TOPIC AREA

FOOD SAFETY, POST-HARVEST, AND VALUE-ADDED PRODUCT MANAGEMENT

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ENHANCING FOOD SECURITY AND HOUSEHOLD NUTRITION OF WOMEN AND CHILDREN THROUGH AQUACULTURE AND CAPTURE FISHERIES IN CAMBODIA AND VIETNAM IN THE DRY SEASON- PART I

Food Safety, Post Harvest, and Value-Added Product Management/Study/16FSV01UC

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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 during the dry season in Cambodia are lacking. This study aimed to identify commonly consumed fish species and Other Aquatic Animals (OAAs); evaluate food consumption, dietary energy, and nutrient intakes among women and preschool children during the dry season. Three hundred women and 327 preschoolers (aged 6 months to 5 years) were randomly selected for study in Cambodia. One hundred and fifty of the eligible women and 150 of the eligible preschool children were randomly selected for study in Vietnam. The 24hr-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 Cambodian women, and 35 fish species and OAAs were consumed by Cambodian preschoolers. Fish provides 75.4% and 72.5% of the total animal protein intake to Cambodia women and preschool children, respectively. Cambodian women consumed fish at 137.4 g/day and preschoolers at 49.1g/day. Cambodian women's total average daily per-capita food consumption was 835.6 g/day, while for preschoolers it was 454.2 g/day. Cambodian women's total average dietary energy intake was 1917.5 kcal/day, while for preschoolers it was 780.8 kcal/day. The overall mean one day per-capita food consumption rate of Vietnamese women and preschool children was 750 g/p/day (1411 Kcal) and 638 g/p/day (764 Kcal), in raw-as-purchased form, respectively. Rice was highly consumed by both Vietnamese women and preschool children at 230g/p/day and 153 g/p/day, respectively, accounting for 30.7% and 22.5% of daily food consumption, respectively. Vegetables and fish were the second top food group commonly consumed by women in the study, at 16.3% and 16.9%, respectively. Vietnamese women consumed 21 fish species, OAAs, and their products, with 127 g/day contributing nearly 16.9% of total diet intake. For the women's diet, fish and fish products are the major contributors of protein at 41.71%,

fats at 22.15 %, iron at 9.53%, calcium at 40.7%, and vitamin A at 25.39%; while for preschool children, milk and milk products play an important role in nutrient intake.
Keywords: 24hr-food recall, Food Consumption, Macronutrient intakes, Women, and Preschool Children, Cambodia and Vietnam

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.

During the previous phase of the AquaFish Innovation Lab (2013-2015), the study of food and nutritional consumption by women and children in Cambodia was conducted during the rainy season under the University of Connecticut Investigation 13HHI02UC. The recommendation provided from the final national workshop on 26 September 2015 at IFReDI in Phnom Penh is that the study of food and nutritional consumption should be conducted in the dry season in Cambodia in order to cover the whole year.

There are two major seasons in the Lower Mekong Basin region, and they bring about changes in people's food consumption patterns. During the wet season, there is an abundance of fish, while during dry season there is less fresh fish available and people use more processed fish products. This study will allow us to make comparisons of food consumption patterns between the seasons to better assess ways to improve nutrition for women and children. Moreover, information about consumption of fish and OAAs from capture fisheries and aquaculture by women and children in the Mekong Delta of Vietnam is limited.

OBJECTIVES

The primary purpose of this activity was to identify the commonly consumed fish species and 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 OAAs and its products to total nutrient intake of studied subjects in Cambodia and Vietnam.

MATERIALS AND METHODS

Study Design and Scope

Stung Treng province (Upstream Mekong River); Prey Veng province (Downstream Mekong River); and Kampong Thom province (Tonle Sap Area) in Cambodia and Long Xuyen city, Châu Phu town and Tan Chau town in Vietnam were selected for study sites. The data collection was conducted during the dry season (January to May 2017) in Cambodia and Vietnam. The target subjects of the study were women and preschool children (aged 6 months to 5 years). Three hundred (300) eligible women and 327 eligible preschool-age children in Cambodia, and 150 eligible women and 150 eligible preschool–age children in Vietnam, were selected by using simple randomized sampling. 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, who was then weighed. All food item consumption by 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 fat); 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 eight trained field enumerators - four enumerators from Cambodia and four from Vietnam. The training aimed to educate field enumerators on how to conduct dietary assessments 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 performed. Pilot testing of questionnaires was conducted in order to identify potential problems in the questionnaires, the questions, and the recall form.

A letter of survey objectives was presented to the local authorities informing them of the survey before the actual field work was started. Questionnaires were cross-checked by 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 then conducted. Descriptive statistics were used.

RESULTS

Food Consumption in Cambodia: 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, and household food distribution. These factors influence the food consumption patterns of individuals, especially for women and children. The majority of foods that made up the sample women's diet came from a plant source (77%), while 23% came from an animal source (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 835.6g/d, in as-purchased raw form. The most highly consumed food was cereal and cereal products at 359.4 g/d (42.9% of the total food intake). Vegetables were the second largest food group commonly consumed by sample women at 148.9 g/d (17.8 % of the total food intake). Intake of fish, and OAAs and their products were the third largest food group commonly consumed at 137.4 g/d (16.4% of the total food intake). Consumption of fruits and beverages was 54.5 g/d (6.5%). The rest of the major food groups consumed in small amounts were fats and oils, eggs, sugar and syrups, legumes, nuts, and seeds, and starch roots and tubers.

Among the studied provinces, the Prey Veng province, located in the Lower Mekong region of Cambodia, showed the highest food intake at 843.9g/d, lower consumption compared to the rainy season which was 884 g/d, followed by Kampong Thom Province, Tonle Sap area, at 830.8g/d, compared to the rainy season consumption which was 855 g/d, while Stung Treng province, located in the Upper Mekong region of Cambodia, was the lowest at 823.2 g/d, compared to the rainy season consumption which was 843 g/d (Table 7).

Intake of cereals and cereal products, predominantly rice, was high in Prey Veng province, at 365.9g/d, followed by Kampong Thom province at 355.2g/d. Stung Treng province consumed 356.1 g/d. Kampong Thom province consumed vegetables at around 150.5 g/d, followed by Prey Veng province at around 149g/d and Stung Treng was around 147.3g/d. Fish, and OAAs and their products were generally eaten more than meat, poultry, or eggs in all sample provinces. Higher consumption

of fish was observed in Kampong Thom province at around 140.5g/d, followed by Stung Treng province at around 139.1g/d, and Prey Veng province at 132.7g/d. The other different food groups, fats and oils, eggs, sugar and syrups, legumes, nuts, and seeds, and starch roots and tubers were also consumed by sample women across the studied provinces.

By Pre-School Children

Diets of sampled pre-school children came from plant sources (76%) and animal sources (24%) (Figure 3). The mean one-day total food intake of children aged 6 months to 5 years was 454.2g, in as-purchased form (Table 2, Figure 4), consisting of 229.5 g (50.5%) of cereal and cereal products, of which rice and rice products were the predominant forms; 45.2g (9.9%) of milk and milk products; 49.1g (10.8%) of fish and OAAs; and a combination of vegetables and fruits at 48.1g (10.6%).

Energy-giving foods such as rice, and body-building foods such as milk, fish, meat, poultry, and eggs, are food items that are needed most importantly in the diet of preschool children to support their 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 10.8%, while intake of meat and meat products was 2.2 %, and intake of poultry and eggs was 1.7 %. Milk and milk products were at 9.9% of the total food intake. Fruits and vegetables amounted to 19.5 and 28.6 g, respectively, which accounted for 4.3% and 6.3% of total food intake, respectively. The intake of fats and oils, at 0.9 g or 0.2% 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 plant tissues.

Table 2 shows the mean one-day food intake of children aged 6 months to 5 years by province. Prey Veng province was the highest at 461g/d, lower consumption compared to the rainy season intake of 547g/d. Stung Treng province was at 456g/d, compared to the rainy season consumption which was 467g/d. The lowest food intake was observed in Kampong Thom province at 444.6g/d, compared to the rainy season consumption, which was 458g/d.

Intake of cereals and cereal products, predominantly rice, in the dry season was high in Stung Treng province at 245.5g, followed by the mountainous Prey Veng province around 227.5g per day, while the lowest intake was observed in Kampong Thom province at around 215.6g/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 province at 48.9 g (10.6%), followed by Kampong Thom province at 47.5 g (10.7%) and Stung Treng province, which had the lowest consumption at 39.1 g (8.6%). Food groups such as fruits, vegetables, eggs, sugar and syrup, starchy roots and tubers, legumes, nuts and seeds, and beverages were also consumed by this age group.

During the dry season, women consume 40 fish and OAA species with an average consumption of 137.4g/d, compared to the rainy season, which was 145.3g/d. The most consumed fish species in terms of weight and percent contribution by women consuming fish were Trey Riel (*Cirrhinus sp.*) at 30g (21.7%) of total fish intake per day; Trey Ros (*Channa striata)* at 18.2g/d (13.2%); and Trey Chrakeng (*Puntioplites proctozystron*) at 14 g/d (10.1%), (Table 3).

During the dry season, preschoolers consumed 35 fish and OAA species, with an average consumption of 49.1g/d, compared to the rainy season at 53g/d. The most consumed fish species in terms of weight and percent contribution by children were Trey Riel (*Cirrhinus sp.*) at 11.9g/d (24.1%); Trey Ros (*Channa striata*), 9.2g/d (18.6%) and Trey Changwa Phlieng (*Esomus longimanus*), 4.5 g/d (9.1%), (Table 4).

Nutrient intake in Cambodia: By women

All major food groups contribute to the caloric intake of individuals, especially women and children; therefore, caloric and protein intake measured against the recommended daily allowance is a good indicator of food adequacy. An intake of 1g of carbohydrate-rich foods such as cereal and its products, starchy tubers and roots, sugar and syrups, or fruits and vegetables will generate 4 Kcal. An intake of 1g of protein-rich foods such as fish, meat, milk, poultry, eggs, dried beans, and nuts, seeds, and their products will also generate 4 Kcal. An intake of 1g of fats and oils, including butter or margarine, will give 9 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 had a total energy of 1917.5Kcal, compared with women's diet during the rainy season was 1976 Kcal, the largest amount of which came from carbohydrates at 69%, with desirable contribution from proteins at 14%, and low contribution from fats and oils at 17% (Figure 5).

The total energy and nutrient intake among the three provinces ranked from 1780.7 Kcal (Kampong Thom) to 1987.6 Kcal (Prey Veng), (Table 5). The sampled women's daily protein intake ranged from 60.8 to 65.8 g, carbohydrate intake from 338.5 to 354.6g, while lipid intake ranged from 28.4 to 42g. Iron intake ranged from 11.4 to 12.6 mg, zinc from 3 to 3.9 mg, calcium intake from 467.1 to 591.2 g, and vitamin A from 386.5 to 518.9mcg RE.

In terms of energy and nutrient adequacy, half of the sampled women met at least 100% of their recommended intake for energy. About 70% of the sampled 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 one-third 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 intake for vitamin A (Table 5).

By preschoolers

The total energy intake of sampled pre-school children among the three provinces ranked from a low of 757.7 Kcal (Stung Treng) to a high of 805.2 Kcal (Kampong Thom), (Table 6). The sampled preschool children's daily protein intake ranged from 26.1 to 27.8 g, carbohydrate intake from 116.2 to 129.2g, and lipid intake from 12.7 to 16g.

