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Decent variety and dietary benefit of nourishments consume by kids in two agro-biological zones of Benin

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Abstract

Food diversification is recognized as an approach to reduce nutrient deficiencies among the population. Samples of food commonly consumed by the children in two agro ecological zones (Coastal Savannah Zone in the South (CSZ) and Sudan Savannah Zone in the North (SSZ)) of Benin were collected for energy, protein, fat, iron, zinc and vitamin A contents determination. Energy content ranged from 76 to 82 kcal/100 g (wet basis) in the cereal paste collected in the CSZ and from 60 to 105 kcal/100 g in the SSZ. In the samples sauces from CSZ, energy ranged between 49 and 189 kcal/100 g; and protein from 1.9 to 5.6 g/100 g; Iron and zinc contents ranged between 1.8 - 5.0 and 0.2 - 1.1 mg/100 g respectively while vitamin A content from 428 to 6394 ∝g RE/100 g. Samples sauces gave 39.0 - 84.1 kcal/100 g of energy; 1.5 - 4.3 g of protein; 1.6 - 5.6 mg of iron; 0.08 - 0.8 mg of zinc and 44.8 - 3805 ∝g RE of vitamin A in the SSZ. The same zone showed high food variability with 12 types of foods versus 5 for CSZ. However, high prevalence of protein-energy malnutrition is observed among the children in the SSZ. Then, the food variability is not a sufficient factor to improve the nutritional status of the children.

Keywords: Agro-ecological zones, nutritional composition, energy content, protein content, iron content, zinc content.

INTRODUCTION

Balanced diets are not accessible to a large proportion of the world's population, particularly those who live in developing countries. Indeed, most of populations in these regions subsist on staple plant-based diets that often lack diversity with insufficient quantity consumed. This results in nutritional deficiencies including micro-nutrients deficiencies (Hoddinott and Yahannes, 2002). Low food intake may be the underlining cause of the growth retardation in children, but further to this, most of these children suffer from micronutrient deficiencies, especially of iron, vitamin A, iodine and zinc (EDSB, 2006). Dietary diversity depends on income and socioeconomic status since the relationships between household income, child nutrition and health have been established (FANTA and USAID, 2006). In West Africa, under-nutrition is one of the main threats to health and well-being of populations, particularly for children with whom one third of children under five years old are undernourished and many of them are affected by acute and chronic malnutrition (UNICEF, 2004). In Benin, prevalence of malnutrition among the children under five years was 43% for stunting, 19% for being underweight, and 8% for wasting (EDSB, 2006), indicating that the nutritional situation in this country is of great concern.

In Africa, food-based strategies to improve nutritional status of the people are recognized to be an adequate solution to alleviate or prevent malnutrition and micronutrients deficiencies (Howsen et al., 1998; Ruel and Menon, 2002). In this respect, a more varied diet, consequently improved micronutrient acquisition, and is associated with increased birth weight (Rao et al., 2001), enhanced child anthropometric status (Sawadogo et al., 2006). Food diversification aims to enhance the availability, access, and utilization of foods with a high content of micronutrients with an elevated bioavailability throughout the year (Gibson and Hotz, 2001).

Despite the intuitive link between increased dietary diversity, improved appetite and increased nutrient intake, the relationship between dietary diversity and adequate micronutrient intake has not yet been sufficiently validated across different cultural settings and in different age groups (Kant et al., 1993). Food consumption practices of children in Africa, particularly in Benin, have not been studied in depth. It is a common practice that children of 6 months and less begin to consume household foods which often do not respond to the specific nutritional needs of children (Ruel and Menon, 2002).

The present study was undertaken to determine the nutritional composition (energy, protein, fat, Fe, Zn, β-carotene and phytate contents) of foods commonly consumed in the Coastal Savannah zone and the Sudan Savannah zone of Benin in order to assess their possible contribution in guarantying the nutritional requirements of the children and the relationship with food diversification.

