy requirement; 50.1% met the protein RDA; 12.3% met the iron RDA; and was 16% lower at meeting Vitamin A RDA. On the other hand, 29.5% of Cambodian preschool children met the recommended intake for energy, 53.3% met at least 80% of the recommended intake for protein, 24.1% met at least 80% of the recommended iron intake, 8% met at least 80% of the recommended intake of zinc, and less than 20% of preschool children met at least 80% of the recommended intake of vitamin A. The Philippines Food Consumption Survey (2008) showed that only 17.8% of Filipino preschoolers met the recommended dietary energy intake, 48.3% met the protein RDA, 25.2% met the iron RDA, and 26% met the vitamin A RDA.

CONCLUSION

Cambodia's natural resources provide a foundation for food security, income, and employment for their livelihood. Most of the rural people rely on rice cultivation, harvesting of fish, and OAAs. Rice and fish are the traditional staple foods playing an important role in the diets of women and children. Rice is the main source of energy and fish is the main source of animal protein. Fish is the major contributor of key micronutrients such as iron, zinc, calcium, and vitamin A in women and children. Nutritional status of the rural poor women and children was low. The low intake of micronutrients in comparison to the recommended daily intake put them in the risk of micronutrient deficiencies. Fish is a nutritionally important animal food source contributing to the daily diets of the women and children in poor rural households.

QUANTIFIED ANTICIPATED BENEFITS

This investigation has provided recommendations for better nutrition in women and children in Cambodia. Two Master's students were involved in this investigation (one female and one male). Four undergraduate students were also supported for their dissertations (two females and two males). Three IFReDI staff were involved (one female and two males). Two hundred and twelve participants (155 women) attended the series of consultation and dissemination meetings and workshops on results of the investigation, and formulating recommendations for better nutrition in women and children. Three hundred fact sheets and policy briefs were directly provided to the women sampled in the study. One thousand and two hundred (1200) fact sheets and policy briefs were delivered to IFReDI/FiA staff, scientists, researchers, government officers, NGOs, and women which are direct and indirect benefits from the projects.

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TABLES AND FIGURES

Table 1. The recommended dietary allowances per day by age group.

Population Group	Weight (kg)	Energy (Kcal)	Protein (g)	Iron (mg)
		Infants, months		
Birth-< 6	6	560	9	0.38
6-<12	9	720	14	10
		Children, years		
1-3	13	1070	28	8
4-6	19	1410	38	9
7-9	24	1600	43	11
		Males, years		
10-12	34	2140	54	13
13-15	50	2800	71	20
16-18	58	2840	73	14
19-29	59	2490	67	12
30-49	59	2442	67	12
50-64	59	2170	67	12
65+	59	1890	67	12
		Females, year		
10-12	35	1920	49	19
13-15	49	2250	63	21
16-18	50	2050	59	27
19-29	51	1860	58	27
30-49	51	1810	58	27
50-64	51	1820	58	27
65+	51	1410	58	10
		Pregnant women		
Trimester				
First		66		27
Second	+300	66		34
Third	+300	66		38
		Lactating Women		
1st 6 months	+500	105		27
2nd 6 months	+500	105		30

Table 2. Percentage distribution of the Cambodian women in this survey by age group and number of children.

Characteristic	Percent (%)
Age Group (Year) (n=300)	
15-19	1.7
20-24	22.7
25-29	30.7
30-34	26.3
35-39	9.0
40-44	6.0
45-49	2.7
50+	1.0
Minimum	17
Maximum	53
Mean	29.6
Std. Deviation	6.6
Marriage Age Group (Year) (n=300)	
15-19	8.3
20-24	86.7
25-29	5.0
Minimum	13
Maximum	46
Mean	21.7
Std. Deviation	4.06
Number of Living Children(n=343)	
1-2 children	70.7
3-4 children	23.7
5+ children	5.7
Minimum	1
Maximum	8
Mean	2.1
Std. Deviation	1.4

Table 3. Percentage distribution of Cambodian women sampled in this survey by educational attainment and employment.

Characteristic	Percent (%)
Educational Attainment(n=300)	
No Schooling	10.3
1-6 grade	29.3
7-9 grade	45.0
10-12 grade	12.3
University	3.0
Ability to read(n=300)	
Yes	69.0
No	31.0
Employment (n=300)	
Fishing	41.5
Agricultural Farmer	62.8
Animal Husbandry	40.0
Employment has wage	13.6
Small business at home	16.3
Labor	42.5
House Wife	3.3
Other Works (28 different kinds of job items)	21.7
Number of Jobs (n=300)	
One Job	12.0
Two Jobs	49.2
Three Jobs	30.2
Four Jobs	8.6

Table 4. Percentage of households (of Cambodian women sampled in this survey) possessing durable goods, using means of transportation, owning types of houses, and owning agricultural land.

Possession	Percent (%)
Household effects (n=300)	
TV	55.8
Radio	29.9
Mobile Telephone	77.4
Others (CD/DVD, refrigerator, generator, fans, thresher, water pump machine, air-condition, wood cutting machine, electric eooker)	15.6
Means of Transport (n=300)	
Bicycle	43.5
Motorcycle	64.1
Car	2.7
Kour Yorn	6.0
Boat	1.0
Housing Type (n=300)	
Wooden House	94.0
Concrete House	6
Ownership of agricultural land (n=300)	
Family has agricultural land (other than the piece of house land lot)	56.0
Family does not have agricultural land (other than the piece of house land lot)	44.0

Table 5. Percentage distribution of drinking water and type of toilet sanitation facilities by Cambodian women sampled in this survey.

Characteristic	Percent (%)
Household drinking water (n=300)	
Rainwater	78.7
River	51.2
Mechanical/Hand Pump	31.6
Pipe/running water	23.9
Electric Pump	1.3
Type of toilet sanitation facilities (n=300)	
Open Air toilet	43.5
Own Toilet	43.2
Shared Toilet	13.0

Table 6. Percentage distribution of breastfeeding status, exclusive breastfeeding, and child health care for preschool children sampled in this survey.

Characteristic	Percent (%)
Breastfeeding Status (n=343)	
Child has ever been breastfed	97.7
Child has not ever been breastfed	2.3
Frequency of Exclusive Breastfeeding (month) among under 6 month child (n=343)	
<=6	84.2
5-4	7.5
3-2	3.4
1-0	3.4
Child Care (n=290)	
Once in a week or more	3.0
Few times in a month	43
Once in a month	22.2
Few times in a year	22.9
Once in a year or less	5.3

Table 7. Percent distribution of the women's mean daily per capita food consumption across the provinces.

Food Group	All Sample Women		Stung Treng Province		Kampong Thom Province		Prey Veng Province	
	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total
Energy-Giving Foods								
Cereals and products	369.38	42.91	366.05	43.42	365.23	42.71	376.86	42.65
Sugars and syrup	5.08	0.59	2.77	0.33	5.93	0.69	6.32	0.72
Starchy roots and tubers	3.99	0.46	4.55	0.54	3.75	0.44	3.67	0.41
Fats and oils	4.76	0.55	3.14	0.37	4.67	0.55	6.46	0.73
Body-Building Foods								
Fish and OAAs	145.34	16.89	141.14	16.74	140.28	16.40	154.61	17.50
Meat and poultry	42.76	4.97	53.20	6.31	26.69	3.12	48.41	5.48
Eggs	9.53	1.11	4.86	0.58	9.42	1.10	14.33	1.62
Milk and products	4.37	0.51	2.00	0.24	6.08	0.71	5.04	0.57
Legumes, nuts and seed	4.15	0.48	3.64	0.43	4.98	0.58	3.83	0.43
Regulating Foods								
Vegetables	150.60	17.50	148.67	17.63	152.21	17.80	150.94	17.08
Fruits	54.54	6.34	51.48	6.11	70.31	8.22	41.83	4.73
Miscellaneous								
Beverages	54.68	6.35	50.78	6.02	53.43	6.25	59.83	6.77
Condiments and spices	11.54	1.34	10.86	1.29	12.16	1.42	11.59	1.31
All Foods	**861**	**100**	**843**	**100**	**855**	**100**	**884**	**100**

Table 8. Percent Distribution of the preschool-age children's mean daily per capita food consumption across the provinces.

Food Group	All Sample Children		Stung Treng Province		Kampong Thom Province		Prey Veng Province	
	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total	Consumption Raw AP (g/day)	% of Total
Energy-Giving Foods								
Cereals and products	256.54	52.46	250.56	53.63	220.96	48.29	300.52	54.95
Sugars and syrup	6.89	1.41	5.23	1.12	7.47	1.63	8.02	1.47
Starchy roots and tubers	1.78	0.36	0.05	0.01	0.03	0.01	5.32	0.97
Fats and oils	0.85	0.17	0.87	0.19	0.57	0.13	1.13	0.21
Body-Building Foods								
Fish and OAAs	52.99	10.84	51.05	10.93	50.42	11.02	57.99	10.60
Meat and poultry	10.93	2.24	11.81	2.53	7.99	1.75	13.10	2.40
Eggs	7.72	1.58	7.66	1.64	5.96	1.30	9.61	1.76
Milk and products	44.57	9.11	38.07	8.15	46.53	10.17	49.53	9.06
Legumes, nuts and seed	0.21	0.04	0.07	0.02	0.47	0.10	0.08	0.02
Regulating Foods								
Vegetables	20.57	4.21	17.18	3.68	21.37	4.67	23.33	4.27
Fruits	29.43	6.02	29.61	6.34	27.03	5.91	31.92	5.84
Miscellaneous								
Beverages	53.42	10.92	52.29	11.19	64.55	14.11	43.93	8.03
Condiments and spices	3.12	0.64	2.78	0.59	4.23	0.92	2.38	0.44
All Foods	489	100	467	100	458	100	547	100

Table 9. Ten commonly consumed fish species and percent distribution of the women's mean daily per capita fish consumption.