Iron intake ranged from 4.6 to 4.8mg, zinc intake from 1.2 to 1.8mg, calcium intake from 202.7 to 281g, and vitamin A intake from 187.2 to 227.9mcg RE. Among the preschool children, only 27% met the recommended dietary intake for energy, less 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 than one-tenth of the preschool children met at least 80% of recommended intake for zinc, about 17% 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 indicates that cereal and cereal products are the top energy contributors in the diet of sampled women, contributing 59.2% (Table 7). Because of the large bulk of this food group, it is also the major contributor of carbohydrates at 77.5%. It is also the second contributor of protein at 30%, fats at 14.4%, iron at 43.1%, calcium at 21.4%, and vitamin A at 7.6%. Fish and fish products are the major contributors of protein at 47.5%, fats at 27.6%, and iron at 25.8%. Meat and meat products follow fish and fish products in their contribution to the total nutrient intake. Vegetables and fruits, on the other hand, are the second largest contributor of carbohydrates at 7.9%, and are the major contributors of iron, zinc,

calcium and vitamin A. Fruits were the top contributor to total vitamin A intake, while beverages were the second largest contributor to total energy intake by the sampled women.

The contribution of different food groups to total energy and nutrients intake indicates that cereal and cereal products are the largest contributors in the sampled pre-school children's diet to energy, carbohydrates, and iron at 53.4%, 73.5%, and 44.5%, respectively (Table 8). It is also the second contributor to protein and fats at 34.6% 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 39.9% and 28.4%, 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 seeds, sugars and syrups, beverages, and condiments and spices were lesser contributors to energy and nutrient intake by pre-school children.

Role of fish in nutrition security in women and preschool children in Cambodia

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 children's diets, and perhaps may mitigate 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-calorie 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, which can be attributed to the availability of protein from fish. It can be noted that the contribution of protein for Cambodian women and pre-school children at 14% and 13%, respectively, to total dietary energy per capita meets the level of recommended protein at 10-15% (Figures 5 and 6).

Fish and OAAs and their products were the major contributors of energy and nutrients of animal origin for women, providing 75.4% of the total animal protein intake (Table 9). Meat, poultry, and eggs contributed less than one-fourth to the total animal protein intake, accounting for about 17% and 2.2%, respectively. Fish and OAAs and their products were also the major contributors of energy, fats, carbohydrates, iron, zinc, calcium, and vitamin A at 66%, 51.1%, 94%, 70.5%, 42.2%, 78.5% and 82.7%, respectively.

Fish and OAAs and their products were also the largest contributors to the total daily energy and nutrient intake from animal sources for preschool children, around 72.5% of the total animal protein intake (Table 10). Meat, poultry, and eggs contributed to the total animal protein intake at about 13.6% and 11.5%, respectively. Fish and OAAs and their products were also the major contributor to energy, fats, carbohydrates, iron, zinc, calcium, and vitamin A at 67%, 55.8%, 87.1%, 53.1%, 41%, 86.2.8% and 52.4%, respectively.

Food Consumption in Vietnam: By Women

Food consumption in different areas of Vietnam may be influenced by topography, religious customs, cultural relationships, trades and price (food affordability), agricultural products (local food availability); family size, and household food distribution. These and others are among the indicators that influence the food consumption patterns of individuals, especially women and children. The majority of foods that made up the sampled women's diet came from plants at 72.3%, while 24% came from animal sources, and 3.7% came from food groups such as condiments and spices (Figure 7). Figure 8 and Table 11 show that total sampled women's diet is basically a rice-vegetable-fish combination. In terms of weight, the total mean one day per-capita food consumption is 750 g/day, in raw-as-purchased form. The highlest consumed food was rice at 230g (30.7% of the total food intake), contributing to around one-third of the total food intake.

Vegetables and fish were the second top food group commonly consumed by sampled women, at around 122 and 127g, respectively (16.3 and 16.9% of the total food intake) per-capita per-day. There was also a high consumption of fruits at 52.2g (7%). The rest of the major food groups consumed in small amounts by the sampled women were fats and oils, beverages, eggs, sugar and syrups, and starch roots and tubers.

By Pre-School Children

The diet of sampled pre-school children came from animal sources accounting for 59.2%, plant sources contributing 38.9%, and 1.9% from condiments and spices (Figure 9). The mean one-day total food intake of children aged 6 months to 5 years was 683g, in as-purchased form, and consisted largely of 259.9 g (38%) of milk and milk products, the second largest intake was of 153 g (22.5%) of rice (mean food), and the third largest intake included cereals, meat and poultry, and fish and OAAs, at 9.6%; 9.1%, and 8.1%, respectively (Figure 10, Table 12).

Energy giving foods such as rice, and body building foods such as milk, fish, meat, poultry, and eggs, are food items that are needed most importantly in preschool children's diet to support the fast rate of growth and development. This age group's intake of milk and milk products was at 38% of the total food intake. Fruits and vegetables amounted to 22 and 20.6g, respectively, which accounted for about 3-3.2% of total food intake. The intake of fats and oils, at 0.7 g or 0.1% 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 plant tissues.

The study found that women consume 21 fish and OAA species, with an average consumption by women of 135.7g per-capita per-day. The 10 most consumed fish species in terms of weight and percentage contribution of sampled women consuming fish species per day is shown in Table 13. Snakehead (*C. striata*) was the highest species consumed at 39.1 g (28.8%) of total fish intake per day. Red tilapia (*Oreochromis sp.*) and Striped catfish (*P. hypophthalmus*) ranked second and third, at 26.2g (19.3%) and 17.6g (13%) of the total fish intake per day, respectively. Other fish species, aquaculture fish, and OAAs were also listed (Table 13).

Preschool children consumed 19 fish and OAAs species, with an average consumption is 67.1 g per-capita per-day. The 10 most consumed fish species in terms of weight and percentage contribution by children consuming fish species per day. Snakehead (*C. striata*) was also the largest consumption at 28.5 g (42.5%) of total fish intake per day. Red tilapia (*Oreochromis* sp.), swam eel *(M. albus*) and striped catfish (*P. hypophthalmus*) ranked 2nd, 3rd and 4th with 10.2g (15.2%), 8.00g (11.9%) and 7.4g (11%) to the total fish intake per day, respectively. Other fish species, aquaculture fish, and Other Aquatic Animals were also listed (Table 13).

Nutrient Intakes: The contribution of particular food groups to total energy and nutrients intake as shows in table 15, rice is top energy contributor in the sample women diet contributing at 56.17%. Because of the large bulk that this food group was eaten, it is also the major contributor of carbohydrates more than 70%. It is also the second contributor of protein at 24.62%, fats at 10.67%, iron at 39.71%, calcium 18.35% and Vitamin A 7.22%. Fish and fish products are the major contributors of protein at 41.71%, fats at 22.15 %, Iron at 9.53%, calcium at 40.7% and vitamin A at 25.39%. Meat and meat products follows fish and fish products in their contribution to the total nutrient intake. Fruits, vegetables and fish were the top contractor to total Vitamin A intake by the sample women. The contribution of different food groups to total energy and nutrients intake as shows in table 16. Milk and milk products are the largest contributors in the sample pre-school children's diet to protein, fat, calcium, zinc and Vitamin A. It is also the second contributor to energy and zinc at about 27% and 21.8%, respectively.

Rice is top contributor to carbohydrate and energy with 84.5% and 28.8%, respectively. Eggs, on the other hand, is the major contributor to vitamin A, while the other food groups such as starchy roots and tubers; sugars and syrup; beverages; condiments and spices were less contributors to energy and nutrient intake by pre-school children.

Table 17 shows that fish, OAAs and products was the major contributor of energy and nutrients to animal source, providing around two-third (61.8%) to the total animal protein intake. Meat and poultry, and eggs contributed around one-third to the total animal protein intake accounting about 28.6 % and 9.55 %, respectively. Fish, OAAs and products was also the major contributor to energy, carbohydrate, fats, iron, zinc, calcium, and vitamin A contributed at 44.2%, 98.1%, 34.6%, 34.5%, 47.2, 76.1%, and 76.8%, respectively.

For the preschool-age children, OAAs and products was the second largest contributor to the total daily energy and nutrient intake from animal food source which sharing around 44.68% to the total animal protein intake (Table 18). Meat, and poultry contributed the largest part to the total animal protein and energy intake which accounting for about 47.5 and 52.3%, respectively. Fish, OAAs and products was also the major contributor to carbohydrate, calcium, and vitamin A contributed at 44.2%, 78.3% and 20.57%. Eggs contributed largest portion in Vitamin A

DISCUSSION

Cambodia

Cambodian women's and preschool children's diets are basically a rice-vegetable-fish combination and have similar proportions: 77% from plant sources, and 23% from animal sources. 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 in dry season and rainy season 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 in dry season of women and preschool children are 853.6g and 454.2g compared to rainy consumption were at 861 g and 499 g in raw as-purchased form, respectively. By comparison, Filipino adult women from 13-19 years old consumed 709g 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 137.4g/d and 49.1g/d compared to rainy season consumed 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 1917.5 Kcal was lower than in rainy season at 1976 Kcal, the largest amount of energy (up to 69%) coming from carbohydrates, with a good contribution from proteins at 14%, but low contribution from fats and oils at 17%. Cambodian preschool children's diet has a total energy of 780.8 Kcal was lower than in rainy season 844.9 Kcal, of which carbohydrate generates the largest amount (70%), protein 13% 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.

Fish, OAAs and their products were the major contributors of energy and nutrients of animal origin to women, providing 75.4% of the total animal protein intake, respectively; and also the major contributors of energy, fats, carbohydrate, iron, zinc, calcium, and vitamin A at 66%, 51.1%, 94%, 70.5%, 42.2%, 78.5% and 82.7%, respectively (Table 9). 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 72.5% of the total animal protein intake and also the major contributor to energy, fats, carbohydrate, iron, zinc, calcium, and vitamin A at 67%, 55.8%, 87.1%, 53.1%, 41%, 86.2.8% and 52.4%, respectively (table 10). 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, 14% for women and 13% 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 rather 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 reduces 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 sampled women met at least 100 % of their recommended intake for energy. About 70% 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. 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, 27% met the recommended dietary intake for energy; less 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 17% met the recommended intake for calcium and more than 18% met the recommended intake for 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.

CONCLUSIONS

Cambodia

The study in both season in dry and rainy season concluded that Cambodia's natural resources provides 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 in both raining and dry season, but is a lower contributor in the dry season compared with rainy season. Nutritional status of the rural poor women and children was low in both season but in dry season even low compared to rainy season. The low intake of micronutrients in comparison to the recommended daily intake in dry season 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.