MATERIALS AND METHODS

Study area and selection of respondents

Surveys were conducted between December 2003 and June 2004 in six villages of the two contrast agro ecological zones of Benin: the Coastal Savannah Zone (CSZ) in the South with Lalo, Sehoue and Sakete rural localities; and the Sudan Savannah Zone (SSZ) in the North with Gogounou, Kouande and Tanguieta rural localities. 45 children in the CSZ and 52 in the SSZ aged between 18 and 36 months fully weaned were chosen in 97 households randomly selected in the six villages.

The two zones are distinguished on the basis of the rainfall and the growing season, and the principal cultivated crops. The CSZ has two growing seasons and average annual rainfall that ranges from 1100 - 1500 mm; and the main crops are: maize, cassava, cowpea and peanut. The SSZ is characterized by one growing season with the average annual rainfall between 900 and 1100 mm; and the principal crops are: maize, cassava, yam, cowpea, peanut, millet, sorghum (Hell et al., 2000).

Data collection

Data were collected from the selected households using a structured questionnaire which was addressed to the child's mother. Data included socio-economic status (age, household size, occupation, educational background), and food consumption pattern (type of foods, consumption frequency, quantity thereof daily consumed by children). The daily dietary intake was assessed by a 24 h dietary recall method (Bingham et al., 1988).

Foods sample collection

Samples of foods consumed by children (solid foods and sauces) were collected from households for the laboratory analysis. In each household, food preparation procedures were observed and recorded. A total of 83 food samples of 42 types of prepared food were collected in the two zones (17 types in the CSZ and 25 in the SSZ). For each product, an aliquot of 70 - 100 g was sampled and packed in aluminum foil, wrapped in polyethylene bags, labeled and placed in an insulated icebox and transported to the laboratory. The containers were sealed to avoid product loss and influx of humidity. The samples were stored at - 20°C until analysis of energy, protein, fat, Fe, Zn, β-carotene and phytate.

Laboratory analyses

The moisture content of the foods was determined according to AACC method (AACC, 2002). The energy content in the food was determined by the oxygen combustion calorimeter bomb 1341EE (PAAR Model). Crude protein (N x 6.25) was determined using the automated Kjeldahl method (AOAC, 1984) and total fat content according to Soxhlet method (AOAC, 1984) . FE and Zn were extracted by dry-ashing in a muffle furnace at 500°C and the resulting ash was dissolved and analyzed using the atomic absorption spectrophotometer (JENWAY 6715) (Benton and Vernon, 1990). β-carotene was extracted by high performance liquid chromatography (HPLC) using tetra hydro furan, as described by Takyi (1999). Retinol activity equivalent was calculated using the conversion factor 12: 1 from β-carotene value. Phytate was determined by colorimetry (Shimadzu Model UV, Kyoto, Japan) following method described by Makower (1970) and modified by Zeder (1998). Samples were analyzed in triplicate. Phytate: Fe and phytate: Zn molar ratios were calculated according to Saha et al. (1994).

Data analyses

Energy and nutrient intakes were calculated using an updated version of the Benin food composition table derived from the FAO food composition database. The amount of the various food categories consumed by the children (in gram) and the energy and nutrient content of each food were calculated using the Komeet 4.0 software (Scholte, 2002).

Statistical analyses were performed using SAS 9.1 software. All data were expressed as mean values and standard deviations. A one-way ANOVA model with the least significant difference (LSD) test was used to compare the daily nutrients intake between the two groups of children.

RESULTS

Food diversity

In the CSZ, maize was the main crop produced, while in the SSZ, 3 types of cereal: maize, millet and sorghum were produced (Table 1). The principal root and tuber were cassava and yam in the SSZ and cassava was mainly cultivated in the CSZ. Cowpea was a major crop in the two surveyed zones. The diversity of crop produced in the SSZ, leads to wider variability of dishes prepared and a higher diversity in the food intake of the populations.

A total of 5 different types of solid foods derived from maize and cassava were recorded in the CSZ versus 12 different solid foods derived from maize, millet, sorghum, cassava and yam in the SSZ (Tables 2 and 3). In Northern Benin, pastes were commonly made by combining maize and cassava or millet/sorghum and cassava, whereas in the south only maize was used to make paste. Others solid foods (rice, cowpea and bambara groundnut) were found in the two zones.

