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Effect of Food Availability Variation on Dietary Consumption and Nutritional Adequacy of Reproductive-Age Women Benefiting from a Multisectoral Intervention: A Longitudinal Study in Benin

Nagassi Whomou Jacob Victor[1*], Fanou-Fogny Nadia[1], Mitchikpè Comlan Evariste Simon[1]

[1]Laboratoire de Nutrition humaine/Université d'Abomey-Calavi, Campus Abomey-Calavi,
01 BP 526, Cotonou-Bénin

*Corresponding author: nagassi.jacob@yahoo.fr

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Abstract

Malnutrition is a multi-causal phenomenon that affects women's health and their children. This study determined the extent to which the dietary intake and nutritional adequacy of women of reproductive age, beneficiaries of a multisectoral intervention, are affected by the seasonality effect of food availability periods (FAP) in northwest Benin. A sample of 165 voluntary women was constituted, and daily food consumption data were collected during increased FAP (November 2018 and January 2019), intermediate FAP (September 2018 and March 2019) and decreased FAP (May 2019 and July 2019). Average food quantities and median nutritional intakes were calculated and compared using SPSS 20.0. The mean age of women was 29.5 ± 7.8 years. Women's dietary intake was dominated by staples (cereals, roots, and tubers) and vegetables, with fewer animal products. This dietary intake did not provide sufficient micronutrient intakes to meet vitamins and minerals requirements of most women (>50%) in all FAP, except intermediate FAP. Increasing the consumption of fruits and vegetables led to an improvement in women's nutritional intakes during intermediate FAP. Therefore, enhancing the availability and accessibility of fruits and vegetables throughout the year will contribute to improving nutritional intakes and reducing malnutrition.

Keywords: seasonality, multisectoral intervention, food, nutrient, women of reproductive age, Benin.

Introduction

Women of reproductive age are vulnerable to malnutrition due to their specific nutritional needs and the social norms that expose them to an increased risk of deteriorating nutritional status when food resources become scarce within households (Coad et al., 2011). Periodic physiological changes resulting from menstruation, pregnancy, and lactation increase their micronutrient requirements, especially for iron (Coad et al., 2011). Furthermore, social and cultural norms often disadvantage women in food distribution within households (Kadiyala et al., 2014; Herforth and Jody, 2014; Narayanan et al., 2017).

Malnutrition has significant consequences for both women and the societies they live in. Malnourished women experience reduced immunity and physio-pathological alterations, making them more susceptible to infections (Coad et al., 2011). Moreover, during pregnancy, nutritional deficiencies are associated with poor intrauterine growth, low birth weight, and stunted growth in newborns. Brain and nervous system development commence early in pregnancy and are largely completed by a child's second birthday (Cusick and Michael, 2012). Therefore, the diet of women during pregnancy and after childbirth plays a pivotal role in the health and productivity of the child. Nutritional deficiencies during this period can significantly affect brain development (Cusick and Michael, 2012). At the societal level, high rates of malnutrition impact productivity across all sectors, resulting in an estimated economic loss ranging from 3% to 16% of the Gross Domestic Product (GDP) (FAO et al., 2021). A study also indicated that malnutrition can lead to decreased school attendance and academic performance, ultimately reducing income-generating capacity by an average of 22% annually (Grantham-McGregor, 2007).

Malnutrition results from various factors, including inadequate access to a diversified and nutritious diet, inappropriate caregiving practices, inadequate healthcare services, and poor hygiene practices (UNICEF, 2013).

Despite extensive efforts to combat malnutrition, in 2019, nearly one in three women aged 15 to 49 worldwide suffered from anaemia, a situation that has shown no improvement since 2012 (FAO et al., 2022). In Benin, the situation worsened between 2012 and 2019, with anaemia prevalence increasing from 41% to 58%. In the Atacora department, the situation is even more concerning, with a 2019 anaemia rate of 67.4% compared to 41.6% in 2012 (INSAE and ICF, 2019). Faced with the ongoing deterioration of women's nutritional status, the question of the effectiveness of interventions in sustainably reducing malnutrition arises. This study focuses on the effectiveness of interventions in reducing malnutrition sustainability by analysing the nutritional adequacy of women of reproductive age who are beneficiaries of a multisectoral intervention in a context of varying periods of food availability. This research builds upon prior studies that have already shown the negative effects of seasonal instability on the nutrition of children and women of reproductive age in Benin (Van Lière *et al.,* 1995; Mitchikpè *et al.,* 2008; Alladayé *et al.,* 2017). A recent study also highlighted variations in dietary diversity among women beneficiaries of a multisectoral intervention, although detailed information on nutritional adequacy was lacking (Nagassi *et al.,* 2021).