Vietnam

The diets of sampled women were basically rice-vegetable-fish combination, in which 72% comes from plant source, 24% comes from animal source, and 3.7% comes from food group such as condiments and spices whereas it was different to preschool children diet. Diet of sampled pre-school children sharing from animal source accounted for 59.2%, plant source contributed 38.9%, and 1.9% came from condiments and spices. The overall mean one day per capita food consumption of women and preschool children was 750 g/p/day (1411 Kcal) and 638 g/p/day (764 Kcal), in raw as purchased form, respectively. Rice was highly consumed in both women and preschool children at 230g/p/day and 153 g/p/day, accounting for 30.7% and 22.5%, respectively. Milk and milk products were the top intake of children, 259.9 g (38%). Vegetables and fish were the second top food group commonly consumed by sample women at around 16.3 and 16.9%, respectively, of the total food intake per capita per day. Twenty-one (21) and 19 of fish species including OAAs (crab, shrimp, etc.) and its products consumed by sample women and preschool children, respectively, in which snakehead (*C. striata*) and red tilapia (*Oreochromis* sp.) were the 1st and 2nd commonly consumed. Fish and OAAs was the second largest food group consumed by women, estimated at 127 g/p/day, sharing nearly at

16.9% to total diet intake. In diet of women, fish and fish products are major contributors of protein at 41.71%, fats at 22.15 %, Iron at 9.53%, calcium at 40.7% and vitamin A at 25.39%, while for preschool children, milk and milk products played an important role for nutrient intake.

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 (two females). Three undergraduate students were also supported for their dissertations (3 females). Six IFReDI staff and Cantho University were involved in the survey, such as the project preparation, data collection and training activities. Four hundred and fifty women and 450 children benefited from the project by improving nutritional status through the proposed nutritional recommendations for adaption options and strategies in Cambodia and Vietnam. One thousand IFReDI/FiA and Cantho University staff, scientists, researchers, government officers and managers, and NGOs understand the nutrition contexts especially in women and children in Cambodia and Vietnam through in series of consultation meeting/workshop and sharing research result findings such as policy brief and technical report. 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. 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
Energy-Giving Foods								
Cereals & products	359.0	42.9	356.1	43.2	355.2	42.3	365.9	43.4
Sugars & syrup	5.0	0.6	2.8	0.3	5.9	0.7	6.3	0.7
Starchy roots & tubers	4.0	0.5	4.6	0.6	3.8	0.4	3.7	0.4
Fats and Oils	4.8	0.6	3.1	0.4	4.7	0.6	6.5	0.8
Body-Building Foods								
Fish & OAAs	137.4	16.4	139.1	16.9	140.5	16.7	132.7	15.7
Meat & poultry	40.7	4.9	49.0	5.9	27.0	3.2	46.0	5.5
Eggs	8.8	1.1	4.5	0.5	8.4	1.0	13.5	1.6
Milk & products	4.4	0.5	2.0	0.2	6.1	0.7	5.0	0.6
Legumes, nuts & seed	4.2	0.5	3.6	0.4	5.0	0.6	3.8	0.5
Regulating Foods								
Vegetables	148.9	17.8	147.3	17.9	150.5	17.9	149.0	17.7
Fruits	54.5	6.5	51.5	6.2	70.3	8.4	41.8	5.0
Miscellaneous								
Beverages	53.0	6.3	49.7	6.0	50.6	6.0	58.7	7.0
Condiments & Spices	10.9	1.3	9.9	1.2	11.8	1.4	11.0	1.3
All Foods	835.6	100.0	823.2	100.0	839.8	100.0	843.9	100.0

Table 2. 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 & products	229.5	50.5	245.5	53.8	215.6	48.5	227.5	49.2
Sugars & syrup	5.9	1.3	4.2	0.9	6.4	1.4	7.1	1.5
Starchy roots & tubers	1.8	0.4	0.1	0.0	0.0	0.0	5.3	1.2
Fats and Oils	0.9	0.2	0.9	0.2	0.6	0.1	1.1	0.2
Body-Building Foods								
Fish & OAAs	49.1	10.8	49.3	10.8	47.2	10.6	50.7	11.0
Meat & poultry	9.9	2.2	10.6	2.3	7.1	1.6	12.1	2.6
Eggs	7.5	1.7	7.2	1.6	6.3	1.4	9.1	2.0
Milk & products	45.2	9.9	39.1	8.6	47.5	10.7	48.9	10.6
Legumes, nuts & seed	0.2	0.0	0.1	0.0	0.5	0.1	0.1	0.0
Regulating Foods								
Vegetables	19.5	4.3	16.5	3.6	20.4	4.6	21.6	4.7
Fruits	28.6	6.3	28.5	6.2	26.3	5.9	30.9	6.7
Miscellaneous								
Beverages	53.4	11.7	51.6	11.3	63.6	14.3	44.9	9.7
Condiments & Spices	2.8	0.6	2.6	0.6	3.1	0.7	2.6	0.6
All Foods	454.2	100.0	456.1	100.0	444.6	100.0	461.9	100.0

Table 3. Ten commonly consumed fish species and percent distribution of the women's mean daily per capita fish consumption

No.	Khmer Name	Scientific Name	Mean	%
1	Trye Riel	*Cirrhinus sp.*	30	21.7
2	Trye Ros	*Channa striata*	18.2	13.2
3	Trey Chrakeng	*Puntioplites proctozystron*	14	10.1
4	Trey Changwa phlieng	*Esomus longimanus*	11.6	8.4
5	Trey Slek Reussey	*Parachela siamensis*	9.2	6.7
6	Trey Kamphlienh Sre	*Trichopodus trichopterus*	8.5	6.2
7	Trey Chhviet	*Pangasius macronema*	6.5	4.7
8	Trey Srakar kdam	*Cyclocheilichthys apogon*	5.2	3.8
9	Trey Kranh	*Anabas tastudineus*	4.3	3.1
10	Trey Ta orn	*Ompok hypophthalmus*	4.2	3.0
11	Other species		25.7	19.2

Table 4. Ten commonly consumed fish and percent distribution of the preschool-age children's mean daily per capita fish consumption

No.	Khmer Name		Scientific Name	Mean (g)	%
1	Trey Riel	ត្រីរៀល	*Cirrhinus sp.*	11.9	24.1
2	Trey Ros	ត្រីរស់	*Channa striata*	9.2	18.6
3	Trey Changwa phlieng	ត្រីចង្វាឆ្លៀង	*Esomus longimanus*	4.5	9.1
4	Trey Ta orn	ាអោន	*Ompok hypophthalmus*	3.9	7.9
5	Trey Chhlang	ត្រីឆ្លាំង	*Hemibagrus sp.(cf.nemarus)*	2.7	5.5
6	Trey Andeng	ែងឺង	*Clarias batrachus*	2.4	4.9
7	Trey Slek Reussey	ត្រីស្លឹកឫស្សី	*Parachela siamensis*	1.2	2.4
8	Trey Chongva	ត្រីចង្វា	*Rasbora sp.*	1.2	2.4
9	Trey Chrakeng	កែង	*Puntioplites proctozystron*	1.1	2.2
10	Trey Kahe krorhorm	រីក្រម៉ម	*Barbus schwanenfeldii*	1.0	2.0
11	Other species			10.0	*20.9*

Table 5. 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)	1917.5	1984.2	1780.7	1987.6
Meeting 100% of Energy Intake (%)	48.5	50.8	41.3	53.5
Protein(g)	63.8	65.8	60.8	64.7
Meeting 80% of Protein Intake (%)	68.9	73.2	64.8	68.7
Iron(mg)	12.6	11.4	13.7	12.6
Meeting 80% of Iron Intake (%)	10.3	12.7	4.9	13.4
Zinc(mg)	3.7	3.0	4.1	3.9
Meeting 80% of Zinc Intake (%)	35.3	27.3	45.2	33.4
Calcium(g)	528.8	467.1	528.1	591.2
Meeting 80% of Calcium Intake (%)	23.0	20.5	25.5	22.9
Vitamin A(mcg RE)	445.5	518.9	431.0	386.5
Meeting 80% of Vitim A Intake (%)	27.2	23.4	28.5	29.6
Carbohydrate(g)	345.3	338.5	342.8	354.6
Fats(g)	34.4	32.7	28.4	42.0

Table 6. 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)	780.8	757.7	805.2	779.5
Meeting 100% of Energy Intake (%)	27.0	21.7	27.7	31.6
Protein(g)	26.5	26.1	25.6	27.8
Meeting 80% of Protein Intake (%)	48.2	45.6	47.1	52.1
Iron(mg)	4.7	4.7	4.6	4.8
Meeting 80% of Iron Intake (%)	21.6	14.9	22.2	27.6
Zinc(mg)	1.5	1.2	1.6	1.8
Meeting 80% of Zinc Intake (%)	7.0	2.8	5.5	12.6
Calcium(g)	254.3	202.7	279.1	281.0
Meeting 80% of Calcium Intake (%)	18.4	14.9	17.5	22.9
Vitamin A(mcg RE)	225.0	227.9	259.8	187.2
Meeting 80% of Vitim A Intake (%)	17.0	13.0	22.2	15.8
Carbohydrate(g)	123.2	116.7	123.6	129.2
Fats(g)	13.8	12.8	12.7	16.0

Table 7. 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 & products	59.2	30.0	14.4	74.9	43.1	16.8	21.4	7.6
Starchy roots & tubers	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0
Legumes, nuts& seed	0.1	0.2	0.5	0.0	0.3	0.3	0.0	0.0
Vegetables	2.0	4.0	1.2	6.2	14.1	15.1	15.7	25.9

Food Group (%)	Energy	Protein	Fats	Cars	Iron	Zinc	Calcium	Vit A
Fruits	1.4	0.8	0.4	1.7	3.1	2.5	1.4	29.1
Meat & poultry	3.5	10.7	16.5	0.0	7.2	32.4	3.7	0.3
Fish & OAAs	9.4	47.5	27.6	12.1	25.8	27.0	38.5	24.2
Eggs	0.6	1.4	7.0	0.0	1.7	1.1	4.2	3.2
Milk & products	0.1	0.1	4.6	0.1	0.1	0.2	3.6	0.1
Fats & Oils	1.1	0.0	13.4	0.0	0.0	0.1	0.1	0.1
Sugars & syrup	0.2	0.1	0.3	0.2	0.0	0.0	0.4	0.1
Condiments and Spices	0.3	1.1	0.5	0.1	4.3	1.0	6.7	2.8
Beverages	19.0	1.2	10.6	1.5	0.3	0.6	1.3	0.8

Table 8. 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	53.4	34.6	21.5	73.5	44.5	4.4	12.1	2.1
Starchy roots and tubers	0.3	0.1	0.1	0.5	0.4	0.3	0.2	0.0
Legumes, nuts and seed	0.1	0.2	0.7	0.0	0.4	0.4	0.0	0.0
Vegetables	0.8	1.5	0.5	5.7	6.6	6.9	5.4	11.7
Fruits	3.5	1.3	1.3	4.8	7.3	5.9	2.1	38.1
Meat & poultry	2.4	7.6	9.3	0.1	5.3	19.5	0.4	0.7
Fish & OAAs	11.3	40.9	28.4	0.9	14.6	18.2	34.9	16.6
Eggs	1.9	3.8	9.6	0.2	5.6	3.6	2.3	12.1
Milk and products	7.2	7.4	12.0	7.4	11.5	39.7	36.3	16.7
Fats and Oils	1.1	0.0	7.9	0.0	0.0	0.0	0.0	0.0
Sugars and syrup	2.0	0.6	3.2	2.1	0.2	0.0	1.8	0.0
Condiments and Spices	0.3	0.8	0.4	0.1	3.1	1.0	2.9	1.2
Beverages	8.6	1.2	5.2	4.7	0.6	0.1	1.5	0.8