Table 1. Main crops and derived foods in some villages of Coastal savanna zone of Benin (CSZ) and Sudan savanna zone (SSZ) of Benin.

Category	CSZ	SSZ
Cereals	Maize (*Zea mays*): boiled, paste (fermented or not), porridge.	Maize (*Zea mays*): boiled, paste (fermented or not), porridge, couscous, paste of maize + cassava chips.
	Rice (*Oriza sativa*): boiled, porridge	Rice (*Oriza sativa*): boiled, porridge
		Sorghum/Millet (*Sorghum bicolor/Pennisetum glaucum*): paste (fermented or not), porridge, paste of sorghum/millet + cassava chips
Roots and tubers	Cassava (*Manihot esculenta*): boiled, paste from the chips, gari.	Cassava (*Manihot esculenta*): boiled, paste from the chips, gari.
		Yam (*Dioscorea* sp.): boiled, fried, paste of yam chips, pounded, couscous.
Leguminous	Cowpea (*Vigna unguiculata*): porridge, porridge of maize + cowpea	Cowpea (*Vigna unguiculata*): porridge, porridge of maize + cowpea
		Bambara groundnuts (*voandzeia subterranea*): porridge

A total of 7 types of sauces in the CSZ and 9 types of sauces in the SSZ were sampled and generally consumed (Tables 2 and 3). In addition, vegetables and leaves of trees were more used in the Northern households than in the Southern households.

Nutritional value of the food samples

Unfermented paste from maize was found to be a predominant solid food that often accompanied various sauces in CSZ. These food samples showed a great variability in nutrients content. In the CSZ, energy content of maize based foods varied from 54.45 to 94.6 kcal/100 g wet weight basis (Table 2). Protein content ranged between 0.97 - 2.13 g/100 g and fat content from 0.11 - 2.26 g/100 g. Iron and zinc content ranged between 0.96 - 8.65 mg/100 g and 0 - 0.38 mg/100 g respectively. Energy content in the different sauces varied from 41.38 to 189.94 kcal/100 g wet weight basis in CSZ. Protein content of sauces samples ranged between 1.95 and 5.57 g/100 g and fat content between 1.73 - 18.24 g/100 g. Iron content varied from 1.77 to 9.59 mg /100 g and zinc content from 0.25 - 1.05 mg/100 g. β-carotene content varied from 428.55 to 6394.31 ∝g/100 g in the sauce samples. Palm nut sauce with egusi (*Cucurbita pepo* L.) has the highest nutritional value among the sauces sampled in the CSZ.

In the SSZ, energy and iron content in the pastes made from mixed flour of maize and cassava or millet/sorghum and cassava were higher than the pastes made from maize or sorghum only: the energy ranged from 87.79 to 105.35 kcal/100 g and 44.53 - 79.07 kcal/100 g, respectively, (Table 3). Protein and fat contents in the various foods were relatively low. Iron content was higher in sorghum and millet derived foods than in the other cereal foods, with levels ranging from 4.54 to 5.21 mg/100 g versus 0.29 - 4.64 mg/100 g for the maize foods.

Protein content in the different sauces collected in the SSZ was 1.46 - 4.27 g/100 g and fat content was 2.10 - 4.18 g/100 g (Table 3). Iron, zinc, and β-carotene content were 1.69 - 5.56 mg/100 g, 0.08 - 0.84 mg/100 g and 44.85 - 3805 ∝g/100 g, respectively. The β -carotene in the sauce sample collected from Northern Benin was lower than that in the sauce from the South. Nutritional values of sauce samples collected in this zone were relatively low when compare with values from samples collected in the Southern zone.

Phytate content

Phytate concentrations ranged from 69.7 to 208.4 mg/100 g wet weight basis in the foods from the Southern zone versus 20.5 to 264.8 mg/100 g in the foods collected in the Northern zone (Table 4). The highest phytate levels were found in the bambara groundnut based foods in the CSZ and in the millet and sorghum based foods in the SSZ.