The objective of the study is to analyze to what extent women of reproductive age, beneficiaries of a multisectoral intervention, maintain stable nutritional adequacy in an area subject to variations in food availability periods in Benin.

The study is based on the Multisectoral Support Program for Food and Nutrition Security in Atacora (AMSANA). From 2015 to 2020, the program was carried out by five Non-Governmental Organizations: Protos, Louvain Coopération, Iles de Paix, Enabel, and Belgian Croix Rouge. The objective of the program was to contribute to the improvement of food and nutritional security of 8,000 households in the 65 targeted villages of Boukoumbé, Cobly, Matéri and Tanguiéta. This objective was achieved through the realization of 4 main results: (i) the improvement of the availability of food and market garden products, (ii) the increase and diversification of the population's income, (iii) the adoption of better nutritional and hygiene practices and (iv) the strengthening of the integration of food and nutritional security in development strategies at the communal, departmental and national levels. The AMSANA program has the particularity of attacking food insecurity through a multisectoral and multi-actor approach as recommended by the FAO and other actors (SPRING, 2014; FAO, 2015).

Methods, Techniques, Studied Material and Area Descriptions

Study design

To achieve the objective of this study, we chose a longitudinal design, allowing us to follow a cohort of 165 women throughout a year, covering all food availability the periods (FAP). The women were tracked from September 2018 to July 2029, and six rounds of data collection were planned and conducted, with two rounds per FAP: November 2018 and January in increased, September 2018 and March 2019 in intermediate and May 2019 and July 2019 in decreased. In the study area, located in the northwest of Benin, households experience variation in food availability across three FAP : increased (October-February), intermediate (March to mid-April and mid-August to September), and decreased (mid-April to mid-August) (Table 1). The month of May marks the start of the agricultural year when seeding and planting starts. Harvesting starts in October and continues until January, depending on the crop. While harvesting allows households to build up their food stocks between October and January, March to September is considered the lean or decreased FAP when households experience increasing rates of food insecurity characterised by tensions in food availability and market price increases. October to February is, theoretically, an increased FAP (PAM, 2009; Table 1).

Data on their food consumption were collected using the 24-hour recall method with multiple passes and quantity estimation in increased FAP (November and January), intermediate (September 2018 and March 2019) and decreased. Socio-demographic characteristics of the women and their households were also collected.

Study Area

The study was conducted in four communities: Boukombé, Cobly, Matéri, and Tanguiéta, situated in the Atacora department of north-western Benin (refer to Figure 1). These communities are located within the geographical coordinates of 10°0' to 11°50' North latitude and 0°10' to 1°83' East longitude, spanning an area of 9,252 square kilometers according to INSAE's 2016 data. The total estimated population in this region was reported as 338,686 inhabitants during the same year, as per INSAE's statistics.

The study area experiences two distinct seasons, with one being the rainy season extending from May to October, and the other being the dry season, spanning from November to April (as detailed in Table 1). Agriculture constitutes the predominant economic activity in this region, engaging 70.4% of the population. Households in the area engage in the cultivation of two main categories of crops: food crops and cash crops.

Food crops in the region encompass a variety of cereals such as corn, sorghum, millet, and rice, as well as roots and tubers like cassava, yam, sweet potato, Irish potato, and taro. Additionally, pulses like beans, cowpeas, and soybeans, as well as oilseeds including peanuts, citrullus, and baobab seeds, are cultivated to support the dietary needs of the community. Moreover, cotton stands as the primary cash crop in the region, according to data from PAM in 2017 (PAM, 2017).

The agricultural calendar in this region start in May with planting and seeding activities. Harvesting typically commences in October and extends through January, contingent upon the specific crop. This period allows households to accumulate their food reserves from October to January. However, the period from March to September is considered a lean season, marked by reduced Food Access and Availability (FAP). During this time, households encounter heightened food insecurity due to limited food availability and rising market prices. In contrast, the period from October to February is theoretically an increased FAP, according to PAM in 2009 (as detailed in Table 1).