No.		Khmer Name	Common Name	Scientific Name	Mean	%
1	Trye Riel	ត្រីរៀល		***Cirrhinus* sp.**	31.05	21.04
2	Trye Ros	ត្រីរស់	Striped snakehead	***Channa striata***	19.14	12.97
3	Trye Chhpin	ត្រីឆ្ពិន	Mekong silver barb	***Hypsibarbus pierrei***	15.04	10.19
4	Trye Kanhchus	ត្រីកញ្ចុះ		***Mystus* sp.**	12.64	8.56
5	Trey Chhlang	ត្រីឆ្លាំង	Asian redtail catfish	***Hemibagrus* sp.(cf. *nemarus*)**	9.6	6.5
6	Trey Andeng	ត្រីអណ្តែងរឹង	Walking catfish	***Clarias batrachus***	9.17	6.21
7	Trey Deab	ត្រីដៀប	Giant snakehead	***Channa micropeltes***	7.48	5.07
8	Trey Chab	ត្រីចាប	Pirapatingga	***Piaractus brachypomus***	5.41	3.66
9	Trey Kranh	ត្រីក្រាញ់	Climbing perch	***Anabas tastudineus***	4.38	2.96
10	Trey Pou	ត្រីពោ	Spotted-ear catfish	***Pangasius larnaudii***	4.34	2.94
11	Other species				27.05	19.9

Table 10. Ten commonly consumed fish and percent distribution of the preschool-age children's mean daily per capita fish consumption.

No.		Khmer Name	Common Name	Scientific Name	Mean (g)	%
1	Trey Riel	ត្រីរៀល		***Cirrhinus* sp.**	12.9	24.3
2	Trey Ros	ត្រីរស់	Striped snakehead	***Channa striata***	9.6	17.8
3	Trey Kanhchus	ត្រីកញ្ចុះ		***Mystus* sp.**	5.1	9.6
4	Trey Chhpin	ត្រីឆ្ពិន	Mekong silver barb	***Hypsibarbus pierrei***	4.2	8.0
5	Trey Andeng	ត្រីអណ្តែង	Walking catfish	***Clarias batrachus***	2.8	5.2
6	Trey Chhlang	ត្រីឆ្លាំង	Asian redtail catfish	***Hemibagrus* sp.(cf. *nemarus*)**	2.6	4.8
7	Trey Chab	ត្រីចាប	Pirapatingga	***Piaractus brachypomus***	1.4	2.7
8	Trey Chongva	ត្រីចង្វា		***Rasbora* sp.**	1.4	2.6
9	Trey Deab	ត្រីដៀប	Giant snakehead	***Channa micropeltes***	1.3	2.5
10	Trey Tuke	ត្រីតុកកែ		***Cephalophlis* sp.**	1.0	2.0
11	Other species				10.8	20.5

Table 11. Mean daily intake and percent adequacy of energy and nutrient intake of Cambodian women surveyed in this study.

Energy and Nutrient	All Women	Stung Treng	Kampong Thom	Prey Veng
Energy(Kcal)	1976.0	2032.1	1813.3	2082.6
Meeting 100% of Energy Intake (%)	50.0	52.0	42.0	56.0
Protein(g)	65.7	67.4	61.9	67.8
Meeting 80% of Protein Intake (%)	71.0	75.0	66.0	72.0
Iron(mg)	13.0	11.7	13.9	13.2
Meeting 80% of Iron Intake (%)	10.7	13.0	5.0	14.0
Zinc(mg)	3.8	3.1	4.2	4.1
Meeting 80% of Zinc Intake (%)	36.3	28.0	46.0	35.0
Calcium(g)	545.2	478.4	537.7	619.3
Meeting 80% of Calcium Intake (%)	24	21.0	26.0	24.0
Vitamin A(mcg RE)	458.4	531.4	438.8	404.9
Meeting 80% of Vitim A Intake (%)	28	24.0	29.0	31.0
Carbohydrate(g)	355.7	346.7	349.0	371.4
Fats(g)	35.5	33.5	28.9	44.0

Table 12. Mean daily consumption and percent adequacy of energy and nutrient intake of the Cambodian preschool-children surveyed in this study.

Energy and Nutrient	All Children	Stung Treng	Kampong Thom	Prey Veng
Energy(Kcal)	844.94	775.94	830.54	922.90
Meeting 100% of Energy Intake (%)	29.58	22.22	28.57	37.38
Protein(g)	28.72	26.72	26.36	32.90
Meeting 80% of Protein Intake (%)	53.37	46.66	48.57	61.68
Iron(mg)	5.09	4.83	4.75	5.67
Meeting 80% of Iron Intake (%)	24.11	15.28	22.85	32.71
Zinc(mg)	1.68	1.26	1.60	2.14
Meeting 80% of Zinc Intake (%)	8.03	2.85	5.71	14.95
Calcium(g)	277.77	207.56	287.95	332.73
Meeting 80% of Calcium Intake (%)	23.79	15.23	18.09	27.10
Vitamin A(mcg RE)	241.03	233.41	268.03	221.59
Meeting 80% of Vitim A Intake (%)	18.64	13.33	22.85	18.69
Carbohydrate(g)	133.72	119.51	127.52	152.95
Fats(g)	15.10	13.08	13.13	18.90

Table 13. Percentage contribution of particular food groups to total energy and nutrient intakes of Cambodian women surveyed in this study.

Food Group (%)	Energy	Protein	Fats	Cars	Iron	Zinc	Calcium	Vit A
Cereals and products	60.93	30.91	14.84	77.14	43.08	17.35	22.08	7.83
Starchy roots and tubers	0.09	0.03	0.01	0.13	0.11	0.02	0.08	0.00
Legumes, nutsand seed	0.13	0.18	0.51	0.03	0.32	0.27	0.05	0.00
Vegetables	2.05	4.15	1.22	6.38	14.11	15.60	16.12	26.63
Fruits	1.45	0.82	0.43	1.76	3.06	2.54	1.45	29.96
Meat and poultry	3.57	11.04	17.01	0.04	7.17	33.37	3.85	0.26
Fish and OAAs	9.73	48.91	28.47	12.51	25.82	27.83	39.65	24.93
Eggs	0.64	1.43	7.20	0.03	1.65	1.14	4.29	3.31
Milk and products	0.14	0.11	4.77	0.13	0.08	0.16	3.71	0.15
Fats and oils	1.15	0.00	13.78	0.00	0.00	0.06	0.10	0.10
Sugars and syrup	0.18	0.08	0.31	0.16	0.03	0.00	0.42	0.10
Condiments and spices	0.33	1.09	0.55	0.12	4.29	1.03	6.88	2.87
Beverages	19.60	1.25	10.89	1.56	0.27	0.60	1.32	0.86

Table 14. Percentage contribution of particular food groups to total energy and nutrient intakes for Cambodian preschool children surveyed in this study.

Food Group (%)	Energy	Protein	Fats	Cars	Iron	Zinc	Calcium	Vit A
Cereals	57.47	34.57	21.50	73.46	44.46	4.44	12.10	2.07
Starchy roots and tubers	0.32	0.06	0.08	0.48	0.40	0.29	0.21	0.00
Legumes, nuts and seed	0.15	0.16	0.71	0.04	0.37	0.38	0.04	0.00
Vegetables	0.82	1.46	0.48	5.70	6.60	6.92	5.44	11.73
Fruits	3.79	1.34	1.25	4.82	7.25	5.91	2.05	38.06
Meat and poultry	2.60	7.63	9.32	0.10	5.32	19.47	0.41	0.71
Fish and OAAs	12.12	40.86	28.41	0.90	14.55	18.21	34.93	16.61
Eggs	2.08	3.84	9.55	0.15	5.58	3.62	2.29	12.12
Milk and products	7.77	7.42	11.99	7.38	11.53	39.71	36.32	16.67
Fats and oils	1.14	0.00	7.89	0.00	0.00	0.00	0.00	0.00
Sugars and syrup	2.19	0.64	3.18	2.12	0.24	0.00	1.82	0.00
Condiments and spices	0.28	0.84	0.40	0.13	3.11	1.01	2.94	1.20
Beverages	9.27	1.16	5.24	4.72	0.60	0.05	1.45	0.82

Table 15. Percentage contribution of fish to total animal energy and nutrient intakes for Cambodian women surveyed in this study.

Animal Food Source (%)	Energy	Protein	Fat	Cars	Iron	Zinc	Calcium	Vit A
Meat and poultry	25.60	17.99	32.29	0.34	20.70	53.53	8.06	0.90
Fish and OAAs	69.78	79.68	54.04	99.39	74.54	44.64	82.97	87.48
Eggs	4.62	2.33	13.67	0.27	4.76	1.83	8.97	11.62

Table 16. Percentage contribution of fish to total animal energy and nutrient intakes for Cambodian preschool children surveyed in this study.