Phytate: Fe molar ratio varied from 1.1 to 5.6 in the CSZ and from 0.9 to 4.9 in the SSZ (Table 4). The highest values were observed in cassava based foods in the South and in millet based foods in the North. Phytate: Zn molar ratio ranged from 0 to 26.2 in the CSZ and between 0 and 35.6 in the SSZ. The highest values were found in bambara groundnut foods in the South and millet based foods in the North.

Average energy, protein and iron supply among the children

Significant difference for the energy and iron supplies were evidenced for the children between the two zones, with mean values of 1256.9 Kcal/day and 76.2 mg/day in the CSZ versus1175.2 Kcal/day and 68.1 mg/day in the Northern zone ($p = 0.0023$) (Table 5). The energy intake

Table 2. Some nutritional components of the foods consumed in the coastal savanna zone of Benin.

Type of food	Moisture (%)	Energy (kcal)	Protein (g)	Fat (g)	Fe (m
Solid food					
Bambara groundnuts (*voandzeia*), porridge + gari + red palm oil stew	57.63 (0.5)*	187.31(0.7)	3.90 (0.2)	6.92 (0.6)	8.60 (0
Cassava (*Manihot*), boiled	71.51 (0.2)	128.84 (0.4)	0.42 (0.6)	0	1.07 (
Maize (*Zea mays*), fermented paste (n = 3)	77.39 (0.4)	81.90 (0.6)	1.2 (0.1)	0.11 (0)	0.96 (0
Maize, fermented porridge of (n = 2)	86.23 (0.5)	54.45 (0.8)	0.97 (0)	0.18 (0)	2.76 (0
Maize, unfermented paste (n = 5)	78.96 (0.2)	76.47 (0.5)	2.13 (0)	0.25 (0)	2.12 (0
Maize, seasoned unfermented paste	81.53 (0.4)	94.60 (0.5)	1.90 (0.1)	2.26 (0.3)	8.65 (0
Rice (*Oriza*), boiled + red palm oil stew	70.84 (0.1)	115.10 (0.7)	1.99 (0)	2.92 (0)	5.70 (0
Rice and cowpea (*Vigna*), Boiled + stew	70.0 (0.2)	145.26 (0.7)	3.18 (0.3)	4.0 (0.2)	3.23 (0
Red cowpea, porridge	61.91 (0.6)	113.11 (1.3)	9.31 (0.6)	0.52 (0)	5.73 (0
Snail (*Achatina* sp.), fried	49.24 (0.1)	128.65 (0.8)	20.78 (0.7)	19.11 (0.3)	6.67 (0
Sauces					
Palm nut sauce (n = 3)	87.62 (0.6)	82.98 (1.6)	1.95 (0.3)	1.73 (0.5)	2.73 (0
Palm nut sauce with egussi (*Cucurbita Pepo L*) (n = 3)	81.62 (0.2)	189.94 (2.9)	4.78 (0.6)	18.24 (0.7)	9.59 (0
Red palm oil sauce of okra (*Hibiscus esculentus*) (n = 2)	90.59 (0.6)	41.38 (0.3)	2.31 (0.1)	2.85 (0)	1.77 (0
Red palm oil sauce of cassava leaves (n = 2)	90.59 (0.4)	102.61 (2.3)	4.08 (0)	8.73 (0.3)	5.03 (0
Red palm oil sauce of cassava leaves and *Vernonia amygdalina* leaves (n = 3)	72.98 (0.4)	151.99 (1.8)	5.57 (0.7)	13.31 (0.6)	3.57 (0
Red palm oil sauce of *Corchorus olitorius* (n = 4)	91.45 (0.4)	49.05 (0.3)	1.95 (0.3)	3.13 (0)	4.99 (0
Red palm oil tomatoes sauce (n = 3)	90.21 (0.1)	65.20 (3.3)	3.34 (0.3)	3.17 (0.6)	3.44 (0

*: Mean (Standard deviation); n = sample number.

versus energy need showed that the children in the SSZ satisfied partially their energy requirements. Average protein intake was similar (21 - 22 g/day) in the two zones.

DISCUSSION

Diets consumed by populations in Benin are based to a large extent on cereals and starchy roots and tubers. Maize and cassava were the main staple foods consumed in the Southern zone (CSZ), while millet/sorghum, cassava and yam were the principal foods consumed in the Northern zone (SSZ). Food, foodstuffs, ingredients and the vegetable leaves are also more available in the SSZ, than in the CSZ.