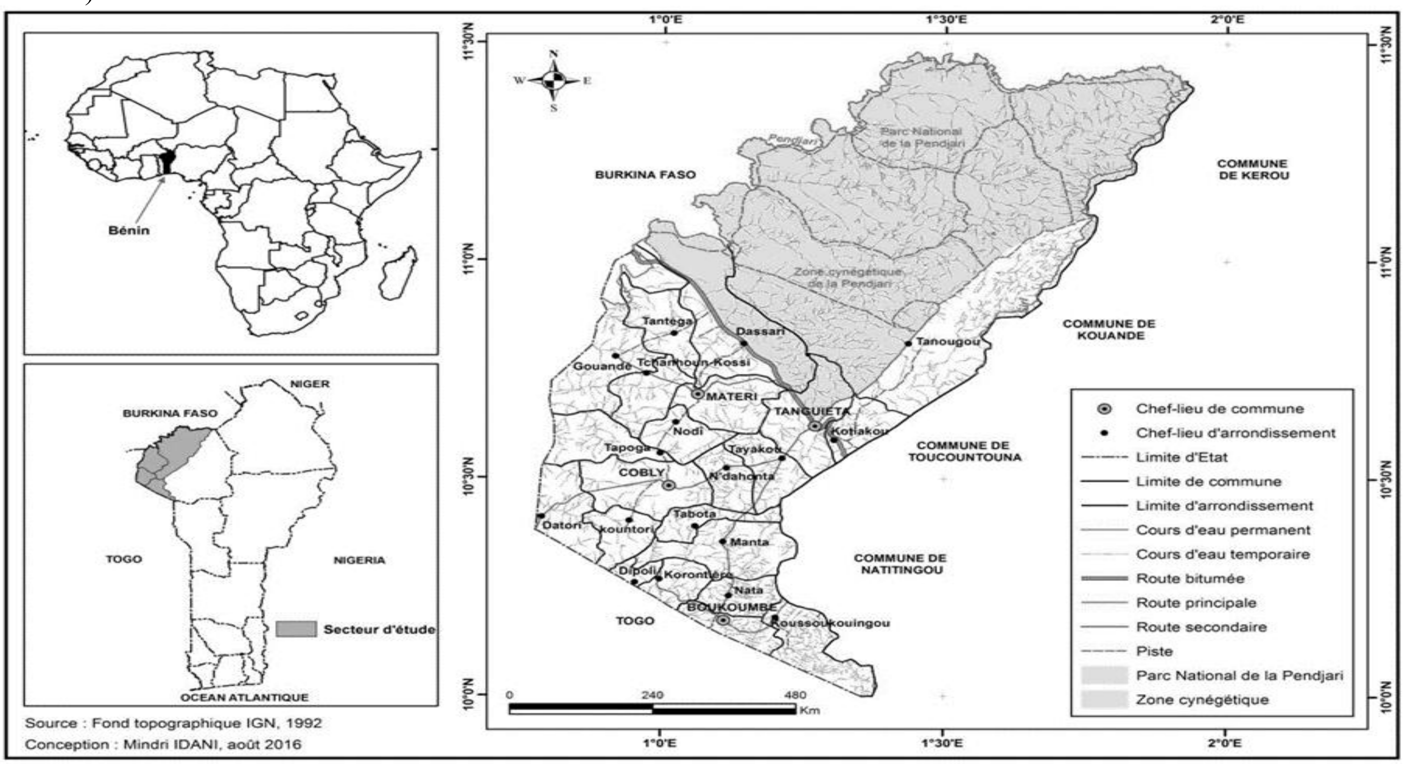

Figure 1 : Geographic area of interest

Table 1 : Food availability periods and agriculture calendar of study area (PAM, 2009)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Climate calendar	Dry season				Rainy season						Dry season	
Agricultural Calendar	Harvest	No farm activity			Planting			No farm activity		Harvest		
Food availability period	Abundance		Intermediate	Lean period					Intermediate	Abundance		

Sampling

Based on voluntary participation, 165 women of reproductive age were recruited from households benefiting from the AMSANA program. To recruit these women, information was disseminated in various intervention villages of the program, and a list was opened with program facilitators. Households interested in participating in the study were enrolled if they met the inclusion criteria. The selection criteria for the women in this study were based on four inclusion criteria: (i) being a woman aged 15 to 49 years and willing to participate in the study, (ii) being a member of a household benefiting from the AMSANA program, (iii) being available during the study period, (iv) residing in the study communes throughout the study period, and (v) consenting to provide necessary information for the study. Women provided their consent after they and their husbands received clear information and explanations about the objectives, duration, inclusion criteria, and purpose of this study.

In total, 170 households were registered; 165 households met the inclusion criteria, while 5 did not. Among the 165 households, one woman of reproductive age was selected. In cases where multiple eligible women were present, priority was given to the woman actively involved in the AMSANA program. If multiple women were involved in the program's activities, a random draw was conducted to select one woman.

Data Collection

The socio-demographic and food consumption data were collected using tools deployed on Android smartphones via the KoboCollect application. The collected socio-demographic data included the main source of income and marital status of the household head, age, and physiological status (pregnant, lactating, or neither) of the women of reproductive age. Individual interviews allowed obtaining the age from official documents (identity card and health record) or estimates in the absence of official documents. The women were asked to declare their physiological status, which was confirmed using their health records for those who had them.