Table 9. 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 & poultry	24.2	17.0	30.5	0.3	19.6	50.6	7.6	0.9
Fish & OAAs	66.0	75.4	51.1	94.0	70.5	42.2	78.5	82.7
Eggs	4.4	2.2	12.9	0.3	4.5	1.7	8.5	11.0

Table 10. 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 & poultry	14.4	13.6	18.3	10.6	19.4	43.8	1.0	2.2
Fish & OAAs	67.0	72.5	55.8	87.1	53.1	41.0	86.2	52.4
Eggs	11.5	6.8	18.8	4.2	20.4	8.1	5.7	38.2

Table 11. Percent Distribution of the women's mean one-day per capita food consumption in An Giang province, Vietnam

Food Group	All Sample Women	
	Consumption Raw AP (g/day)	% of Total
Energy-Giving Foods		
Rice (mean food)	230.0	30.7
Cereals & products	62.9	8.4
Sugars & syrup	10.5	1.4
Starchy roots & tubers	13.4	1.8
Fats and Oils	1.9	0.3
Body-Building Foods		
Fish & OAAs	127.0	16. 9
Meat & poultry	83.0	11.1
Eggs	18.9	2.5
Milk & products	9.8	1.3
Legumes, nuts & seed	0	0.0
Other Aquatic products	8.8	1.2
Regulating Foods		
Vegetables	122.0	16.5
Fruits	52.2	7.0
Miscellaneous		
Beverages	2.7	0.4
Condiments & Spices	7.3	1.0
All Foods	**750.3**	**100**

Table 12. Percent Distribution of the preschool-age children's mean one-day per capita food consumption across the provinces in Vietnam

Food Group	All Sample Children	
	Consumption Raw AP (g/day)	% of Total
Energy-Giving Foods		
Rice	153.5	22.5
Cereals& products	65. 4	9.6
Sugars &syrup	4.1	0.6
Starchy roots &tubers	4.4	0. 6
Fats and Oils	0.7	0.1
Body-Building Foods		
Fish & OAAs	55.4	8.1
Meat & poultry	62.2	9.1
Eggs	15	2.2
Milk &products	259.9	38.0

Food Group	All Sample Children	
	Consumption Raw AP (g/day)	% of Total
Other aquatic products	11.7	1.7
Regulating Foods		
Vegetables	20.6	3.0
Fruits	22.0	3. 2
Miscellaneous		
Beverages	6.5	1.0
Condiments &Spices	1.7	0.2
All Foods	683	100

Table 13. First 10 commonly consumed fish and percent distribution of the women's mean one day per capita fish consumption in Vietnam

No.	Vietnamese name	Common name	Scientific name	Mean	%
1	Cá lóc	Snakehead	*Channa striata*	39.1	28.8
2	Cá điêu hồng	Red tilapia	*Oreochromis* sp.	26.2	19.3
3	Cá rô đồng	Climbing perch	*Anabas tastudineus*	5.4	4.0
4	Cá tra	Striped catfish	*Pangasianodon hypophthalmus*	17.6	13.0
5	Lươn	Swam eel	*Monopterus albus*	8.0	5.9
6	Cá trê	Clarias catfish	*Clarius* spp.	4.0	2.9
7	Mè vinh, he, chép	Siver barb, common carp	*Barbonymus gonionotus, Barbonymus schwanenfeldii, Ciprinus carpio*	8.1	6.0
8	Ếch	Frog	*Hoplobatrachus rugulosus*	66.2	44.6
9	Cá lăng	Bagridae fish	*Hemibagrus wyckioides*	6.5	4.8
10	Tôm, tép, cua, ghẹ	Shrimp, prawn, crab, blue swimming crab	Penaeidae shrimp, *Macrobrachium resenbergii,* decapod crustaceans	4.2	3.1
11	Other species			10.4	7.7
	Total			**135.7**	**100**

Table 14. First 10 commonly consumed fish and percent distribution of the preschool-age children's mean one day per capita fish consumption in Vietnam

No	Vietnamese name	Common name	Scientific name	Mean	%
1	Cá lóc	Snakehead	*Channa striata*	28.5	2.5
2	Cá điêu hồng	Red tilapia	*Oreochromis* sp.	10.2	5.2
3	Cá rô đồng	Climbing perch	*Anabas tastudineus*	2.0	.0
4	Cá tra	Striped catfish	*Pangasianodon hypophthalmus*	7.4	1.0
5	Lươn	Swam eel	*Monopterus albus*	8.0	1.9
6	Cá trê	Clarias catfish	*Clarius spp.*	0.1	0.1
7	Mè vinh, he, chép	Siver barb, common carp	*Barbonymus gonionotus, Barbonymus schwanenfeldii, Ciprinus carpio*	0.5	0.7
8	Ếch	Frog	*Hoplobatrachus rugulosus*	3.5	5.2
9	Cá lăng	Bagridae fish	*Hemibagrus wyckioides*	2.2	3.3
10	Tôm, tép, cua, ghẹ	Shrimp, prawn, crab, blue swimming crab	Penaeidae shrimp, *Macrobrachium resenbergii,* decapod crustaceans	2.5	3.7
11	Cá thát lát	Bronze featherback	*Notopterus notopterus*	2.3	1.2
12	Other species			1.4	2.1
	Total			**67.1**	**100**

Table 15. Percentage contribution of particular food groups to the women's total energy and nutrient intakes in Vietnam

Food group (%)	Energy	Protein	Fats	Carbohydrate	Iron	Calcium	Zinc	Vit A
Rice (mean food)	56.17	24.62	10.67	70.11	39.71	18.35	15.99	7.22
Cereals & products	6.32	1.11	0.00	1.11	2.72	2.88	3.25	0.00
Sugars & syrup	2.56	0.71	0.28	3.69	1.29	1.27	0.57	0.00
Fats and Oils	1.12	0.00	12.39	0.26	7.70	0.23	1.32	0.00
Starchy roots & tubers	1.57	0.80	0.93	4.87	1.30	0.11	0.35	0.33
Vegetables	3.63	1.33	1.08	4.41	7.30	3.63	6.37	26.19
Fruits	3.22	1.41	0.95	0.04	8.55	4.28	5.69	28.12
Meat & poultry	10.06	19.32	29.43	0.11	16.41	5.89	28.77	0.96
Eggs	2.88	6.44	12.43	0.14	1.65	6.87	4.14	6.71
Milk & products	0.38	0.30	7.03	0.36	0.07	10.14	0.44	0.41
Fish & OAAs	10.27	41.71	22.15	13.24	9.53	40.70	29.46	25.39
Aquatic product others	0.60	0.27	1.04	0.94	1.83	1.40	0.00	0.33
Condiments & Spices	1.16	1.93	1.54	0.74	0.02	3.96	3.63	4.10
Beverages	0.06	0.03	0.03	0.00	1.96	0.27	0.00	0.20
All Foods	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 16. Percentage contribution of particular food groups to the preschool-age chidren's total energy and nutrient intakes in Vietnam

Food Group (%)	Energy	Protein	Fats	Carbohydrate	Iron	Calcium	Zinc	Vit A
Rice (mean food)	28.8	9.30	10.00	84.50	69.40	15.60	46.70	7.01
Cereals & products	12.4	0.40	1.80	0.40	2.60	0.70	1.40	0.00
Sugars & syrup	1.9	0.00	0.00	2.20	0.03	0.00	0.00	0.00
Fats and Oils	0.3	0.00	4.50	0.00	0.00	0.00	0.00	0.00
Starchy roots & tubers	0.6	0.05	0.02	0.50	0.60	0.10	0.20	0.00
Vegetables	0.9	0.20	0.08	0.70	2.10	1.40	0.70	0.00
Fruits	1.7	0.10	0.30	1.60	1.90	0.80	1.00	0.00
Meat & poultry	12.4	6.70	20.80	0.00	7.20	0.90	23.70	3.20
Eggs	3.5	1.10	8.70	0.10	5.00	2.00	1.90	19.20
Milk & products	27.0	74.40	46.30	9.10	3.90	65.10	21.80	64.20
Fish & OAAs	7.7	6.30	6.70	0.08	4.90	10.50	0.70	5.80
Aquatic product others	1.6	0.90	0.30	0.10	1.90	1.50	1.60	0.60
Condiments & Spices	1.0	0.50	0.20	0.60	0.60	1.20	0.06	0.00
Beverages	0.2	0.01	0.20	0.20	0.10	0.10	0.04	0.00

Table 17. Percentage contribution of fish to the women's total animal energy and nutrient intakes in Vietnam

Animal Food Source (%)	Energy	Protein	Fats	Carbohydrate	Iron	Calcium	Zinc	Vit A
Meat & poultry	43.33	28.64	45.98	0.82	59.50	11.02	46.13	2.91
Fish & OAAs	44.25	61.82	34.60	98.1	34.53	76.13	47.24	76.80
Eggs	12.42	9.55	19.42	1.04	5.97	12.85	6.63	20.29
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 18. Percentage contribution of fish to the preschool-age children's total animal energy and nutrient intakes

Animal Food Source (%)	Energy	Protein	Fats	Carbohydrate	Iron	Calcium	Zinc	Vit A
Meat & poultry	52.38	47.52	57.46	0.55	42.11	6.72	90.11	11.35
Fish & OAAs	32.72	44.68	18.51	44.20	28.65	78.36	2.66	20.57
Eggs	14.89	7.80	24.03	55.25	29.24	14.93	7.22	68.09
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

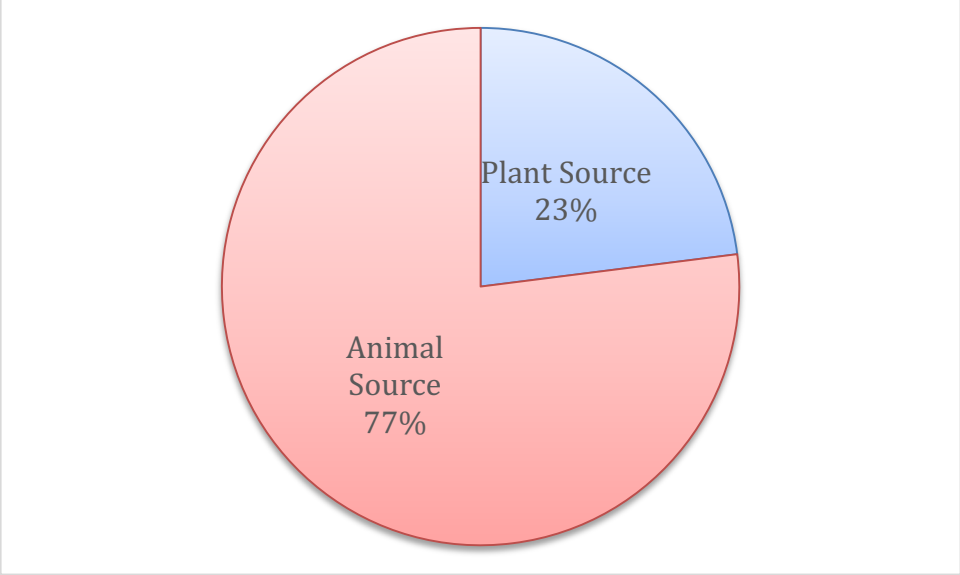

Figure 1. Percent contribution of food sources of mean daily per capita food consumption for Cambodian women surveyed in this study.