However, in spite of the exchange of the foods within and between the two zones, variances in the foods prepared and foods items have been notified, particularly, in the households of the North. This could be explained considering food habit and food pattern which differed from one zone to another and in the same zone, also from one socio-cultural group to another. Concerning food habit, in the SSZ, the basic staple food was

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Table 3. Some nutritional components of the foods consumed in the Sudan Savanna Zone of Benin.

Type of food	Moisture(%)	Energy (kcal)	Protein (g)	Fat (g)	Fe (mg)
Solid food					
Bambara groundnut, cake	49.21 (0.7)	117.94 (1.5)	5.65 (0.3)	2.51 (0.6)	8.26 (0.4
Bambara groundnut, fritter	56.32 (0.9)	288.24 (1.3)	9.19 (0.2)	12.53(0.3)	8.79 (0.1
Maize, couscous	79.14 (1.1)	71.92 (1.3)	1.47 (0)	0.08 (0)	2.53 (0.2
Maize, fermented paste	72.50 (2.3)	79.07 (1.6)	2.19 (0.4)	0.14 (0)	0.29 (0)
Maize, fermented porridge (n = 2)	87.12 (2.5)	68.97 (1.4)	1.52 (0.7)	0.22 (0.3)	4.64 (0.1
Maize, unfermented paste (n = 2)	74.98 (2.3)	59.63 (1.8)	2.37 (0.2)	1.17 (0.3)	3.44 (0)
Maize and bambara groundnut unfermented porridge	83.95 (3.6)	55.37 (2.3)	2.16 (0.7)	0.59 (0)	2.22 (0)
Maize and Cassava chips, unfermented paste (n = 4)	77.57 (2.2)	100.55 (4.7)	1.42 (0)	0.32 (0)	4.38 (0.3
Maize, millet and cassava chips, unfermented paste (n = 2)	76.87 (2.4)	105.35 (3.7)	1.87 (0)	0.35 (0)	5.01 (0.5
Millet and cassava chips, unfermented paste (n = 4)	78.11 (2.1)	87.79 (2.3)	1.69 (0.2)	0.33 (0)	4.54 (0.6
Rice, unfermented paste	78.21 (1.6)	104.81 (6.4)	2.20 (0.4)	0.12 (0.2)	0.63 (0)
Rice and cowpea, boiled + stew	70.0 (1.3)	116.59 (3.7)	2.81 (0.3)	1.2 (0.1)	1.96 (0.2
Sorghum, fermented porridge (n = 2)	87.19 (1.7)	44.53 (1.3)	0.90 (0.6)	0.31 (0)	1.70 (0.2
Sorghum and cassava chips, unfermented paste (n = 2)	77.29 (0.9)	91.65 (1.4)	1.67 (0.4)	0.26 (0)	5.21 (0.8
Sorghum unfermented paste (n = 2)	78.29 (3.2)	59.97 (1.9)	2.78 (0.3)	0.98 (0)	4.80 (0.8
Yam, chips paste (n = 2)	77.87 (2.7)	73.84 (1.3)	1.10 (0.6)	0.16 (0.3)	3.41 (0.4
Yam, couscous with shea butter (n = 2)	69.75 (1.6)	169.05 (2.3)	1.25 (0)	4.24 (0.9)	3.34 (0.4
Sauces					
Palm nut sauce with *Hibiscus sabdariffa* leaves and peanut (*Arachis hypogea*) (n = 2)	86.41 (2.3)	62.23 (1.2)	2.52 (0.3)	4.18 (0.4)	1.57 (0)
Peanut sauce	86.13 (3.6)	47.38 (1.3)	4.27 (0.3)	3.08 (0.2)	2.04 (0.6
Sauce of dried baobab (*Adansonia digitata*) leaves with cowpea flour	94.22 (2.3)	39.89 (1.3)	3.42 (0.7)	2.10 (0.1)	2.67 (0)
Okra (*Hibiscus esculentus*) sauce with shea butter (*Vitellaria paradoxa*) (n = 2)	90.49 (3.7)	42.65 (2.3)	1.46 (0.3)	4.02 (0.2)	3.63 (0.1
Okra fruit and leaves sauce with shea butter (n = 3)	88.21 (3.8)	51.58 (2.3)	1.73 (0.5)	3.65 (0.4)	5.56 (0.3
Dried baobab leaves sauce with shea butter (n = 3)	81.40 (4.3)	83.27 (3.7)	3.42 (0.6)	4.10 (0.3)	2.19 (0.4
Okra sauce with cowpea flour with shea butter	83.43 (3.1)	73.74 (1.3)	4.22 (0.5)	3.31 (0.2)	1.69 (0.2
Ocimum sp. leaves sauce with shea butter	73.54 (2.9)	51.25 (1.2)	1.75 (0.3)	3.74 (0.6)	5.36 (0.7