Individual interviews with the women of reproductive age were used to collect information about their food consumption during a typical day. To reduce memory biases, the 24-hour recall method with multiple passes was used (Johnson et al., 1996; Gibson and Ferguson, 2008). During each data collection, the women were asked to indicate the foods and beverages they consumed in the 24 hours preceding the survey day. For each food mentioned, the women estimated the quantities ingested using pre-calibrated household utensils (bowls, spoons, ladles, cups, and calabashes), monetary values, and photographs of pre-calibrated meal portions. Moreover, food recipes consumed by the women and prepared within the household were described by the person responsible for cooking in the household. The description of the recipes included listing the names of ingredients composing the recipe and the quantity of each ingredient and the total recipe after cooking. For recipes consumed outside the household, an average recipe was established based on three recipes collected in the study area. A table for converting household units to the International System (grams) was established based on an average of five repeated weighings of each food using an electronic scale (precision 1 g and 5 kg capacity) in village and commune markets within the study area (Gibson and Ferguson, 2008). As a result, the estimated food quantities in household units were converted to their equivalent weight (grams). Additionally, shops and markets were visited to note the weights and nutritional compositions indicated on manufactured products consumed by the women (e.g., biscuits, canned goods, etc.).

A total sum (in grams) of the quantities ingested for each food was calculated for each woman and per month. The foods were then categorized, with some adjustments, into 12 food groups according to the FAO classification for calculating nutritional intake (Vincent et al., 2020). The adjustment involved merging the meat and poultry group with the fish group.

Description of Food Quantities and Nutritional Intake

Nutritional intake was calculated using the ingredient method recommended by Gibson and Ferguson (2008) and the FAO for the calculation of nutritional values per 100g of food portion (available online at https://www.fao.org/fileadmin/templates/food_composition/documents/upload/french/recipe_and_other_calculations-F.pdf) and the food composition table. The food composition table was compiled from food composition data obtained from previous research work conducted at the Human Nutrition Laboratory of the Faculté des Sciences Agronomiques de l'Université d'Abomey-Calavi (LNH/FSA/UAC) and data from the West Africa Food Composition Table (Vincent *et al.,* 2020). The calculation of nutritional intake using the ingredient method involves summing the corrected nutritional values of each ingredient. The correction of nutritional values involves applying retention factors to the raw nutritional values derived from the raw ingredients (Bognar, 2002). In this study, the retention factors were integrated into the compiled table to correct the nutritional values. The retention factors were calculated considering the food processing operations, such as cooking, frying, smoking, etc. (Bognar, 2002; FAO and Republic of Kenya, 2018; Vincent *et al.,* 2020).

Data Analysis and Statistics

Descriptive statistics and comparison tests were conducted using SPSS software, version 20.0. Proportions of socio-demographic characteristics, average daily quantities (g/day) of foods and food groups, median intakes of energy and nutrients, the proportion of women of reproductive age with adequate nutrient intake, and the average contribution of each food group to total nutrient intake were calculated using descriptive statistics.

The quantities of foods and median nutritional intakes were compared using generalized estimating equations. The Tweedie model and the logarithmic link function adapted to various types of distributions (symmetric and asymmetric) were employed. The Tweedie model also accounts for observed "zero" quantities for certain foods and non-linearity between dependent variables and predictors (Liang *et al.,* 1986; Hanley *et al.,* 2003). The difference between months is tested using the month with the lowest food/nutritional quantity as the reference.

Results

In total, 165 women of reproductive age constituted the initial sample, of which 13.3% were pregnant, 45.5% were lactating, and 41.2% were neither pregnant nor lactating. The mean age of the women was 29.5±7.8 years. More than three-quarters (78.8%) of the women lived in monogamous households, while 21.2% lived in polygamous households. Agriculture was the main source of household income (73.9%), followed by civil service employment (20.6%), craftsmanship (3.0%), and trade (2.4%).

The analysis of food consumption showed that women of reproductive age had a diet mainly composed of cereals (maize, rice, sorghum, millet, etc.) consumed as porridge or paste (prepared with flour and water), accompanied by sauces made from leafy vegetables (baobab leaves, okra, jute, etc.) and/or other vegetables (fresh or dried okra, sorrel, eggplant, tomato, chili, onion). The vegetable-based sauces were also enhanced with the addition of salt, soumbala, oil, and sometimes peanut paste and pieces of meat or soy cheese. Legumes, nuts, and seeds, which also play an important role in the women's diet, were mixed with cereals (rice, sorghum, or millet) and boiled to prepare dishes like "*watché*". They were also used as ingredients in the sauces that accompany cereal-based pastes. In the latter case, they were either directly crushed into paste (peanut, sesame, etc.) or hulled and prepared like other sauce ingredients.