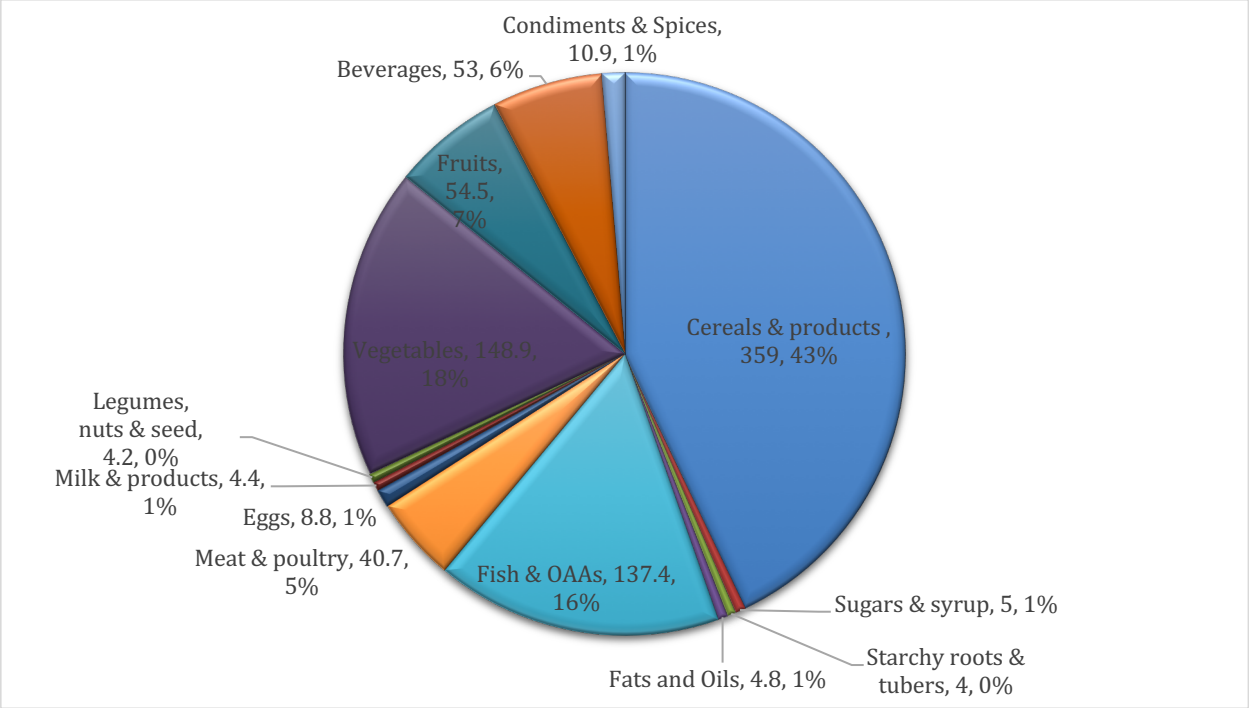

Figure 2. Percent distribution of mean daily per capita food consumption by particular food group for Cambodian women surveyed in this study.

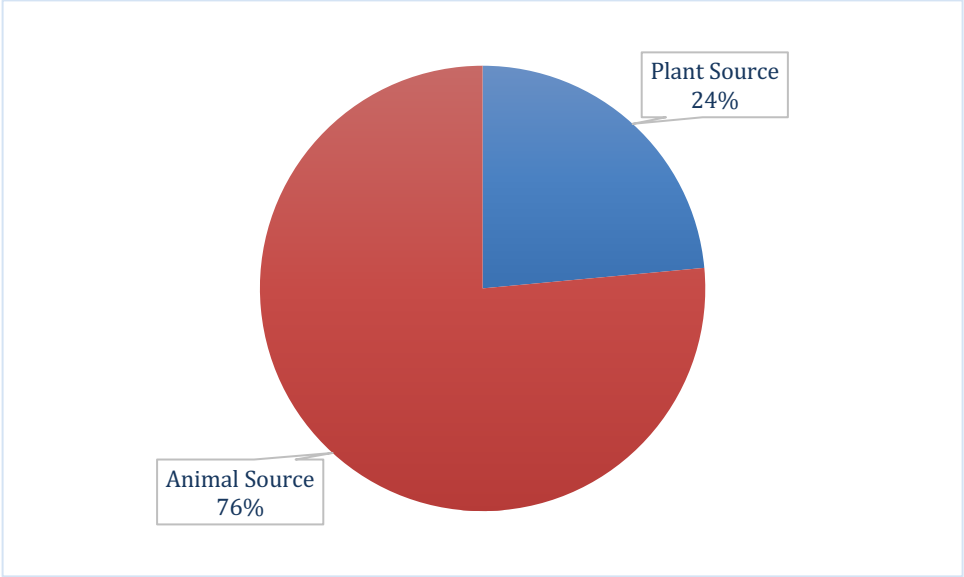

Figure 3. Percent contribution of food sources to mean daily per capita food consumption by Cambodian preschool children surveyed in this study.

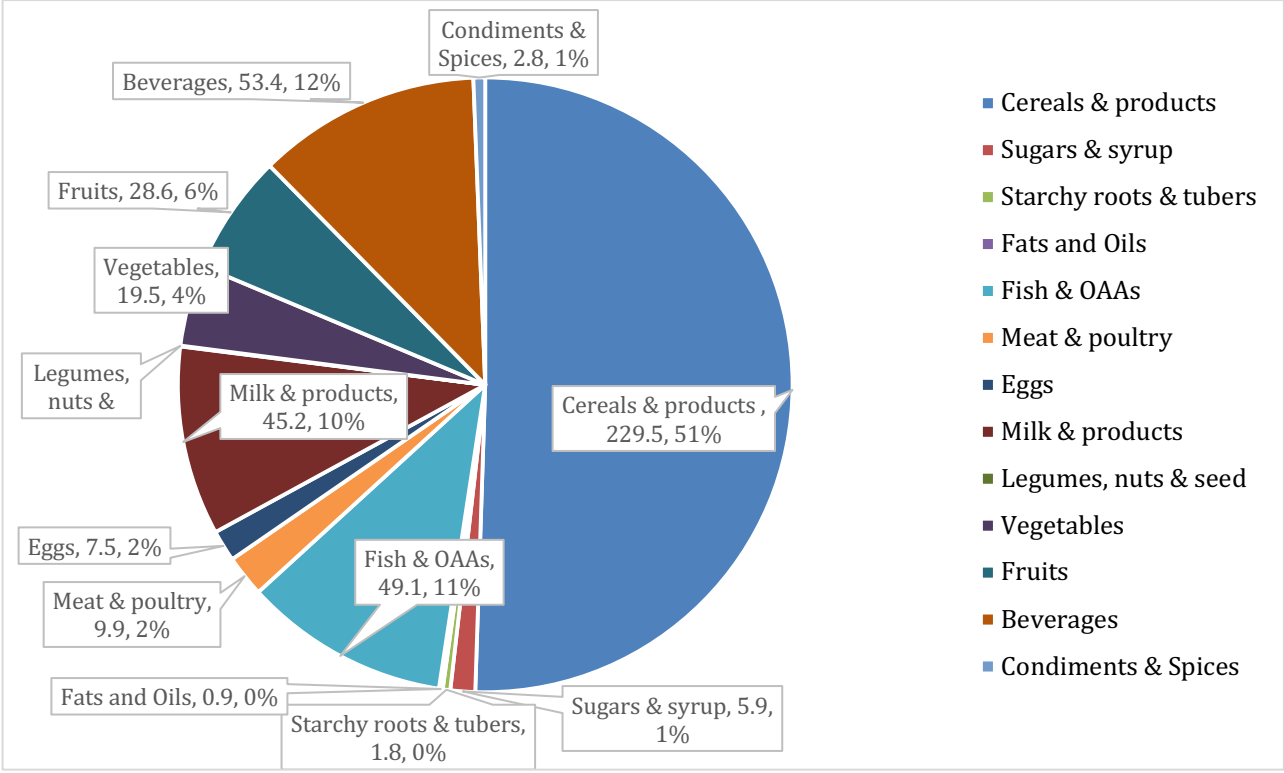

Figure 4. Percent distribution of the mean daily per capita food consumption by particular food group for Cambodian preschool children surveyed in this study.

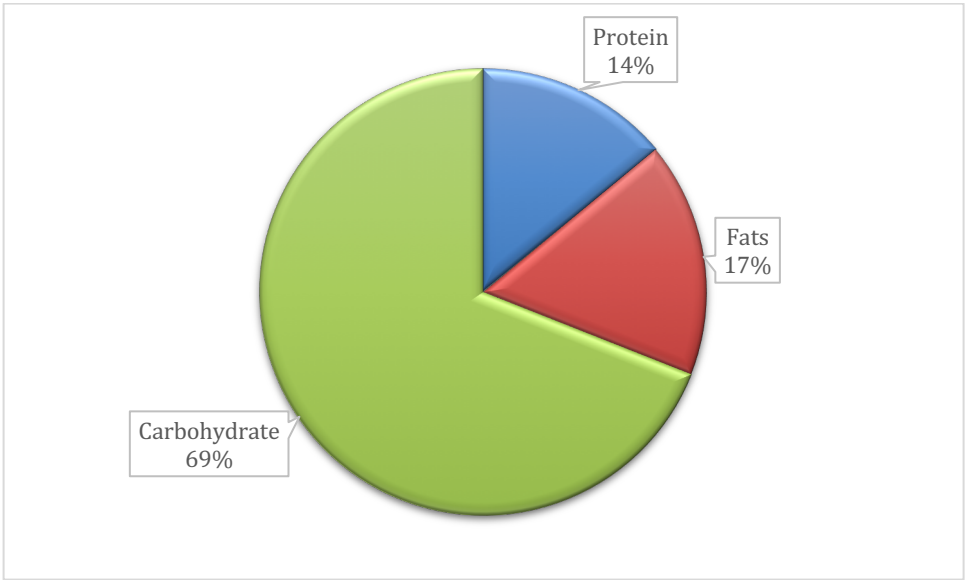

Figure 5. Percent contribution of carbohydrate, fats and protein to total dietary energy for Cambodian women surveyed in this study.

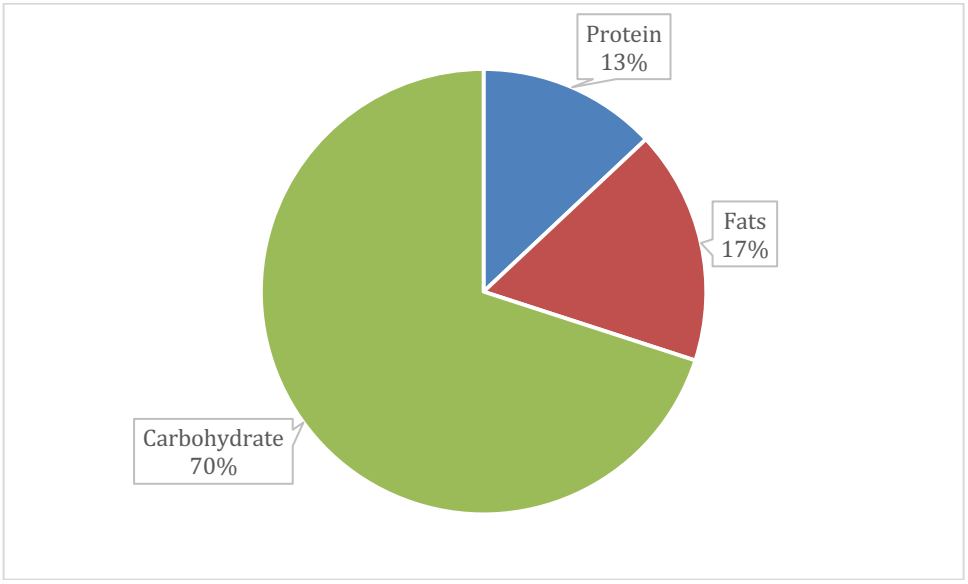

Figure 6. Percent contribution of carbohydrate, fats and protein to total dietary energy for Cambodian preschool children surveyed in this study.