Animal Food Source (%)	Energy	Protein	Fat	Cars	Iron	Zinc	Calcium	Vit A
Meat and poultry	15.49	14.59	19.72	11.46	20.89	47.14	1.08	2.42
Fish and OAAs	72.14	78.08	60.08	93.75	57.19	44.10	92.83	56.41
Eggs	12.37	7.33	20.20	4.49	21.92	8.77	6.09	41.17

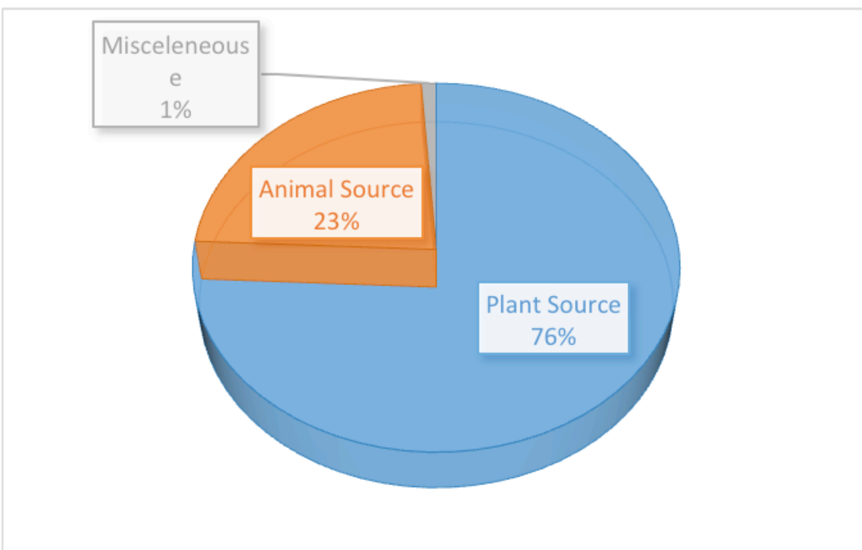

Figure 1. Percent contribution of food sources of mean daily per capita food consumption for Cambodian women surveyed in this study.

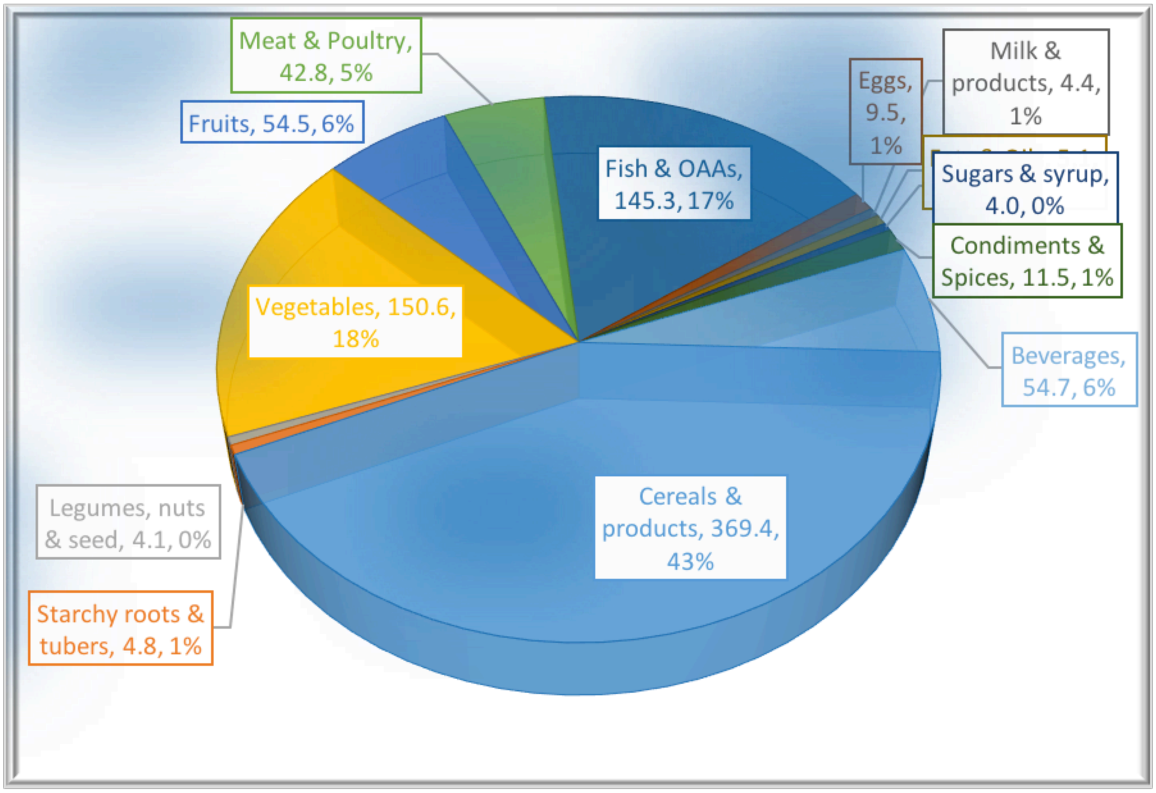

Figure 2. Percent distribution of mean daily per capita food consumption by particular food group for Cambodian women surveyed in this study.

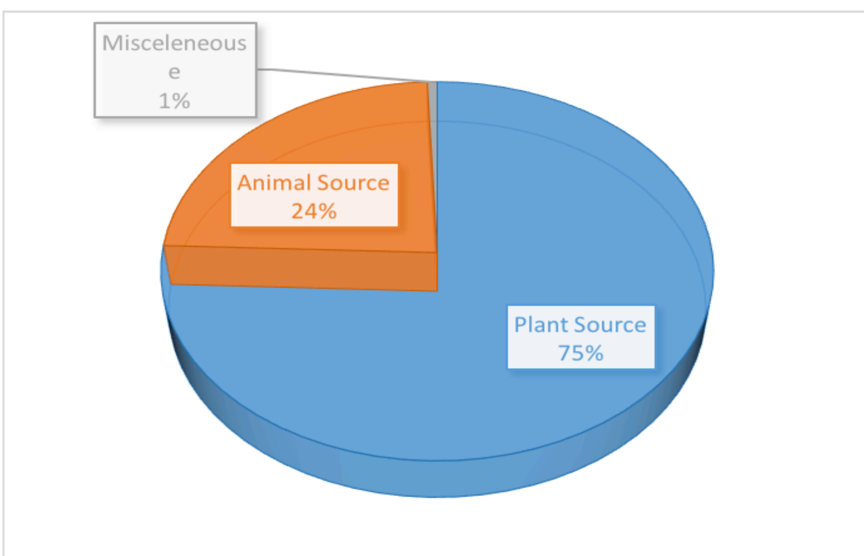

Figure 3. Percent contribution of food sources to mean daily per capita food consumption by Cambodian preschool children surveyed in this study.

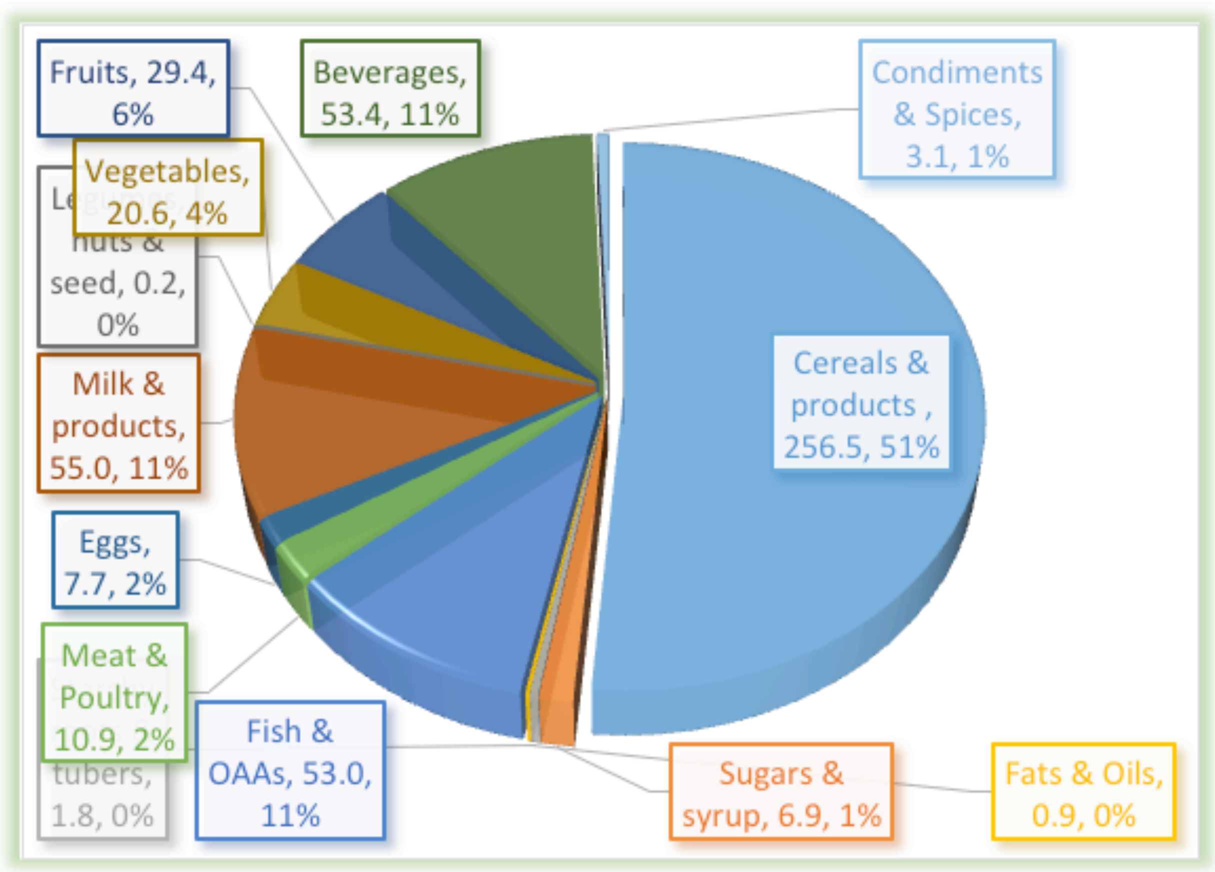

Figure 4. Percent distribution of the mean daily per capita food consumption by particular food group for Cambodian preschool children surveyed in this study.