The average daily quantities (g/day) of the main foods and food groups consumed by women of reproductive age during food available period (FAP) are presented in Table 2. With the exception of cereals, there were significant variations in the consumption of other food groups between different Food Availability Periods (FAP) with a p-value of less than 0.05. Cereal consumption, which was approximately 710 g (obtained in September) during the Intermediate FAP, decreased to 672 g in November and 703 g in January during the increased FAP. Cereal consumption during the decreased FAP was around 700 g. The main cereals consumed by women were maize, rice, sorghum, and millet. Maize was by far the most consumed cereal, accounting for more than 50% of the total cereal consumption regardless of the time of year. Maize consumption improved during decreased FAP and in September during intermediate FAP, while consumption of the other cereals decreased. Regarding pulses, their consumption during decreased FAP (133.0±152.5 g in May; 162.3±219.2 g in July) and intermediate FAP (110.9±233.4 g in March) was higher than that obtained during increased FAP (96.7±134.6 g in November and 103.8±137.9 g in January). The main pulses consumed in all periods was cowpea (more than 50% of the total legume quantity). The vegetable group, which includes leafy vegetables and other vegetables, was most consumed in September (191.5±204.5 g) during intermediate FAP. In increased FAP, vegetable consumption decreased to below 60 g before increasing again to 85.4±89.1 g in July during decreased FAP. The main vegetables consumed were leafy vegetables (baobab, okra, jute, etc.), fresh or dried okra, tomato, and chili. The consumption of other vegetables was higher during intermediate FAP (in September), while the consumption of leafy vegetables was higher during decreased FAP. In September, harvests from fields improved the availability of many vegetables, including tomato, okra, chili, sorrel, and eggplant. These vegetables are rare during increased FAP, and those available come from off-season crops, which are not widely practiced in the study area. In decreased FAP, the first rains promote the blooming of young shoots of plants, some of which are used for food, such as baobab leaves, sorrel leaves, sesame leaves, and other gathered leaves.

Fruits and animal products were consumed in small quantities in all food availability periods (FAP), except for intermediate FAP (March), where fruit consumption increased significantly. In fact, fruit consumption, which was below 100g in all FAP, rose to 1020.5±905.6 g in March during intermediate FAP. The peak fruit consumption in March is caused by an increase in the consumption of available and accessible fruits during this time of year. As for the consumption of eggs and dairy products by women, it was almost non-existent (less than 5 g for eggs and 40 g for dairy products). It should be noted that the consumption of dairy products tripled during decreased FAP (in May), reaching 36 g (compared to a maximum quantity of 11 g in other FAP). The quantity of meat, poultry, and fish remains low in all FAP (31 to 69 g).

As observed, the food consumption of women of reproductive age, except for cereals, was unstable between food availability periods. The quantities of foods rich in micronutrients such as fruits and animal products were consumed at low levels in all FAP. Despite the women having benefited from a multisectoral intervention, their food consumption remained relatively stable between food availability periods.

Table 2 : Average (mean ± standard) quantities (g/day) of the main foods and food groups consumed by women of reproductive age according to FAP