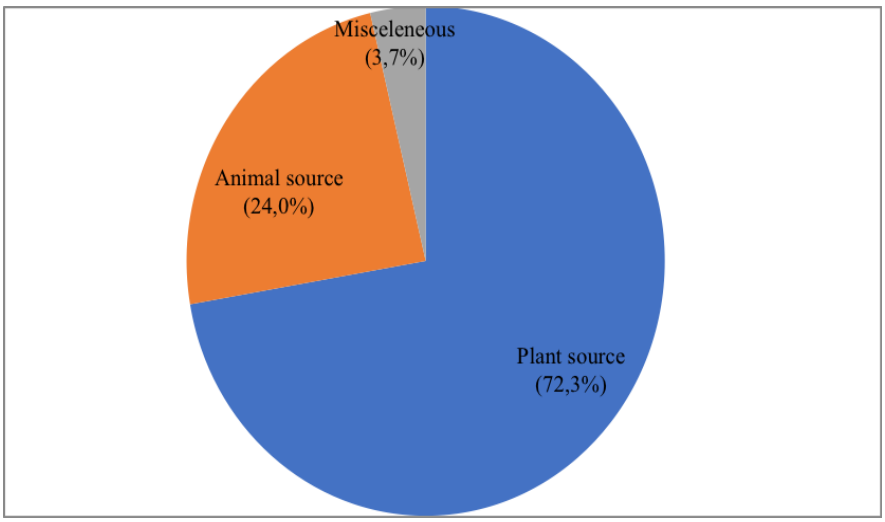

Figure 7. Percent contribution of food sources of the women's mean one day capita food consumption in Vietnam

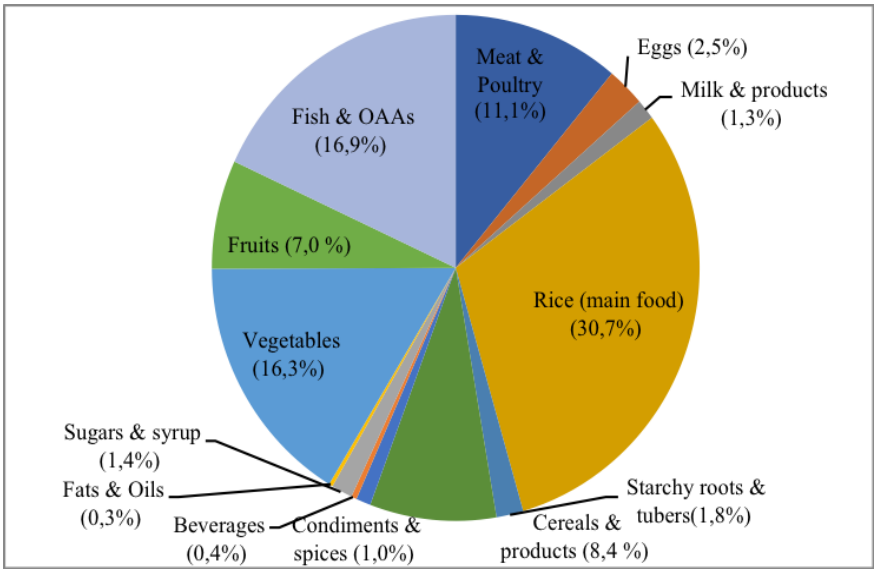

Figure 8. Percent Distribution of the women's mean one-day per capita food consumption by particular food group.

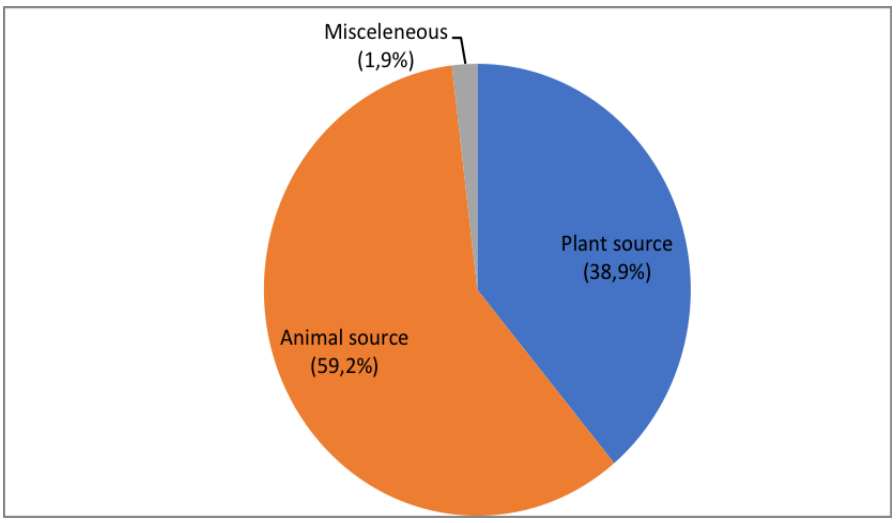

Figure 9. Percent contribution of food sources of the preschool-age children's mean one day capita food consumption in Vietnam

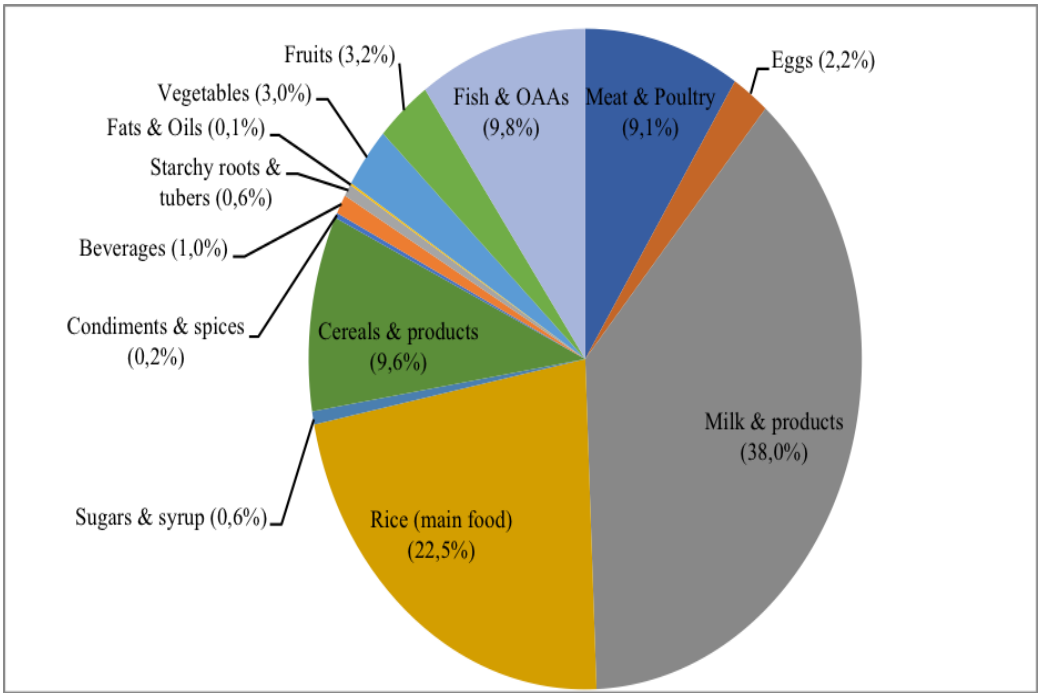

Figure 10. Percent Distribution of the preschool-age children's mean one-day per capita food consumption by particular food group in Vietnam.

ENHANCING FOOD SECURITY AND HOUSEHOLD NUTRITION OF WOMEN AND CHILDREN THROUGH AQUACULTURE AND CAPTURE FISHERIES IN CAMBODIA AND VIETNAM IN THE DRY SEASON- PART II

Food Safety, Post-Harvest, and Value-Added Product Management/Study/16FSV01UC

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ABSTRACT

In Cambodia where malnutrition remains a key development challenge, fish is an exceptional and cheaper animal-source food in the diets and livelihoods of millions. Knowledge of nutrient composition of fish from Cambodia is poor and the pre-existing data on the nutrient components of fish do not reflect the large diversity available and have focused on only a few select species and nutrients. The present study aimed to analyze the nutrient contents of 8 selected fresh and two processed fish species commonly consumed by women and preschool children in Cambodia with a specific focus on calcium, iron, phosphorus, protein, fat, carbohydrate, energy, ash and moisture as a supplementary data to our previous nutrient evaluation on other commonly-consumed fresh and processed fish, and other aquatic animal species. When comparing species, the composition of nutrients of public health significance was diverse. In fresh fish, iron ranged from 1.11 to 5.11 mg/100g, phosphorous (116.33 to 512.5 mg/100g) and calcium (126.84 to 534.48 mg/100g). Several species were rich in calcium, particularly *Esomus longimanus* (355.69 mg/100g), *Cyclocheilichthys apogon* (534.48 mg/100g), *Parachela siamensis* (423.65 mg/100g) and *Barbus schwanenfeldii* (512.44 mg/100g), largely when small fish are eaten whole with bones included in the edible parts. In processed fish, iron ranged from 6.09 to 6.96 mg/100g, phosphorous (893.05 to 1,280.62 mg/100g) and calcium (471.5 to 2,488.25 mg/100g), as well as other tested components include protein, fat, carbohydrate, energy and ash in general showing greater values than in fresh fish, except moisture having lower values due to smoked-drying process reduced water in processed fish. These data illustrate the diversity in nutrient composition of fish species and in particular the rich nutrient components of small species, which should guide policy and programs to improve food and nutrition security in Cambodia, particularly for vulnerable groups, women and preschool children.
Keywords: Small fish species, nutrient density, proximate component, women, children, Cambodia

INTRODUCTION

The food and nutritional consumption survey in dry season in Cambodia in women and preschool children within Investigation 5 found that women commonly consume 40 species of fish and OAA and preschoolers commonly eat 35 species of fish and OAAs (first FIR for Investigation 5). Eight selected fresh and two processed fish species commonly consumed by women and preschool children in Cambodia with a specific focus on calcium, iron, phosphorus, protein, fat, carbohydrate, energy, ash and moisture as a supplementary data to our previous nutrient evaluation on other commonly-consumed fresh and processed fish, and other aquatic animal species (table 1).