*: Mean (Standard deviation); n = sample number.

products were consumed by the populations (Codjia et al., 2003).

Considering the nutritional value of the food, no significant differences were observed in energy

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Table 4. Phytate content and phytate : Fe and phytate : Zn molar ratios in foods consumed the Coastal and Sudan savanna zones of Benin.

Type of foods	Phytates (mg/100 g, dry weight basis)	Phytate: Fe[1]	Phytate: Zn[2]
Southern zone			
Bambara groundnuts (*voandzeia subterranea*), porridge + gari + red palm oil stew	208.4 (2.7)	2.1	26.2
Cassava (*Manihot esculenta*), boiled	70.0 (1.3)	5.6	ND
Maize (*Zea mays*), fermented paste (n = 3)	70.2 (1.2)	3.2	11.7
Maize (*Zea mays*), unfermented paste (n = 5)	130.1 (1.3)	5.2	16.2
Maize (*Zea mays*), seasoned unfermented paste of	157.8 (2.7)	1.5	21.2
Rice (Oriza), boiled + red palm oil stew	69.7 (1.1)	1.1	17.1
Rice (Oriza) and cowpea (*Vigna unguiculata*), Boiled + stew	101.0 (2.3)	2.8	22.2
Red cowpea (*Vigna unguiculata*), porridge	165.2 (2.7)	2.5	18.7
Northern zone			
Maize (*Zea mays*) couscous	99.8 (1.3)	3.4	ND
Maize (*Zea mays*), fermented paste	130.0 (2.1)	3.2	18.8
Maize (*Zea mays*), unfermented paste (n = 2)	140.1 (2.3)	1.9	ND
Maize (*Zea mays*) and Cassava (*Manihot*) chips, unfermented paste (n = 4)	50.2 (0.9)	1.1	35.6
Maize (*Zea mays*), millet (*Pennisetum glaucum*), and cassava (*Manihot*) chips, unfermented paste (n = 2)	264.8 (1.3)	4.5	24.5
Millet (*Pennisetum glaucum*) and cassava (*Manihot*) chips, unfermented paste (n = 4)	262.5 (2.6)	4.9	24.1
Rice (*Oriza*), unfermented paste	27.2 (0.3)	3.7	6.3
Rice (*Oriza*), and cowpea (*Vigna unguiculata*), boiled + stew	20.5 (0.6)	0.9	15.2
Sorghum (*Sorghum bicolor*) and cassava (*Manihot*) chips, unfermented paste (n = 2)	206.7 (3.6)	3.4	26.5
Sorghum (*Sorghum bicolor*), unfermented paste (n = 2)	150.0 (0.9)	2.6	25.2
Yam (*Dioscorea* sp.), chips paste (n = 2)	40.1 (0.6)	1.2	ND
Yam (*Dioscorea* sp.), couscous with shea butter (n = 2)	121.7 (1.8)	3.1	19.4

*: Mean (Standard deviation); ND: not detected.
[1] = (mg of phytate / molar mass of phytate [660]) / (mg of iron / molar mass of iron [55.85]).
[2] = (mg of phytate / molar mass of phytate) / (mg of zinc / molar mass of zinc [65.39]).

Table 5. Average daily nutrient supply of children (18-36 months) in the Coastal and Sudan savanna zones of Benin.