	Intermediate FAP	**Increased FAP**		**Intermediate FAP**	**Decreased FAP**	
Foods groups / Foods	**September 2018 (n=165)**	**November 2018 (n=158)**	**January 2019 (n=159)**	**March 2019 (n=136)**	**May 2019 (n=120)**	**July 2019 (n=149)**
Cereals	**709.7±486.8**	**672.2±397.4**	**703.8±394.6**	**641.5±455.8**^{ref}	**697.6±432.8**	**699.9±355.0**
Maize	587.2±483.1	466.0±337.1	465.7±337.7	431.2±371.0	507.2±426.2	562.9±305.0
Rice	70.6±158.1	150.1±221.6	155.5±188.7	155.0±197.7	122.8±176.3	125.4±200.9
Millet	16.3±91.7	21.7±113.1	52.8±218.3	20.3±98.0	26.4±111.1	6.4±47.3
Roots and tubers	**308.9±482.0**$^{\&}$	**193.0±322.9**$^{\&}$	**127.8±299.2**$^{\&}$	**39.5±154.0**	**21.4±58.0**^{ref}	**24.5±110.2**
Yams	297.1±465.4	131.0±289.1	119.3±295.0	38.2±154.1	11.1±48.7	11.9±102.8
Nuts and seeds	**18.0±66.8**$^{\&}$	**26.2±90.8**$^{\&}$	**13.6±45.5**$^{\&}$	**14.9±52.2**$^{\&}$	**5.9±16.3**^{ref}	**6.6±20.9**
Peanuts	14.1±64.6	25.6±90.4	11.6±44.4	9.5±47.0	5.5±16.3	6.3±20.6
Pulses	**84.1±168.1**^{ref}	**96.7±134.6**	**103.8±137.9**	**110.9±233.4**	**133.0±152.5**$^{\&}$	**162.3±219.2**$^{\&}$
Cowpea	75.5±161.9	53.8±99.2	72.5±116.2	79.9±187.3	96.4±125.8	91.4±158.9
Soybeans	7.3±31.1	19.0±60.5	16.2±40.0	15.5±49.6	9.7±26.8	7.7±34.7
Bambara groundnut	1.3±16.8	23.7±77.8	15.1±77.4	15.0±107.5	26.9±98.5	61.9±178.3
Vegetables	**191.5±204.5**$^{\&}$	**55.9±97.1**	**54.2±69.2**^{ref}	**58.9±127.4**	**56.5±66.1**	**85.4±89.1**$^{\&}$
Leafy vegetables $^{(1)}$	18.5±62.0	10.4±34.4	6.0±21.2	13.3±30.5	27.9±45.1	46.2±73.6
Vegetables rich in vitamin A $^{(2)}$	2.0±25.4	3.0±37.8	0.0±0.5	0.0±0.0	0.0±0.0	0.2±2.4
Other vegetables $^{(3)}$	171.0±190.8	42.5±82.5	48.1±66.4	45.6±123.9	28.6±44.2	39.0±62.7
Fruits	**14.5±156.3**	**65.6±213.0**$^{\&}$	**21.1±97.6**	**1020.5±905.6**$^{\&}$	**123.6±309.3**$^{\&}$	**7.6±72.1**^{ref}
Fruits rich in vitamin A $^{(4)}$	0.1±1.4	5.4±46.7	9.6±74.2	1015.9±907.9	3.6±39.1	0.0±0.0
Other fruits $^{(5)}$	14.4±156.3	60.3±205.0	11.5±54.4	4.6±39.0	120.1±308.3	7.6±72.1
Meats. poultry. and fish	**69.4±147.6**$^{\&}$	**36.0±71.3**	**54.1±92.2**$^{\&}$	**86.2±151.6**$^{\&}$	**36.8±60.5**	**30.5±60.0**^{ref}
Dairy products	**11.0±73.6**	**4.1±30.2**	**2.9±19.4**	**1.7±18.0**	**36.8±176.5**$^{\&}$	**1.2±9.3**^{ref}
Eggs	**3.2±27.0**	**5.5±50.6**	**0.0±0.0**	**1.5±9.4**	**3.7±19.9**	**0.0±0.0**^{ref}
Beverages	**158.8±375.5**$^{\&}$	**133.7±452.0**$^{\&}$	**153.1±517.8**$^{\&}$	**321.6±1010.5**$^{\&}$	**218.2±606.7**$^{\&}$	**36.7±228.9**^{ref}
Miscellaneous	**28.5±93.0**	**30.1±46.0**	**27.8±47.6**	**19.6±41.2**	**25.5±24.6**	**25.7±25.1**^{ref}
Oils and fats	**28.3±61.3**	**31.7±45.9**	**34.9±65.3**	**24.8±38.2**	**35.9±52.0**	**38.1±66.5**^{ref}

Note: Food intakes have an asymmetric distribution. The P-value is used to test differences between months, using the month with the lowest food consumption (g/day) as the reference. Food group composition: (1) Baobab leaves, okra, jute, sorrel, cowpea leaves, and other forest leaves; (2) Carrot, squash; (3) Okra, tomato, chili, eggplant, sorrel fruit, onion; (4) Mango, soumbala fruit, annona, baobab fruit; (5) Orange, lemon, shea butter, vitex, ebony, baobab. **Significance:** The Tweedie model and the logarithmic link function were employed to compare average quantities (g/day) of food groups. The reference is the month with the lowest food consumption, used as the reference in multiple comparisons; & months that show a significant difference from the reference month ($p<0.05$).

The results from Table 3 indicate that, except for lipids, the nutritional intakes of women differ significantly between food availability periods (FAP; $p<0.05$). The highest intakes were observed during the Intermediate FAP (March and September) for energy (8917.1 KJ), iron (23.0 g), zinc (7.2 g), vitamin A (3476.5 µg), and vitamin C (580.4 g). In contrast, the lowest intakes for energy (5754.2 KJ), iron (18.0 g), and zinc (5.2 g) were found during the decreased FAP (July), and the lowest intakes for vitamin A (88.5 µg) and vitamin C (5.8 g) were observed during the increased

FAP (November and January) (Table 3). The energy intake primarily came from carbohydrates (56.5% to 68.2%), followed by lipids (17.5% to 24.6%) and proteins (9.5% to 11.9%) (Fig. 2).