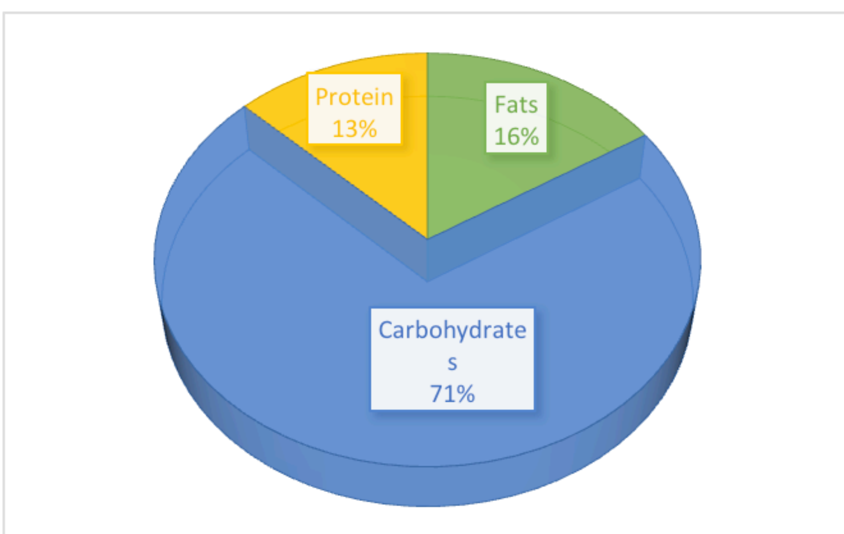

Figure 5. Percent contribution of carbohydrate, fats and protein to total dietary energy for Cambodian women surveyed in this study.

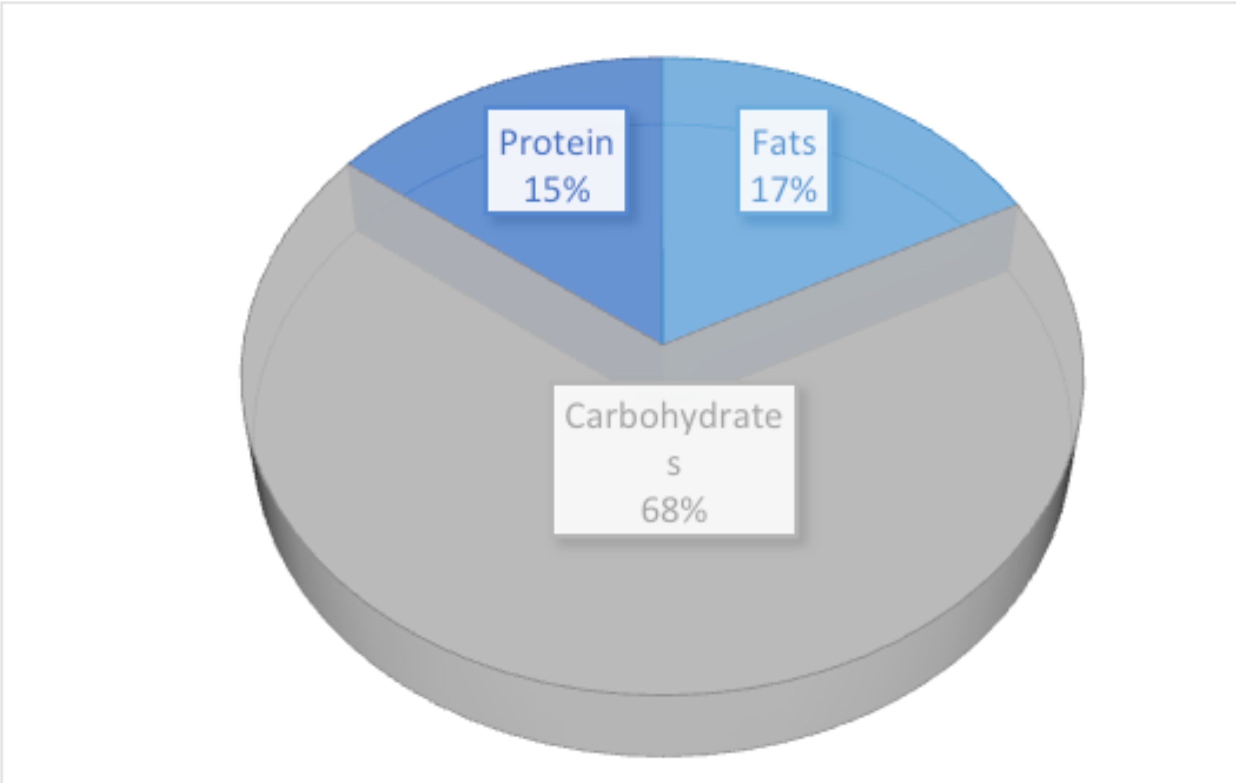

Figure 6. Percent contribution of carbohydrate, fats and protein to total dietary energy for Cambodian preschool children surveyed in this study.

Enhancing Food Security and Household Nutrition of Women and Children with a Focus on Nutrient Dense Commonly Consumed Fish from Capture Fisheries and Aquaculture in Cambodia, Part II

NUTRITIONAL COMPOSITION OF NUTRIENT DENSITY OF COMMONLYCONSUMED FISH, OTHER AQUATIC ANIMALS, AND PROCESSED FISH CONSUMED BY WOMEN AND CHILDREN IN CAMBODIA

Enhanced Trade and Investment for Global Fishery Markets/Study/13HHI02UC

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ABSTRACT

The results from our food and nutrient consumption survey found that women commonly consume 43 species of fish and Other Aquatic Animal (OAA) species and preschoolers commonly eat 38 species of fish and OAAs. Thirteen commonly consumed fish species; three OAAs species; and two processed fish species were selected for nutrient evaluation. The primary purpose of this activity was to determine the nutritional composition of the selected commonly consumed fish species; OAAs; and processed fish that are consumed by women and preschool children with a focus on the key micronutrients iron, calcium, and phosphorus and the key macronutrients protein and fat. Protein content varied from 10.11% to 16.81% in fresh fish and from 37.38% to 38.52% in processed fish. Fat content ranged from 0.99% to 4.25% in fresh fish and from 6.01% to 24.65% in processed fish. Calcium content ranged from 15.0 to 123.9 mg/100 g in fresh fish and from 19.1 to 83.3 mg/100 g in processed fish. Phosphorus content ranged from 0.57 to 3.89 mg/100g in fresh fish and from 1.15 to 2.06 in processed fish. Iron content ranged from 0.21 to 0.83 gm/100g in fresh fish and from 0.30 to 0.38 mg/100g in processed fish.

INTRODUCTION

The food and nutritional consumption survey in women and preschool children within Investigation 5 found that women commonly consume 43 species of fish and OAA and preschoolers commonly eat 38 species of fish and OAAs (first FIR for Investigation 5). Thirteen commonly consumed fish species, specifically Trey Riel (*Cirrhinus caudimaculatus*), Trey Ros (*Chitala chitala),*Trey Kanhchos (*Mystus spp.),* Trey Chhpin (*Barbonymus gonionotus),* Trey Changwamoul (*Rasbora tornieri),* Trey Slat (*Notopterus notopterus*), Trey Andaing Toun (*Clarias microcephalus*), Trey Andaing Roueng (*Clarias batrachus*), Trey Chhlounh (*Macrognathus siammensis*), Trey Po (*Pangasius larnaudii*), Trey Chhlang (*Hemibagrus nemurus*), Trey Changvasrei (*Esomus longimanus),* and Trey Kranh (*Anabas testudineus*); three OAAs, specifically fresh snail (*Pila ampullaceal*)*,* fresh rice field shrimp (*Macrobrachium lancasteri*)*,* and fresh rice field crab (*Potamon sp.*); and two processed fish species smoked Trey Riel (*Cirrhinus caudimaculatus*)*,* and sun-dried-salt Tre Ros (*Chitala chitalaI*) were selected for nutrient evaluation.

OBJECTIVE

The primary purpose of this activity was to determine the nutritional composition of the selected commonly consumed fish species, OAAs, and processed fish that are consumed by women and preschool children with a focus on key micronutrients (iron, calcium, and phosphorus) and macronutrient (protein and fat).

METHODS

Collection of samples. Samples of fish were purchased or collected from public markets in Kompong Chhnang, Kandal, and Takeo provinces and Phnom Penh city; and from Dai fisheries in Tonle Sap River in Cambodia. The samples of fish were randomly selected and physicochemical properties were analyzed in the Industrial Laboratory Centre of Cambodia (ILCC), Ministry of industry in Cambodia.

Proximate analyses. Fresh and processed samples were analyzed for proximate composition using standard methods (AOAC 1990). Proximate analysis is a quantitative method of determining the macronutrients in food. This includes moisture, total ash content, crude fat, and protein. Moisture was determined using a drying oven, ash in a muffle furnace, protein was by the Kjeldahl method and fat was by Soxhlet extraction.