In Cambodia, fish, fish products and other aquatic animal (OAAs) species are an irreplaceable and cheaper animal-source food in the diets and livelihoods of millions, both in terms of quantity - accounting for roughly 12% of the total energy intake, 28% of total fat intake, 37% of iron consumed, 37% of total protein intake and 76% of animal protein intake at 173 g per person per day that is 63 kg per person per year - and very high frequency of consumption, far exceeding that of any other animal-source food (Mogensen, 2001; Roos et al., 2003; FAO and WHO, 2004; Hortle, 2007; Chamnan et al., 2009; So and Touch, 2011; IFReDI, 2013; Baran et al., 2014; FAO, 2014; Vilain and Baran, 2016). Thus, fish plays an extraordinarily important role in Cambodia's national food and nutrition security (Chamnan et al., 2009; Vilain and Baran, 2016). The country possesses diverse and abundant aquatic resources with more than 490 freshwater fish species and features the fifth in inland fisheries productivities after China, India, Bangladesh and Myanmar with an annual average of 400,000 tones (Baran et al., 2014; Vilain and Baran, 2016). Despite improvement in some food and nutrition security indicators, malnutrition, largely caused by inadequate micronutrient intake, remains widespread with 6.7% of population suffering from severely underweight, 39.9% moderate and severe stunting and 10.9% wasting (NIS et al., 2011; So and Touch, 2011; Vilain and Baran, 2016). Malnutrition kills more than 6,400 children per year in Cambodia (UNICEF Australia, 2014) and school-aged children are the most energy deficient (IFReDI, 2013). Eighty-nine percent (89%) of rural people achieve the recommended intake of protein, however only 51% of the population meets the adequate energy intake, 25% reach recommended levels of energy and 19% meet the recommended levels of iron. In general, women and children under five years are the vulnerable groups receiving more sensitive to deficiencies (SCN, 2004; Roos et al., 2007c; Vilain and Baran, 2016). Despite the clear importance of fish in Cambodian diets and livelihoods, existing composition data do not reflect the great diversity of species available for consumption and have simply focused on a few select species and nutrients rather than all-inclusive nutrient profiles. The newly pre-established Food Composition Table for Cambodia is a useful compilation of existing composition data on important foods including numerous fish and fish products; however, the data come from various sources including regional databases with varying sampling and analytical methods, some of which are now several decades old (FAO/INFOODS, 2013).

Despite the recently report on nutrient components of 15 selected fresh and processed fish, and three OAAs species commonly consumed by women and preschool children in Cambodia, the nutrient contents of other species describing in food and nutritional consumption survey (Touch et al., 2016a; 2016b) remains still unexplored. Therefore, the present work aimed to determine the nutrient composition of eight selected fresh and two processed fish species that are commonly consumed by Cambodian women and preschool children with a specific focus on calcium, iron, phosphorus, protein, fat, carbohydrate, energy, ash and moisture, which are of known public health concern and food and nutrition insecurity issues in the country as an additional data to our previous nutrient evaluation on other commonly-consumed fresh and processed fish, and OAAs species (Touch et al., 2016b) as well as to extend the data to incorporate more species diversity.

MATERIALS AND METHODS

Sample collection and preparation

Fresh and processed fish samples were purchased from local public markets in Prey Veng, Kampong Thom and Kandal provinces in Cambodia during the dry season of April to May 2017. The length of each fish species sample was measured to the nearest centimeter upon purchasing at the markets to ensure that the samples had uniformity for the analysis. The identification details of each sample including local or common name, scientific name, length and sample preparation details are shown in Table 1. Depending on the fish species, edible parts may or may not include the bones, head, viscera, scales, tail, fins and other parts according to traditional practice commonly-consumed by women and school children (Table 1). To avoid contamination of samples, non-metal equipment such as plastic cutting boards, buckets and strainers, and stainless steel cutting knives were used to obtain raw edible

parts. Fish samples were washed with water after dissecting out the head, viscera, scales, tail, fins, bones and other parts on collection site and before being tightly packed in polyethylene bags and transported in a storage box lined with ice chips and away from direct sunlight, to the Industrial Laboratory Centre of Cambodia (ILCC), Ministry of Industry and Handicraft in Phnom Penh for nutrient and proximate composition analyses. Fish species were ground and homogenized as per raw edible parts prior to analysis and subsamples of the homogenate were taken, with size appropriate for individual analytical tests (70-3,000mg). For several species, the homogenate included bones, and for others, bones, head and other parts were removed prior to homogenization if they are typically discarded as plate waste, as shown in Table 1.

Proximate analysis

Protein, energy, moisture and ash contents of fresh and processed fish samples were analyzed according to the standard analytical methods as per the Association of Official Analytical Chemists (AOAC). Protein was determined using based on the total nitrogen content of the Kjeldahl method (AOAC, 2000), whereas energy, fat, moisture and ash were evaluated following the standard methods of AOAC (2005) and carbohydrate was calculated according to FAO (2003). All analytical measurements were performed in 3 independent experiments, each performed in triplicate and mean value were calculated.

Micronutrient analysis

Calcium and phosphorus were analyzed according to the standard methods of AOAC (2005), whereas iron was spectrophotometrically determined following Tsutomu et al. (2007). All analytical measurements were performed in 3 independent experiments, each performed in triplicate and mean value were calculated.

RESULTS AND DISCUSSION

Proximate composition

The energy, protein, fat, carbohydrate, moisture and ash composition of all fish species are shown in Tables 2, 3a and 3b. The total energy content varied greatly with a range of 90.18 to 197.7 Kcal/100g and 426.12 to 589.65 Kcal/100g in fresh and processed fish, respectively which is related to variation in fat content in the different species (Tables 3a and 3b). Several studies indicated that only 51% of the Cambodian population meets the adequate energy intake whereas 25% reach recommended levels of energy. In general, children and women are more sensitive to deficiencies (SCN, 2004; Roos et al., 2007c; Vilain and Baran, 2016). Fish, fish products and OAAs contribute 12% of the total energy intake (Vilain and Baran, 2016), thus consumption of fish alone is not able to ensure adequate energy intake, however with rice combination will provide an additional average of 1,095 Kcal, i.e. 60% of the total energy intake and when the latter cannot be supplied by rice and fish, consume other starchy food items are necessary (IFReDI, 2013). Results of the total protein content in fish species ranged from 14.53 to 18.82% (fresh) and 38.02 to 50.06% (processed) in our study; these can be assumed to be of high dietary quality, being an animal-source protein (WHO, 2007). When comparing the protein content, the processed fish showed higher value than the fresh fish (Ahmed et al., 2011). Fish and OAAs provide 37% of the total protein intake and 76% of the animal protein intake (49% from freshwater fish and 5% from freshwater aquatic animals, 20% from marine fish and animals and 2% from aquaculture fish) (Chamnan et al., 2009; So and Touch, 2011; IFReDI, 2013; Baran et al., 2014; Vilain and Baran, 2016). Several studies reported 89% of rural Cambodian poor reach the recommended intake of protein (SCN, 2004; Roos et al., 2007c; Vilain and Baran, 2016), which may due to the fact that Cambodians consume very high consumption of fish at 63 kg per person per year in addition to their 35% of the total protein intake from other animal and vegetable-source foods (IFReDI, 2013; Baran et al., 2014; Vilain and Baran, 2016). The fat content ranged from 1.92 to 13.99% and 20.18 to 47.15% in fresh and processed fish, respectively. Fat generally varies much more widely than other nutrient components of fish, and usually reflects differences in the way fat is

stored in particular species but may also be affected by processing (e.g. smoked-drying), seasonal or lifecycle variations and the diet or food availability of the species at the time of sampling (Ababouch, 2005; Ahmed et al., 2011). Cambodians consume 19 g of total fat per capita per day (Mogensen, 2001). In Cambodia, fish, fish products and OAAs contribute 28% of the total fat intake (IFReDI, 2013; Vilain and Baran, 2016), whereas fish especially the white and black species, account for 27.81 % of the total fat intake of the household (IFReDI, 2013). Fat composition of fish is unique and of high quality fat compared to other animal food sources (Kawarazuka, 2010), particularly the two essential pre-formed long chain omega-3 polyunsaturated fatty acids (PUFA), Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) that cannot be found elsewhere (McKeown, 2006; Morris, 2008; FAO, 2010; Kawarazuka and Béné, 2010). Fish, especially fatty fish contains high levels of omega-3 fatty acids and should be consumed at least twice a week to combat deficiencies and meet dietary requirements in EPA and DHA, (Fernandes, 2012). The FAO recommends 250 mg EPA and DHA per day for men and non-pregnant women (FAO, 2010), whereas childbearing women require double their normal intake of DHA from diet to accommodate the needs of the fetus or infant (McKeown, 2006). Moreover, to avoid coronary heart disease, it advised to consume at least 225 g of fish or shellfish per week per person (Vannice and Rasmussen, 2014). This represents two or more servings of fish per week with an average daily intake of 450 to 500 mg EPA and DHA (Vilain and Baran, 2016). Results also showed that water is the main constituent in the edible parts ranged from 66.83% to 76.38% in fresh and 5.31% to 9.76% in processed fish, and as expected was negatively associated with fat and energy content (Tables 3a and 3b) and the content was much lower in processed fish in which water may largely be dehydrated during smoked-drying process (Ahmed et al., 2011). Ash content ranged from 0.78 to 3.47% (fresh) and 6.23 to 8.94% (processed) Table 3a and is positively linked with mineral content, particularly calcium, phosphorus and iron whereas fresh fish has lower ash content, most likely the high ash content of processed fish were due to water loss during processing, i.e. smoked-drying concentrated other components such as minerals (Ahmed et al., 2011). The variation in ash content is likely related to inclusion of bones as edible parts in some species, which would lead to higher ash content (Tables 1 and 3a). The content of carbohydrate was also analyzed for data completeness but it is not associated with significant public health concerns currently, and therefore, its nutritional significance is not discussed here. In this study, carbohydrate content ranged from 1.57 to 8.45% in fresh and 3.29 to 11.07% in processed fish. Carbohydrate is generally detected at very low level (lower than 0.5%). In fact, fish is a good source of all nutrients except for carbohydrate and vitamin C. The fish carbohydrate is present in the striated muscle as glycogen and as part of the chemical constituents of nucleotides (Huss, 1995).

Micronutrient composition

The iron, calcium and phosphorus composition for all species are shown in Tables 2, 3a and 3b. Iron content varied considerably with a range from 1.11 to 5.11 mg/100g in fresh and 6.09 to 6.96 mg/100g in processed fish. These results show a greater range in iron content of all fish species compared to those values indicated in our previously report on other selected fresh and processed fish and OAAs species commonly consumed by Cambodian women and preschool children (Touch et al., 2016b) and the ASEAN Food Consumption Table (2000), however slightly lower values than the global FAO/INFOOD database on fish and shellfish (FAO/INFOODS, 2013). Of interest is that iron content of *Esomus longimanus* (Trey Changwa plieng) showing the lowest value (2.04 mg/100g) compared to other species; this could be explained by the fact that in fish, iron is concentrated in the head and viscera which is compatible with our analysis that viscera was excluded (Kawarazuka and Béné, 2010). This may also be partly attributable to sampling and analytical variability, species and size differences, or may reflect real differences in the accumulation of iron in these species based on differing environmental conditions (Huss, 1995; Roos et al., 2007c). The true nature and magnitude of these differences should be further investigated. Overall, the data presented here indicate that several species may contribute significantly to dietary iron intakes in Cambodia which is of high bioavailability as an animal-source food (FAO and WHO, 2004). In Cambodia, fish contributes 37%

of the iron consumed and sour soup made with the *Esomus longimanus* species can cover as much as 45% of the daily iron requirement for women and children. However, iron absorption is reduced by rice consumption containing phytate – the known inhibitor of the absorption of proteins, iron, zinc, calcium and 70% of pregnant women and 74% of children under five years are affected by iron deficiency. These may also have important policy implications given the public health significance of iron deficiency anemia (IDA) in Cambodia, with prevalence recently estimated at around 5% in preschool children and women (Wieringa et al., 2016), and the well-documented negative effects of deficiency on physical and cognitive and immune system development, pregnancy outcomes, morbidity and mortality (WHO, 2001; Roos et al., 2007a).