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Table 3: Median intakes of energy and nutrients by women of reproductive age during food availability periods (FAP)

Nutrient	September 2018 (n=165)	November 2018 (n=158)	January 2019 (n=159)	March 2019 (n=136)	May 2019 (n=120)	July 2019 (n=149)
			Median (25th-75th percentile)			
Energy (KJ)	8207.8 (4756.5-11483.1)[&]	6702.5(4831.3-9966.4)[&]	6356.4(4126.5-9509.6)	8917.1(6232.0-12873.1)[&]	6555.2(4467.1-9953.5)	5754.2(3566.6-8678.6)[ref]
Protein (g)	47.3 (24.9-77.2)[&]	37.6 (26.8-57.5)	38.5 (25-65)	42.6 (26.5-64.5)[&]	36.7 (20.0-60.2)	30.9 (21-53.4)[ref]
Carbohydrates (g)	282.3 (161.8-470.4)[&]	245.8 (171.7-351.8)[&]	217.9 (140.6-313.9)	377.9 (216.8-499.5)[&]	225.3 (152.2-357.4)	203.4 (136.4-304.6)[ref]
Lipids (g)	33.9 (15.9-65.1)	37.9 (14.9-72.9)	34.5 (13.0-64.2)	36.5 (13.4-62.0)	35.2 (14.7-64.8)	30.1 (10.8-59.9)[ref]
Iron (mg)	23.0 (13.6-37.0)[&]	18.7 (12.0-27.4)[&]	19.2 (10.7-29.1)[&]	22.5 (14.2-29.9)[&]	18.7 (11.5-29.9)	18.0 (12.8-24.8)[ref]
Zinc (mg)	7.2 (4.4-12.2)[&]	6.8 (4.1-9.7)[&]	6.1 (3.8-9.6)	6.8 (4.3-9.8)[&]	6.0 (3.6-9.4)	5.2 (3.7-8.0)[ref]
Vitamin A (RE. µg)	98.7 (59.4-199.5)[&]	88.5 (55-180.3)[ref]	92.9(44.6-180)[&]	3476.5 (915-6581)[&]	160.5 (86.0-347)[&]	164.3 (85-317)[&]
Vitamin C (mg)	53.7 (25.3-102.7)[&]	14.9 (1.4-66.3)	5.8 (1.5-33.4)[ref]	580.4 (158-1088)[&]	14.9 (3.8-44.5)	12.3 (4.3-24.1)[&]

The Tweedie model and the logarithmic link function were employed to compare Median intakes of energy and nutrients. The P-value was used to test differences between months, using the month with the lowest intake as the reference, adjusted for the main household activity, marital status of the household head, sex, and age of the woman. Significance: ref. refers to the month with the lowest food consumption, used as the reference in multiple comparisons; & indicates months that show a significant difference from the reference month ($p<0.05$).

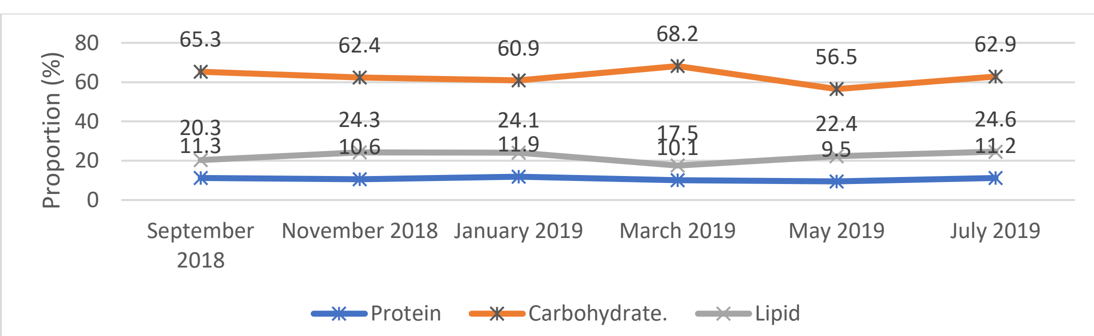

Figure 2: Contribution of macronutrients to the energy intakes of women of reproductive age during food availability periods (FAP).

Like nutritional intakes, the adequacy rates of vitamins (A and C) and minerals (iron and zinc) during the Intermediate FAP are higher than those of other food availability periods ($p<0.05$; Fig.3). The highest adequacy rates for vitamins (A and C) and minerals (iron and zinc) were found in the months of March and September during the Intermediate FAP. However, during the decreased FAP (July), the adequacy rates for minerals and vitamins (except vitamin A) were lower than those of other food availability periods. Furthermore, most women (>50%) did not achieve adequate intakes of iron, zinc, vitamin A, and vitamin C during all food availability periods, except for vitamins during the Intermediate FAP. It is evident that despite benefiting from the AMSANA program intervention, most women did not meet the recommended minimum intakes.