Micronutrient analyses. Phosphorus, iron, and calcium were also analyzed by AOAC (1990) methods, specifically the molybdovannate method for phosphorus, the hydroxylammonium method for iron, and the muricide method for calcium.

RESULTS

Table 1 and 2 show the nutrient density value of 13 fresh water fish species, three OAAs (rice-field snail, rice-field shrimp, and rice-field crab); and two processed fish (smoked *Henicorhynchus sp*., and sun-dried-salt *Channa sp*.). The protein content in fresh and processed fish varied from 10.11% to 16.81% for fresh fish and 37.38% to 38.52% for processed fish (Table 1). Fat content ranged from 0.99% to 4.25% in fresh fish and 6.01% to 24.65% in processed fish (Table 1). Ash contents were crab (13.34 %), *Channa sp*. dried fish (22.78%), Trey Chhlounh (*Macrognathus siammensis*) (25.33%), and Trey Slat (*Notopterus notopterus)* (25.66%). Fresh fish had low ash content (2.17% to 4.26%) (Table 2). The moisture content of Trey Andeng Reung ranged from 63.42% to 84.48% in fresh fish and from 20.86% to 27.59% in processed fish (Table 2). The calcium content in fresh fish ranged from 15.0 to 123.9 mg/ 100 g (Table 1). The phosphorus content ranged from 0.57 to 3.89 mg/100g in fresh fish and 1.15 to 2.06 in processed fish (Table 1). Iron content ranged from 0.21 to 0.83 gm/100 g in fresh fish and 0.30 t0 0.38 mg/100g in processed fish (Table 1).

DISCUSSION

Fish are an excellent source of protein, a macronutrient that provides all the essential amino acids that humans need. Proteins are made up of amino acids that are the body's building blocks. These proteins tend to break down and need to be replaced on a daily basis by eating foods that are rich in protein. Protein can be found in both animal and plant foods, however, the concentration of protein is higher in animal foods. For example, 100 g of raw fish has 14-20 g of protein depending on the species compared with only 2.7 g in cooked rice or 8.7 g in cooked beans.

Fish and meat are also more efficient sources of protein. This means that humans are better able to absorb the protein contained in these animal foods compared with plant foods. For many households, fish is more accessible and affordable than meat. People can raise fish in small ponds and rice fields or catch wild fish even if they do not have money to buy fish.

Protein content varied from 10.11% to 16.81% for fresh fish and 37.38% to 38.52% for processed fish. It can be concluded that the protein content was not lost during processing. The slight increase in protein contents after drying may be due to product dehydration which concentrated proteins, thus increasing the nutritional value of fish. According to Ahmed et al. (2011), fresh fish had lower protein content (between 18.81 and 21.23 g/100g) compared to smoked-dried (69.10 and 75.72g).

Fat content ranged from 0.99% to 4.25% in fresh fish and 6.01% to 24.65% in processed fish. Fresh fish flesh appeared to be relatively low in fats and this is also due to the concentration of other components of fish after drying. According to Ahmed et al. (2011) fat content is slightly raised after sun-drying and smoke-drying.

Ash content was high in crab (13.34%), Treyros dried (*Channa* sp.) (22.78%), Trey Chhlounh (*Macrognathus siammensis*) (25.33%), and Trey Slat (*Notopterus notopterus)* (25.66%). Fresh fish was low in ash content (2.17% to 4.26%) (Table 2). Ahmed et al. (2011) found that ash content of smoked-dried fish were high, 8.13-9.86 g/100 g, while much lower values were obtained for fresh fish. Probably the high ash values of sun-dried or smoke-dried fish flesh were due to water loss during drying that concentrated other components of fish like its mineral contents.

The moisture content of Trey Andeng Reung ranged from 63.42% to 84.48% in fresh fish and from 20.86% to 27.59% in processed fish. The moisture content of the fresh fish is comparable to that in the study conducted by Ahmed et al. (2011); however, dried samples (around 79-80% moisture content) in this study contained considerably high values. Ahmed et al. (2011) reported that moisture content varied between 81.49 and 84.33 g/100 g for fresh fish; between 7.58 and 8.95 g/100 g for smoked-dried fish and between 11.5 and 14.06 g/100 g for sun-dried fish. This could be explained by the fact that during smoke-drying the flesh loses water in the initial phase. Contrary to sun-dried fish, which tends to absorb moisture from high ambient air humidity, the protective coating of smoked-dried fish minimizes rehydration.

The effect of traditional drying processes on the nutritional values of fish was studied by Eves and Brown (1993). They observed that different processing and drying methods have different effects on nutritional compositions of fish. This is because heating, freezing, and exposure to high concentrations of salt lead to chemical and physical changes and therefore digestibility is increased, due to protein denaturation, but the content of thermolabile compounds and polyunsaturated fatty acids is often reduced (George, 2012).

Fish bones are very rich in calcium which humans need to develop and maintain strong bones and teeth. The popular Cambodian meal of small fish species that are fried and eaten whole including the head and bones is an important dietary source of calcium. Teenage boys and girls need calcium because they are growing rapidly at this age. A serving of 100 g of small fish species such as *chanwa phlieng* or *chanwa mool* will provide 50% of their daily requirement. The same serving will provide 70% of the daily requirement for adult men and women.

The calcium content in fresh fish ranged from 15.0 to 123.9 mg/100g. Kotchanipha et al. (2012) similarly reported that fresh fish had a calcium content of 111.92 mg/100 g. On the other hand, processed fish contained between 19.1 and 83.1 mg/100g. Kotchanipha et al. (2012) reported that processed fish had 60 mg/100 g. According to the ASEAN Food Consumption Table (2000), calcium levels are 44 mg/100 g for fresh fish and 274 mg/100 g for processed fish. However, Dipak et al. (2013) reported that calcium content was 52.79 mg/100 g in fresh fish.

Small fish 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 (Roos, 2001). In Cambodia, the majority (80%) of households cook the commonly consumed fish, *Trey Changwa Plieng*, with the head intact. The contents of calcium and iron were considerably higher (58, and 25%, respectively) in raw, cleaned samples with the head than in samples in which the head was discarded during cleaning (Thorseng and Gondolf, 2005). The calcium in small fish has been shown to have the same high bioavailability as that from milk in both humans and rats (Hansen et al. 1998; Larsen et al. 2000).

The phosphorus content ranged from 0.57 to 3.89 mg/100g in fresh fish and 1.15 to 2.06 in processed fish. Kotchanipha et al. (2012) reported that fresh fish had a calcium content of 50.54 mg/100 g compared to processed fish at 23.48 mg/100 g. However, the ASEAN Consumption Table (2000) indicated phosphorus content of 0.15 % for fresh fish and 0.53 % for processed fish.

The iron content ranged from 0.21 to 0.83 gm/100 g in fresh fish and 0.30 to 0.38 mg/100g in processed fish. The ASEAN Food Consumption Table (2000) indicated that iron content was 0.12 mg/100g in fresh fish and 0.2 mg/100g in processed fish. 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 (Roos et al. 2007). 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 % for complex-bound nonheme iron and 10% for inorganic iron (Roos et al. 2007).

CONCLUSION

Fish have high protein, calcium, phosphorus, and iron content. Protein content varied from 10.11% to 16.81% in fresh fish and from 37.38% to 38.52% in processed fish. Calcium content ranged from 15.0 to 123.9 mg/100 g in fresh fish and from 19.1 to 83.3 mg/100 g in processed fish. Phosphorus content ranged from 0.57 to 3.89 mg/100g in fresh fish and from 1.15 to 2.06 in processed fish. Iron content ranged from 0.21 to 0.83 gm/100g in fresh fish and from 0.30 to 0.38 mg/100g in processed fish.

The study of food and nutritional survey on women and preschool-children founded that low intakes of iron, zinc, calcium, and vitamin A put Cambodian women and children at risk of micronutrient deficiencies. The recommendations for better nutrition in women and children in Cambodia are below:

- More research should be done to identify nutrient contents of commonly consumed fish species and processed fish products, especially micronutrients consumed by women and children. Since rice-field fisheries are the major source of micronutrients for the rural poor women and children in Cambodia, micronutrient-dense fish species should be incorporated in the cultural practices;
- A program using fish to combat micronutrient deficiencies in women and children in rural areas, focusing on iron, zinc, calcium, and vitamin A;
- Research into improved processing of fish and other aquatic animals caught in open water, lakes, and rice fields, including methods of handing and preservation;
- Research into species, parts of fish and other aquatic animals (such as eyes, head, skin, and meat) and processed fish products that are rich in micronutrients such as iron, zinc calcium, vitamin B complex and Vitamin A with the aim of incorporating these species into cultural practices;
- A nutritional education program at in partnership with partners such as the Cambodian Red Cross in consultation with the National Maternal and Child Health Center and the National Nutrition Program on commonly consumed nutrient-dense species for women (mothers) and young children with additional focus on hygiene and sanitation.

QUANTIFIED ANTICIPATED BENEFITS

This investigation has provided recommendations for better nutrition in women and children in Cambodia. Two Master's students were involved in this investigation (one female and one male). Four undergraduate students were also supported for their dissertations (two females and two males). Three IFReDI staff were involved (one female and two males). Two hundred and twelve participants (155 women) attended the series of consultation and dissemination meetings and workshops on results of the investigation, and formulating recommendations for better nutrition in women and children. Three hundred fact sheets and policy briefs were directly provided to the women sampled in the study. One thousand and two hundred (1200) fact sheets and policy briefs were delivered to IFReDI/FiA staff, scientists, researchers, government officers, NGOs, and women which are direct and indirect benefits from the projects.