	Energy (kcal/day)	Proteins (g/day)	Iron (mg/day)
Southern zone (N = 45)	1256.92 (418.3) a	22.35 (10.1) a	76.21 (39.6) a
Northern zone (N = 52)	1175.21 (426.6) b	21.34 (11.8) a	68.12 (51.4) b
Requirement	1250 a	22 a	13 c

Mean (Standard deviation); for each parameter, means with the same letter are not significantly different.

two zones except for unfermented samples pastes (p = 0.0015). These differences could be related to the gap in moisture content of the maize paste from one zone to other (79% of moisture content in the maize paste collected in the CSZ versus 75% in samples collected in the SSZ). The similarity in energy requirement and nutrients contents for derived foods of maize is not expected since earlier studies showed cultivars effect in nutrients content of food sample (Salounkhe et al., 1985).

Proteins derived from the leguminous (cowpea, bambara groundnut) are more consumed than those coming from livestock in the two zones. This result is in accordance with the one reported by Oniang'o et al. (2003) in the rural area of Africa.

In spite of the variability of ingredients, and the addition of vegetable and vegetable leaves, in the sauces cooked in the SSZ, the micronutrients composition of this sauces were low compared to the sauce samples collected in the CSZ, particularly the β-carotene content which differed significantly between the two zones (P = 0.0013). These differences could be due to the form of the vegetable leaves and fruits used for cooking. Red palm oil, with a high content in β-carotene (Benadé, 2003) is usually used in the CSZ households, while shea butter (*Vitellaria paradoxa*) remains the cooking oil in the SSZ households. Vegetables and fruits, potential sources of micronutrients and β -carotene (Sommer and West, 1996; McLaren and Frigg, 2001) are often dried in the SSZ. However, the drying leads to a partial lost of β-carotene in the vegetables and fruits as pointed out by Delisle et al. (1997) who reported that drying induces a 50% loss of pro-vitamin A in the foods.

Phytate is the major chelator of Fe and Zn, reducing the bioavailability of these minerals (Gibson and Ferguson, 1999). Bioavailability of these minerals is impaired when Phytate: Fe and phytate: Zn molar ratios are above the thresholds of 10 - 14 and 15, respectively, (Oberleas and Harland, 1981; Saha et al., 1994). All of the solid foods analyzed in the two zones had phytate: Fe ratios less than 10. This suggests that Fe availability from these foods was prior good. Some foods in the two zones had phytate: Zn ratios higher than value of 15, indicating poor Zn bioavailability. Phytate content and phytate: Zn molar ratio was high in millet and sorghum paste, and in composed paste of cereals and root. The finding is in agreement with Adeyeye et al. (2000), who found phytate: Zn molar ratio of 29 - 33 in the cereals (maize, millet) and 16 - 27 in roots and tubers (cassava, yam). Kayode et al. (2006) also reported phytate: Zn molar ratio of 44 - 58 in different cultivars of sorghum foods in Benin.

Quantitative food intake by children in the CSZ was comparable to the recommended value, thus satisfactory. However, in the SSZ, although there was a large crop diversity and ingredient variability, a high prevalence of protein-energy malnutrition is observed among the children in this zone; prevalence of stunting and wasting were 38.6 and 7% against 37 and 0% in the CSZ, respectively. Average daily intake of energy and protein by the children in this zone were lower than 1250 kcal/day and 22 g/day recommended by the FAO (Latham, 2001).

Several authors showed that dietary diversity is positively associated with a greater energy intake and nutrients among young children (Onyango et al., 1998; Brown et al., 2002); this study showed the contrast of this finding specifically among the SSZ children were. This contrast could be due to the quality of the foods in spite of their variability and the quantity consumed. Therefore, the use of dietary diversity as indicator of household food security is limited (Hoddinott and Yohannes, 2002).

Conclusion

This paper provides the basis for the examination of the possible contribution of food variability in the guarantee of food security of the populations, especially children. The presented study shows that food variability is not sufficient to reduce food deficiency; increasing the total food intake and the improving of food quality are also important to ameliorate the food and nutritional situation of the children.

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