Calcium content ranged from 126.84 to 534.48 mg/100g in fresh and 471.5 to 2,488.25 mg/100g in processed fish. These results are within the range of fish and seafood reported elsewhere (Kotchanipha et al., 2012; FAO/INFOODS, 2013) and significantly higher than those values reported by the ASEAN Food Consumption Table (2000). As would be expected, calcium content was much higher in species in which bones are commonly consumed and included in the edible parts (Mogensen, 2001; Roos et al., 2007c; IFReDI, 2013; Vilain and Baran, 2016). Of interest, several species were rich in calcium particularly *Esomus longimanus* (Trey Changwa phlieng*,* 355.69 mg/100g), *Cyclocheilichthys apogon* (Trey Srorka kdam, 534.48 mg/100g), *Parachela siamensis* (Trey Slek reussey, 423.65 mg/100g) and *Barbus schwanenfeldii* (Trey Kahe krorhorm, 512.44 mg/100g). Calcium deficiency among children results in terrible dentition, whereas it leads to hypertension, preterm birth or fetal death among pregnant women. In Cambodia, fish is the second food item consumed after rice with average consumption of 173 g per person per day, i.e. 63 kg per person per year (Baran et al., 2014; Vilain and Baran, 2016) and the most important dietary source of high calcium bioavailability since dairy products are nearly non-existent and if consumed is very low (Roos et al., 2007c; IFReDI, 2013). Many small fish species fully consumed with bones are a rich source of calcium that balance the limited calcium input through dairy products (Roos et al., 2007a; 2007b; 2007c) and small fish constitute up to 86% of the total calcium intake from fish and OAAs as large bones from big fish are not eaten (Mogensen, 2001; Roos, 2001). In particular, the bioavailability of calcium from bones of whole small fish is as high as that from milk (Hansen et al., 1998; Larsen et al., 2000). The data presented here further support the conclusion that in Cambodia, small fish eaten whole with bones are a major source of highly bioavailable dietary calcium (Larsen et al., 2000; Roos et al., 2007a; 2007b; So and Touch, 2011), however large fish do not contribute much to calcium intake because their bones are discarded (Roos, 2001).

Phosphorus content ranged from 116.33 to 512.5 mg/100g (fresh) and 893.05 to 1,280.62 mg/100g (processed), with higher composition in fish species with bones included in edible parts, and consistent with values reported in FAO/INFOODS (2013). Of interest is that phosphorus content of all fish species is much higher than those reported values from the ASEAN Food Consumption Table (2000) and Kotchanipha et al. (2012). This may possibly be partly attributable to species and size differences, edible parts, or differing biodiversity conditions. Phosphorus, like calcium, is also involved in bone and teeth mineralization (Michaelsen et al., 2009; Soetan et al., 2010). Fish, particularly soft-boned fish eaten whole, is an excellent source of highly available phosphorus (Michaelsen et al., 2009). Malnourished children are frequently suffering from hypophosphatemia (low phosphate levels in the body), which can lead to rickets-like bone changes and increases the risk of mortality (Michaelsen et al., 2009). In adults, phosphorus deficiency may cause osteomalacia, a softening of the bones (Soetan et al., 2010) whereas pregnancy and lactation do not affect the recommended intakes (DRI, 1997).

CONCLUSION

Data presented in this study are of prime importance providing nutrient composition of selected fresh and processed fish species commonly consumed by women and preschool children in Cambodia, both

in terms of the number of species and the nutrient components analyzed to date with a specific focus on calcium, iron, phosphorus, protein, fat, carbohydrate, energy, ash and moisture. Our data show that from a nutritional perspective, fish species mostly small species hold the potential to provide a greatly contribution to micronutrient intakes of women and preschool children compared to common aquaculture species. This is likely partially due to the way in which small fish are consumed, that is whole with head and bones. Further still, given the large range in nutrient components of the different species reported here, diversity in fish consumption, particularly of small species, is promising to promote a more all-inclusive nutrient intake. This supports the compelling argument that to effectively target malnutrition, resources should be directed towards ensuring a more balanced approach of both sustainable capture fisheries management and aquaculture, including the development of innovative aquaculture technologies which incorporate nutrient-dense species, in particular small species. This study significantly expands the current knowledge on nutritional value of the great diversity of fish species in Cambodia, and demonstrates that many species, predominantly small species of rice-field fisheries and those from inland capture fisheries, have the potential to contribute significantly to recommended nutrient intakes for a variety of nutrients. In future studies, it would be useful to determine the actual contribution of different species to nutrient intakes of women and preschool children based on consumption, to better inform programs targeting improved access, availability and consumption of nutritious diets.

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TABLES AND FIGURES

Table 1. Identification details of fish samples and anatomical parts removed prior to analysis.

Local/common name	Scientific name	Length (Cm)	Anatomical parts excluded prior to analysis
Fish species			
Trey Chrakeing	*Puntioplites proctozystron*	15.0	Bones, head, scales, viscera, fins, tail
Trey Ta orn	*Ompok hypophthalmus*	17.0	Bones, head, viscera, fins, tail
Trey Changwa phlieng	*Esomus longimanus*	0.7	Viscera
Trey Chhviet	*Pangasius macronema*	14.5	Bones, head, viscera, fins, tail
Trey Kamphlienh sre	*Trichopodus trichopterus*	9.5	Head, scales, viscera, fins, tail
Trey Srakar kdam	*Cyclocheilichthys apogon*	7.5	Scales, viscera, fins, tail
Trey Slek reussey	*Parachela siamensis*	10.0	Head, scales, viscera, fins
Trey Kahe krorhorm	*Barbus schwanenfeldii*	16.0	Bones, head, viscera, fins, tail
Processed fish			
Smoked Trey Changwamoul	*Rasbora tornieri*	-	No parts removed
Smoked Trey Slek reussey	*Parachela siamensis*	-	No parts removed

-, no data available.

Table 2. Summary of nutrient composition of selected fresh and processed fish species commonly-consumed by women and preschool children in Cambodia.

Nutrients	Fresh		Processed	
Proximate components	Min (%)	Max (%)	Min (%)	Max (%)
Protein	14.53	18.82	38.02	50.06
Fat	1.92	13.99	20.18	47.15
Carbohydrate	1.57	8.45	3.29	11.07
Ash	0.78	3.47	6.23	8.94
Moisture	66.83	76.38	5.31	9.76
	Min (Kcal/100g)	Max (Kcal/100g)	Min (Kcal/100g)	Max (Kcal/100g)
Energy	90.18	197.70	426.12	589.65
Micronutrients	Min (mg/100g)	Max (mg/100g)	Min (mg/100g)	Max (mg/100g)
Calcium	126.84	534.48	471.50	2488.25
Phosphorous	116.33	512.50	893.05	1280.62
Iron	1.11	5.11	6.09	6.96

Data are the means of 3 independent experiments, each performed in triplicate.

Table 3a. Details of nutrient composition of selected fresh and processed fish species commonly-consumed by women and preschool children in Cambodia.

Local/common name	Scientific name	Protein (%)	Std	Fat (%)	Std	Ash (%)	Std	Moisture (%)	Std	Calcium (mg/100g)	Std
Fish species											
Trey Chrakeing	*Puntioplites proctozystron*	16.49	1.18	2.02	0.74	1.05	0.38	73.84	3.95	189.30	18.62
Trey Ta orn	*Ompok hypophthalmus*	16.63	2.68	3.14	0.51	1.27	0.30	74.69	2.64	181.75	13.18
Trey Changwa phlieng	*Esomus longimanus*	16.67	3.0	2.39	1.58	3.47	0.33	75.90	0.50	355.69	84.59
Trey Chhviet	*Pangasius macronema*	14.53	2.98	13.99	4.87	0.78	0.08	67.28	5.72	126.84	22.33
Trey Kamphlienh sre	*Trichopodus trichopterus*	18.82	2.61	2.27	0.81	2.40	0.34	74.59	0.72	194.50	27.24
Trey Srakar kdam	*Cyclocheilichthys apogon*	14.93	0.75	1.92	0.19	3.47	0.07	76.38	0.52	534.48	6.22
Trey Slek reussey	*Parachela siamensis*	16.32	0.52	9.79	0.49	2.29	0.10	69.21	0.71	423.65	8.76
Trey Kahe krorhorm	*Barbus schwanenfeldii*	18.0	0.36	5.62	0.23	1.11	0.13	66.83	1.16	512.44	28.0
Processed fish											
Smoked Trey Changwamoul	*Rasbora tornieri*	50.06	3.04	20.18	0.63	8.94	0.30	9.76	1.41	471.50	24.20
Smoked Trey Slek reussey	*Parachela siamensis*	38.02	2.13	47.15	1.51	6.23	0.47	5.31	0.94	2488.25	352.94

Data are the means of 3 independent experiments, each performed in triplicate. Std – standard deviation

Table 3b. Details of nutrient composition of selected fresh and processed fish species commonly-consumed by women and preschool children in Cambodia.

Local/common name	Scientific name	Phosphorus (mg/100g)	Std	Iron (Fe) (mg/100g)	Std	Carbohydrate (%)	Std	Energy (Kcal/100g)	Std
Fish species									
Trey Chrakeing	*Puntioplites proctozystron*	134.0	53.31	2.53	0.23	6.61	3.26	110.53	20.07
Trey Ta orn	*Ompok hypophthalmus*	116.33	23.15	4.42	0.25	4.27	2.91	111.85	11.34
Trey Changwa phlieng	*Esomus longimanus*	474.63	103.52	2.04	0.52	1.57	1.80	94.51	9.46
Trey Chhviet	*Pangasius macronema*	178.76	79.81	2.53	0.69	3.42	2.64	197.70	47.0
Trey Kamphlienh sre	*Trichopodus trichopterus*	353.23	42.71	1.11	0.27	1.93	2.28	103.42	5.81
Trey Srakar kdam	*Cyclocheilichthys apogon*	512.50	22.08	3.05	0.29	3.31	0.73	90.18	2.87
Trey Slek reussey	*Parachela siamensis*	271.68	22.35	3.29	0.43	2.40	0.44	162.93	5.40
Trey Kahe krorhorm	*Barbus schwanenfeldii*	148.32	7.71	5.11	0.14	8.45	1.0	156.34	5.30
Processed fish									
Smoked Trey Changwamoul	*Rasbora tornieri*	1280.62	121.57	6.96	0.33	11.07	2.49	426.12	7.81
Smoked Trey Slek reussey	*Parachela siamensis*	893.05	80.46	6.09	0.39	3.29	2.28	589.65	12.93

Data are the means of 3 independent experiments, each performed in triplicate. Std – standard deviation