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TABLES AND FIGURES

Table 1. Summary of macronutrient and micronutrient composition of fresh and processed fish species in this study.

Nutrients	Fresh		Processed	
Macronutrients	Min (%)	Max (%)	Min (%)	Max (%)
Protein	10.11	16.81	37.38	38.52
Fat	0.99	4.25	6.01	24.65
Micronutrients	Min (mg/100g)	Max (mg/100g)	Min (mg/100g)	Max (mg/100g)
Calcium	15	123.9	19.1	83.3
Phosphorous	0.57	3.98	1.15	2.06
Iron	0.26	0.83	0.3	0.38

Table 2. Nutritional composition of the selected commonly consumed fresh and processed fish species eaten by women and preschoolers in Cambodia.

Loca/Common Name	Scientific Name	Protein (%)	Fat (%)	Ash (%)	MC (%)	Ca (mg/100g)	P (%)	Fe (mg/100g)
Fish Species								
Trey Kanhchos	*Mystus* spp.	13.09	3.70	3.48	76.38	66.1	3.60	0.33
Trey Chhpin	*Barbonymus gonionotus*	16.05	3.46	3.69	67.43	46.9	0.57	0.34
Trey Changwamoul	*Rasbora tornieri*	16.40	1.74	3.48	68.29	62.1	3.89	0.35
Trey Riel	*Cirrhinus caudimaculatus*	13.22	4.25	3.16	70.95	58.2	1.05	0.21
Trey Ros	*Chitala chitala*	15.36	1.61	4.26	76.40	15.0	1.15	0.27
Trey Slat	*Notopterus notopterus*	13.64	1.00	25.66	74.34	102.4	3.97	0.26
Trey Andaing Toun	*Clarias macrocephalus*	14.81	1.00	2.45	73.62	45.3	3.01	0.26
Trey Andaing Roueng	*Clarias batrachus*	14.22	1.00	2.20	63.42	87.3	3.06	0.28
Trey Chhlounh	*Macrognathus siammensis*	14.07	1.00	25.33	74.67	91.1	3.85	0.30
Trey Po	*Pangasius larnaudii*	10.11	1.00	3.54	68.34	72.5	3.20	0.24
Trey Chhlang	*Hemibagrus nemurus*	15.30	0.99	2.17	73.82	123.9	3.48	0.30
Trey Changvasrei	*Esomus longimanus*	16.81	1.00	2.21	73.51	97.9	3.98	0.35
Trey Kranh	*Anabas testudineus*	15.99	1.00	3.37	69.51	82.3	3.70	0.27
Other Aquatic Animals								
Fresh Rice-Field Snail	*Pila ampullacea*	11.63	1.44	2.4	84.48	66.1	1.04	0.83
Fresh Rice-Field Shrimp	*Macrobrachium lanchsteri*	12.01	1.64	2.92	82.16	60.5	0.65	0.34
Fresh Rice-Field Crab	*Potamon sp.*	13.82	2.65	13.34	67.03	56.0	0.75	0.50
Processed Fish								
Smoked Trey Riel	*Cirrhinus caudimaculatus*	38.52	24.65	10.20	20.86	83.3	2.06	0.38
Sun-dried-salt Trey Ros	*Chitala chitala*	37.38	6.01	22.78	27.59	19.1	1.15	0.30

Assessing the Nutritional Impact of Aquaculture Policy in Fish Farming Districts in Tanzania and Ghana

Human Nutrition and Human Health Impacts of Aquaculture/Study/13HHI01PU

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ABSTRACTS

The study assessed the benefits that manifest themselves in nutritional outcomes from households engaged in fish farming in Ghana (Ashanti and Brong Ahafo regions) and Tanzania (Morogoro and Mbeya regions). Fish is an important source of protein and essential micronutrients for many African households and participation in fish farming could have both direct effect through fish consumption, and indirect pathway through an income effect for nutritional impact. The study used the World Food Program's (WFP) Food Consumption Score (FCS) measures to assess nutritional quality with a target on fish. The average FCS value for fish-farming households in Ghana was 72 while that of nonfish-farming households (control group) was 68. In Tanzania, it was 56 for fish-farming households and 58 for the control group respectively. The results suggest that in Ghana, fish-farming households have higher diet diversity and food security than the nonfish-farming households, while in Tanzania, the opposite is the case. A two-stage least squares (2SLS) approach used to analyze the data for Ghana showed that household income, mother's education and residing in an urban area positively affect FCS and consequently dietary diversity and nutritional quality. In Tanzania however, an ordinary least squares (OLS) analysis of the data showed household income, residing in an urban area and the index for wealth positively affect dietary diversity and nutritional quality. The mother's education appears to be a very strong predictor of the household FCS because of her being the main caregiver, and her influence on the household's nutrition can be substantial. Moreover, an educated person is assumed to know the right kinds of foods to buy in terms of nutritional quality as well as the dietary diversity to boost household health. The index for wealth is a good indicator of the household's socioeconomic status and is assumed to influence the purchase and consumption of high-quality and nutritionally balanced foods.

INTRODUCTION

The Millennium Development Goals (MDGs) adopted by the world's leaders at the Millennium Summit of the United Nations in 2000 sought to achieve peace and decent standards of living for every man, woman and child. The MDGs aim to eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability, and develop global partnerships for development. Tanzania and Ghana committed to the time-bound MDGs and the associated indicators.

Aquaculture is one of the world's fastest growing food production sectors with great potential for food supply and poverty alleviation and is responsible for at least 50% of the fish consumed by humans (Diana 2009). Fish farming has contributed toward poverty alleviation in poor societies in various parts of the world where it is traditionally practiced, e.g., Bangladesh (Jahan et al. 2010) and Nepal (Bhujel et al. 2008). Aquaculture expansion in Asian countries such as Bangladesh and Thailand has led to enhanced food security among adopters and the population at large (De Silva and Davy 2010, Jahan et al. 2010, Lazard et al. 2010). In Bangladesh, Thilsted et al. (2014) reported that even though fish is quite expensive, consumption in small quantities makes a significant difference in contributing to the nutritional quality of the diets of poor people. In Asia, fish was found to be the major source of protein for low income households even though they consumed less compared to rich households (Dey et al. 2005).

Helen Keller International (HKI) established a direct linkage between agriculture and nutrition particularly for farmers and agricultural laborers from homestead food production in Bangladesh, Cambodia, Nepal, and the Philippines (HKI/Asia-Pacific 2001). The HKI program promoted small-scale production and consumption of micronutrient-rich crops and small animals, which resulted in vulnerable members of low-income households producing and consuming more micronutrient-rich foods and earning increased incomes from the sale of high-value products. Thus, improving food and nutritional security requires adequate food supply, and access to food by households from own production, the market or other sources, and the appropriate utilization of those foods to meet the dietary needs of the households. Effective agricultural interventions on household nutrition involve diverse and complementary processes and strategies that focus on agricultural production for food as well as a focus on women empowerment, livelihoods and optimal use of intra-household resources (World Bank 2007).

In sub-Saharan Africa, aquaculture development aims to improve food security and human nutrition; increase domestic fish production; create employment; promote diversification and reduce risk; promote economic development; and improve efficiency in the use of resources, especially water (Béné and Heck 2005, Satia 2011). Households along Lake Chad that were plagued by chronic food shortages were reported to have sold part of their fish harvests from ponds to improve incomes compared to well-off farming households (Karim 2006). Bueno (2009) suggests that the fish farmer's goal is often to produce the family animal protein food supply and sell part of the harvest for additional family income. Aquaculture is considered an option for rural development because it provides an important opportunity to help solve problems of poverty, and protein malnutrition of the rural poor. Consequently, small scale aquaculture has been identified as an occupation for income generation, women empowerment and increase in food availability in developing countries (Stepan 2013).

As the Tanzania and Ghana governments continue to implement their fisheries and aquaculture strategic plan, it is important to highlight nutritional impacts to ensure that the nutritional outcomes of aquaculture development or, for that matter, any new agricultural policy are accounted for in the implementation or intervention plans. Accounting for changes in nutritional outcomes is particularly relevant in Tanzania and Ghana given the efforts of the various governments to improve nutritional security.

OBJECTIVES

The focus of this study is to look beyond the direct production measures from fish farming in rural communities and consider the additional benefits that manifest themselves in nutritional outcomes. Given that fish is an important source of protein and essential micronutrients for almost all African households, this study evaluated the impact of participating in fish farming on household nutrition. Some empirical questions that were addressed were: (1) How much better off is a fish-farming household compared to a nonfish-farming household in terms of dietary diversity and nutritional adequacy? (2) What are the impact pathways for aquaculture on household nutritional improvement? The objectives of the study were to:

- Assess improvements in household food security and nutrition in selected fish-farming communities using measures of household nutrient adequacy (food security) and dietary diversity;
- Measure the effect of aquaculture as an input and technology transfer program on household food security using nutritional indicators; and
- Suggest some policy recommendations regarding aquaculture and nutrition improvements.

METHODS

Measurement of the impact of technology adoption in the agriculture literature, especially in sub-Saharan Africa (SSA) has traditionally been done using monetary and farm production measures, particularly income and expenditure. These measures indirectly capture the impact of adopting the technology using household welfare measures as a proxy (Magrini and Vigani 2014). Some studies have made indirect conclusions about household food consumption using household poverty indexes combined with the income or expenditure consumption measures (see for example Kassie et al. 2011, Amare et al. 2012, Asfaw et al. 2012). In these studies, the impact of adopting an agricultural technology on poverty has been found to be significantly negative. Poverty was used as an indicator of the household's economic access to food. The problem with these measures is the assumptions made about the utilization of food (Hidrobo et al. 2012). In a recent paper published by the World Bank, it was identified that enhancing agricultural productivity does not necessarily improve the food security of a household (Herforth et al. 2012). The Food and Agriculture Organization of the United Nations (FAO) agreed to this assertion by concluding that the fact that a household participates in an agricultural intervention does not necessarily mean their nutrition will improve. To better assess nutritional impacts of policy interventions, a number of frameworks have been introduced to capture the nutritional influence on household health through direct and indirect impact ways. For aquaculture, the direct ways include the household consuming fish from their pond, and also selling the fish to buy other sources of protein. The indirect ways include employment creation, economic growth and environmental benefits. This study focused on the impact through direct consumption and the income effect.

The concept of measuring household nutritional quality and food security is elusive. Such measures are often believed to be based on the diversity in the household's diet. The World Food Program (WFP) and other development organizations have consequently developed and validated some indicators for assessing household food security. Some of the measures are Household Food Insecurity and Access Scale (HFIAS), The Household Hunger Scale (HHS), Food Consumption Score (FCS), and Household Dietary Diversity Scale (HDDS) (Maxwell et al. 2003).

The FCS appears to be the commonly used measure in the literature. For example, Arimond et al., (2010) in their study outlined dietary diversity from a number of foods consumed over a period of seven days and used FCS to capture the quality of the diet as well. The International Food Policy Research Institute (IFPRI) used FCS to assess food security and vulnerability in Malawi and reported that 11.5% of the population fell in the "poor" category, 36.7% in the "borderline" category and 51.8% in an "acceptable" consumption status (IFPRI 2011). The study concluded that growth in staple crops contributed more to calorie intake and poverty reduction than growth in export crops (IFPRI 2011). Saaka and Osman (2013) used FCS because of its accuracy in capturing food quality for the household as well as nutritional value and the frequency of consumption of particular food items. The FCS measure involves the collection of seven days' worth of information of food consumed by the household and are weighted differently according to the energy content of food item (Maxwell et al. 2013). This study adopted the FCS as the measure of household food security due to its ability to give a complete picture of the household's consumption of a specific food item as well as details on food consumption pattern.

Food consumption score (FCS). The FCS is used as a proxy for food security and is measured as a summation of the weighted frequencies of the various food groups consumed (Table 1):

$$FCS = \sum y_i f_i \qquad (1)$$

where y_i is the weight or the nutritional value of food group i, f_i is the frequency of food consumption of food group i. Frequency of food consumption is the number of days in a week the food group is consumed. The food groups in equation (1) are cereals and tubers, pulses, vegetables and fruits, meats and fish, sugar, milk, and condiments. We hypothesize that fish-farming households have higher diet diversity and food security than the nonfish-farming households. The assumption is that engaging in fish farming is expected to have a positive and direct impact on the household income. Households will then be able to purchase and consume more diverse food items particularly vegetables, meat, dairy and fresh fruits and a shift away from the cereals and tubers.

In identifying the food security status of a household, the WFP has proposed the following thresholds for the FCS (Table 2): Households with FCS of 0–21 are categorized as having "poor food consumption," those within 21.5–35, "borderline food consumption" and above 35 categorized as having "acceptable food consumption." For households that tend to eat oil and sugar on a daily basis, the threshold are 0 – 28 for "poor food consumption," 28.5–42 and > 42 respectively for "borderline food consumption" and "acceptable food consumption" levels (WFP 2008).

Data and study design. The data used for the study was collected through face-to-face interviews with households in the Ashanti and Brong Ahafo regions in Ghana and in the Morogoro and Mbeya regions in Tanzania. Fish-farming households were selected based on their participation in Aquafish Innovation Lab and AquaFish CRSP training workshops during the past five years. A total of 126 households in Ghana and 55 in Tanzania were interviewed using structured questionnaires. For each fish farming household recruited in Ghana, two nonfish-farming households were selected in the same communities while three non-farming households to one fish farming household was selected in Tanzania. The nonfish-farming households were selected to serve as comparative controls.

Dietary assessment. A three-day-repeated 24-hour dietary recall was collected for each household involving the woman and child. The 24-hour dietary recalls interviews were conducted by two trained personnel of postgraduate nutrition and dietetics students. Usually, one person asked the question and the other recorded. Interviews also were conducted in the local language spoken in the study area. The 24-hour dietary recall included two weekdays and a weekend. Portion sizes of foods consumed were determined using household or handy measures such as tea spoons, desert spoons, orange sizes, egg sizes, matches boxes, sardine tins, stew spoons and soup ladles. These quantities were later on translated to grams based on food composition tables and converted to nutrient intakes using the Nutrient Analysis Templates.

Food consumption frequency. A 42-item, structured food frequency questionnaire (FFQ) was used to collect data on habitual dietary intake for mothers and children in the past six months prior to the study. The essence of the FFQ was to establish if patterns of dietary intake and proportion of intake of specific food groups were different between fish farming and nonfish-farming households. The food items on the questionnaire were grouped into seven main food groups namely: cereals and grains, tubers and roots, meat and meat products, legumes and nuts (pulses), fruits, vegetables and fats and oils. For each food item seven options for frequency of consumption were provided for participants to indicate their habitual consumption of those foods. The options were daily, weekly, fortnightly, monthly, occasionally, once in six months and never.

Fish farming activities and other socioeconomic factors. Households also were asked questions pertaining to household socioeconomic characteristics, especially their income sources from both fish farming and nonfish farming activities. A wealth index was constructed using questions related to household assets. The household income and wealth index were used as indicators of the family's economic status. Information on the education, age, household size, and location also was collected.

RESULTS

Results for Ghana. The statistical summaries of the relevant variables selected for the analysis for Ghana are reported in Table 3. The FCS range from a minimum of 17 to a maximum of 112. A high FCS depicts high diversity in foods consumed by the household. The mean FCS for fish farmers was higher (72.6) than that for nonfish-farming households (68) (Table 3). Fish-farming households also had a higher average income (GHS 4832 = $1,264.92) than nonfish-farming households (GHS 263 = $68.59). The average age was 36 with 93% of respondents being female. Females were actually targeted since they are the traditional care givers. The average years of education for the mother was about eight years and an average of about six people per household. The details of other sample characteristics are found in Table 3.

The data was then analyzed in an econometric framework using the 2SLS analysis approach. In assessing the impact of participation in aquaculture on household dietary diversity, the main challenge is selectivity bias. This is because farmers' participation in aquaculture is self-selective, which poses a potential bias where the participation decision is likely to be correlated with the error term in a regression analysis. The endogenous nature of the participation decision can be addressed econometrically using instrumental variables (IV). The 2SLS approach with instrumental variables captures both the observable and unobservable factors influencing the decision to participate in fish farming and its outcome.

The following represents the conceptual regression equation of the household dietary diversity model:

$$y_1 = \alpha_1 y_2 + \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + u \quad (2)$$

where y_1 is the dependent variable FCS; x_1 to x_n are exogenous independent variables namely geographic area (urban=1), age, household income, wealth index, mother's education and household size; and y_2 represents fish farming participation variable, which is assumed to be correlated with the error term u. The inclusion of y_2 as a regressor requires the introduction of instrumental variable(s) z, which should be uncorrelated with the error term but is strongly correlated with y_2;

$$corr(z, u) = 0 \; but \; corr\,(z, y_2) \neq 0 \quad (3)$$

The endogeneity of the fish farming participation variable (y_2) was tested using a Durbin-Wu-Hausman, and the result indicated the presence of endogeneity. A correlation analysis showed that fish farming participation was strongly correlated with households that received technical support (0.87) and those who had participated in an AquaFish training (0.97). Therefore, these two variables were used as instruments.

The 2SLS regression results are presented in Table 5, which show that with the exception of household income, geographic area and mother's education that are significant, the rest are not statistically significant. The coefficient of residing in an urban area is positively significant at the 10% as we expected. The household income was also found to be positively significant at the 1%. The mother's education was positively significant at 5%.

Results for Tanzania. The mean FCS for fish farmers was lower (56.0) than that for nonfish-farming households (58.4) as reported in Table 4. This is contrary to what was expected: that participation in fish farming improves the nutritional status of the household. The average income for fish farming was higher (TZS 487,121 = $229.22) than nonfish-farming households (TZS 113,095 = $53.22) but lower compared to households in Ghana. The average age of respondents was 45 with approximately 41% of respondents being female. The average years of education for the mother was approximately two years and an average of six people per household. Other summary statistics are reported in Table 4.

The econometric analysis of the Tanzania data was done using OLS because there was no issue with endogeneity. The dependent variable was also FCS with fish farming, geographic area, age, household income, wealth index, household size, and mother's education as independent variables. The results presented in Table 6 show that with the exception of household income, geographic area and wealth index which are significant, the rest are not significant. This is similar to results obtained for Ghanaian households, which had the mother's education being significant instead of the wealth index.

Discussion

Reports from the literature suggest that aquaculture is more developed in Ghana than in Tanzania, which is also revealed in the higher average FCS in Ghana for fish-farming households than for Tanzania fish-farming households where nonfish-farming households seem to be more food secure. Nevertheless, the mean FCS of 72.6 for fish farmers and 68.0 for nonfish-farming households in Ghana and 56.0 for fish farmers and 58.4 for nonfish-farming households in Tanzania suggest that, on the average, households in Ghana and Tanzania have “acceptable food consumption” patterns based on WFPs thresholds scores reported in Table 2. The income range is higher in Ghana than in Tanzania as well as the average years of education of the mother. A potential problem with comparing the two studies is the difference in sample sizes with Ghana having a higher sample than Tanzania. These could contribute to differences in the results.

The results from the econometric analyses for both countries indicate that household income and residing in an urban area are the common socioeconomic factors that significantly impacted household food security and dietary diversity. The coefficient of 0.00 index points in the Ghana model implies that a 1% change in the household’s income will have a very negligible change to the household’s access to a variety of foods. A similar result is found for Tanzania households. The impact of income is consistent with results from Kabunga et al., (2011), who also reported that income earned by women especially, positively impacted household food security and welfare. The income variable was hypothesized to be positive.

These results also suggest that a household residing in an urban area in Ghana has the probability of increasing the family’s diet diversity and quality foods by 4.95 index points. The coefficient for Tanzania households is also positively significant at the 10% as expected implying that a Tanzania household that resides in an urban area has the probability of having a diverse diet and higher nutritional quality by 10.11 index points. The effect is quite high in Tanzania compared to households in Ghana. Kabunga et al, (2011) as well as Larochelle and Alwang (2014) reported similar results for Rwanda households.

In Ghana, the mother’s educational level is statistically significant, which implies that an additional year in school for the mother will increase the household’s food security by 0.80 index points. The mother’s education has been reported to be a very strong predictor of the household FCS because she is the caregiver, and her influence on the household’s nutrition is substantial (Larochelle and Alwang 2014; Karki and Bauer 2004). An educated person knows the right kinds of foods to buy in terms of nutritional quality as well as the dietary diversity to boost health.

In Tanzania, the index for wealth was positively significant at 1%. This is expected because it is a measure of wealth and assumed to influence the purchase and consumption of high quality and nutritionally balanced foods. Saaka and Osman (2013) and Zeng et al. (2014) concluded that the wealth index is a good indicator of the household’s socioeconomic status and could be used as a predictor of the household’s ability to comfortably access food.

Conclusions and Recommendations

The study evaluated the impact of participating in aquaculture on the nutritional status of households in two regions of Ghana (Ashanti and Brong Ahafo) and Tanzania (Morogoro and Mbeya) to assess both direct and indirect pathways for nutritional impact. The study used FCS, which is a relatively better measure of food security when targeting a particular food item, in this case fish. The average FCS value for fish-farming households in Ghana was 72 while that for the nonfish-farming household (control group) was 68. In Tanzania, it was 56 for fish-farming households and 58 for the control group respectively.

A 2SLS method was used to analyze the data for Ghana due to selection bias among the fish-farming group. The household income, mother's education and residing in an urban area were found to significantly affect FCS and consequently dietary diversity and nutritional quality. The impacts of being a fish farmer on household nutritional quality is likely to be higher and more pronounced than what the study results show. This is because of the different pathways of household income and direct consumption impact household food security.

Food security is diverse and complex (Cunningham 2005) and assessing the impact of aquaculture on it will require a combination of methodologies. Therefore, future studies should involve a much larger sample size as well as coverage area of study. The use of a combination of food security indicators as was done by Saaka and Osman (2013) in northern Ghana to measure the impact of adopting fish farming on household food security is recommended. Field observations indicated that most households consumed low value fish due to affordability. Therefore, the nutritional benefits of consuming fish should be part of the messages that accompany aquaculture development strategies in addition to economic development and employment creation.

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TABLES AND FIGURES

Table 1. WFP food groups and weights used in calculating FCS.

Food Items	**Food Groups**	**Weights**
Maize, maize porridge, rice, sorghum, millet, pasta, bread, other cereals; and cassava, potatoes and sweet potatoes	Cereals and tubers	2
Beans, peas, groundnuts, cashew nuts and other nuts	Pulses	3
Vegetables, leave and fruits	Vegetables and fruits	1
Red meat, poultry, eggs, fish	Meat and fish	4
Milk, yoghurt and other dairy products	Milk	4
Sugar and sugar products	Sugar	0.5
Oils, fat and butter	Oil	0.5
Condiments	Condiments	0

Source: WFP (2008)

Table 2. Typical thresholds for FCS for grouping households.

Profiles	**Threshold**	**Threshold with oil eaten and sugar eaten on daily basis (~7 days/week)**
Poor food consumption	0 - 21	0 - 28
Borderline food consumption	21.5 - 35	28.5 - 42
Acceptable food consumption	>35	>42

Source: WFP (2008)

Table 3. Summary statistics of variables for Ghana.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Combined Sample					
FCS	159	70.44	18.51	17.30	112.02
Status	162	0.34	0.48	0	1
Geographic area	162	0.43	0.50	0	1
Age	160	36.14	12.34	19	76
Sex	162	0.93	0.26	0	1
Wealth index	162	329.01	230.40	-111.18	841
Mother's education	162	7.85	4.26	0	16
Household size	162	5.64	3.36	1	25
Household income	155	1,736.74	6,282.37	20	71,000
Fish-farming households					
FCS	55	72.55	20.65	25	112.02
Status	55	1	0	1	1
No of ponds	52	3.51	3.04	0	16
Years of farming	54	6.39	5.11	1	28
Pond size	51	1,801.64	2,620.45	150	12,000
Age	55	46.57	13.82	22	76
Geographic area	52	0.44	0.50	0	1
Sex	55	0.80	0.40	0	1
Wealth index	55	409.92	251.05	-35.37	841
Mother's education	55	7.18	5.34	0	16
Household size	55	7.11	4.16	1	25
Household income	50	4,832.02	10,450.19	80	71,000
Nonfish-farming households					
FCS	106	68.02	19.55	0	109
Fish farming	107	0	0	0	0
Age	107	30.82	7.05	19	63
Geographic area	107	0.42	0.50	0	1
Sex	107	0.99	0.10	0	1
Wealth index	107	287.41	208.28	-111.18	812
Mother's education	107	8.18	3.55	0	14
Household size	107	4.89	2.59	1	21
Household income	105	262.79	436.57	20	2,500

Table 4. Summary statistics of variables for Tanzania.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Combined Sample					
FCS	54	56.96	16.41	1	84.5
Fish farm	54	0.61	0.49	0	1
Geographic area	54	0.81	0.39	0	1
Age	54	45.17	16.86	17	86
Sex	54	0.41	0.50	0	1
Wealth index	54	-1,770,529	489,781.3	-2,612,837	-485,181.7
Mother's education	54	1.89	1.46	1	5
Household size	54	5.87	2.48	1	12
Household income	54	341,666.8	758,932.8	25,000	382,5000
Fish-farming households					
FCS	33	56.01	13.04	31.01	84.5
Fish farming	33	1	0.00	1	1
No of ponds	32	1.78	1.21	1	6
Years of farming	33	7.54	8.48	0	40
Pond size	33	8.07	5.77	1	20
Age	33	47.85	17.84	17	86
Geographic area	33	0.82	0.39	0	1
Sex	33	0.42	0.50	0	1
Wealth index	33	-1,720,552	552,030.1	-2,328,885	-485,818.7
Mother's education	33	1.97	1.51	1	5
Household size	33	6.33	2.56	1	12
Household income	33	487,121.3	942,170.9	25,000	3,825,000
Nonfish-farming households					
FCS	21	58.44	20.92	1	84.5
Fish farming	21	0	0	0	0
Age	21	40.95	14.61	17	60
Geographic area	21	1.15	0.37	1	2
Sex	21	0.38	0.50	0	1
Wealth index	21	-1,849,065	370,837.1	-2,612,837	-927,195.6
Mother's education	21	1.76	1.41	1	5
Household size	21	5.14	2.20	1	10
Household income	21	113,095.3	124,403.4	25,000	425,000.5

Table 5. 2SLS regression results for Ghana.

Variable	Coefficient	Std. Error	z	P > ‖z‖	95% C .I.	
Fish farming	2.70	4.19	0.65	0.52	-5.58	10.98
Geog. area	4.95	3.12	1.57	**0.12***	-1.28	11.13
Age	0.03	0.14	0.21	0.83	-0.25	0.31
HH income	0.00	0.00	4.20	**0.00*****	0.00	0.00
Wealth index	-0.01	0.01	-0.81	0.42	-0.02	0.01
Mother's educ.	0.80	0.32	2.48	**0.01****	0.16	1.44
Household size	-0.26	0.59	-0.43	0.67	-1.44	0.93
Constant	61.68	5.91	10.43	0.00	49.99	73.37

* = 10% significance level, ** = 5% significance level, *** = 1% significance level.

Table 6. Ordinary least squares regression results for Tanzania.

Variable	**Coefficient**	**Std. Error**	**t**	**P > ‖t‖**	**95% C .I.**	
Fish farming	0.30	5.09	0.06	0.954	-9.94	10.53
Geog. area	10.12	5.90	0.71	**0.093***	-1.76	21.99
Age	-0.06	0.15	-0.04	0.966	-0.31	0.29
HH income	-0.00001	4.24e-06	-2.40	**0.020****	-0.00002	-1.66e-06
Wealth index	0.00002	6.49e-06	2.92	**0.005*****	5.91e-06	0.00003
Mother's educ.	1.33	1.72	0.78	0.440	-2.12	4.79
Household size	0.38	1.05	0.36	0.72	-1.73	2.49
Constant	80.30	14.73	5.45	0.000	50.66	109.93

* = 10% significance level, ** = 5% significance level, *** = 1% significance level.