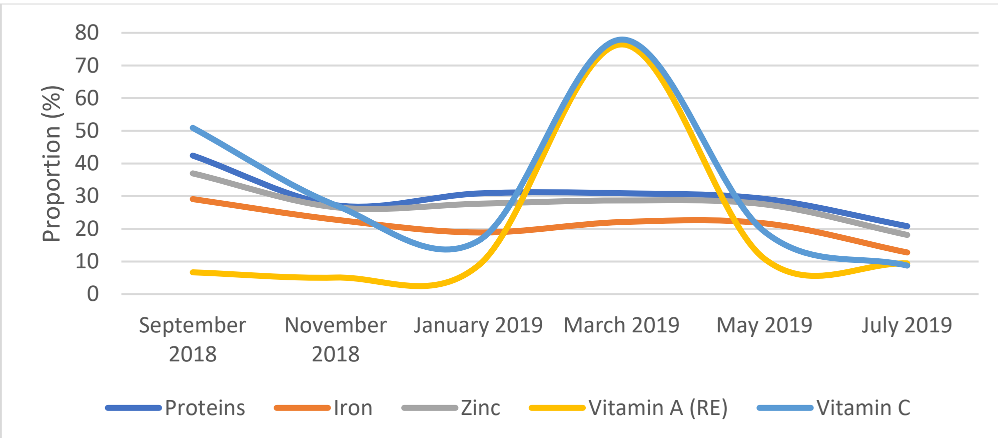

Figure 3: Percentage (%) of women of reproductive age with adequate intake of protein, iron, zinc, vitamin A, and Vitamin C during different food availability periods (FAP). Recommended nutrient intakes by FAO/WHO (FAO/WHO, 1985; FAO/WHO, 2001)

Discussion
The main research question of this study was: To what extent are the dietary consumption and nutritional adequacy of women of reproductive age, beneficiaries of a multisectoral intervention, affected by the effect of seasonal food availability periods (FAP) in the northwest of Benin? To address this question, the study was conducted among beneficiaries of the AMSANA program implemented in the Atacora department in the northwest of Benin. The Atacora department was selected due to the prevalence of malnutrition, especially its persistence among children and women of reproductive age. The department is also characterized by a seasonality of food availability that exacerbates malnutrition. The results of this study found that the dietary pattern of women is characterized by a high consumption of cereals, roots, and tubers in the form of a paste accompanied by vegetable-based sauces. However, the consumption of fruits and animal products was less prominent in the diet of women during all FAPs (except for fruits in Intermediate FAP). This dietary pattern is like that regularly described in the study area (Ategbo, 1993; PAM, 2017) and in most vulnerable households in Sub-Saharan Africa (Lourme-Ruiz *et al.,* 2016; Waswa *et al.,* 2021). In terms of quantity consumed by women, only the consumption of cereals did not vary significantly between FAPs ($p>0.05$). The quantities of cereals consumed by women fluctuated between 650 g to 710 g during different FAPs. The few variations in cereal consumption between FAPs is a different result from what is usually observed in the study area. Typically, during the decreased FAP, most households often have reduced food stocks, resulting in increased risk of malnutrition due to food scarcity (Mitchikpè, 2007). The fact that cereal consumption varied very little could indicate a positive effect of the AMSANA program intervention, which supported the production, post-harvest management, and consumption of cereals and vegetables throughout the year. The program focused on ensuring the stability of maize availability and consumption during the increased FAP/harvest, which can be objectively verified. Results from the final evaluation of the AMSANA program showed an increase in maize yield of 1.15t/ha (1.11t/ha to 2.26t/ha) among beneficiary producers compared to 0.61t/ha (1.11t/ha to 1.72t/ha) for non-beneficiaries. These positive outcomes were mainly attributed to factors such as yield/production improvement, reduction of post-harvest losses, and measures against food waste (group sales and warrantage). The program aimed to increase maize production to improve the duration of food stocks and reduce or eliminate food scarcity during the lean period. By

the end of the program, the proportion of beneficiary households with sufficient maize stocks to cover their food needs during the lean FAP had increased from 54% in 2016 to 78% in 2019. In contrast, the proportion of non-beneficiary households with sufficient maize stocks had decreased from 54% in 2016 to 49% in 2019.

In the study area, households tend to reduce the number and consistency of meals during the decreased FAP (PAM, 2017). Thus, maintaining the same number of meals (at least 3 meals/day) and consistency throughout the decreased FAP helps to highlight households' resilience to food insecurity. The proportion of beneficiaries who maintained the same number of meals and consistency from the increased FAP to the decreased FAP increased from 12% at the start of the program to 70% at the end of the program in 2019. Among non-beneficiary households, this proportion increased from 12% to 64% at the end of the program. Other studies have also indicated that improved agricultural production positively affects household food security in Benin (PAM, 2017; Yessifou *et al.,* 2021). Agriculture is still considered a vital pathway to impact household food security and nutrition (SPRING, 2014; FAO, 2015).

Unlike cereals, vegetable consumption showed significant variation between FAPs ($p<0.05$). Throughout all FAPs, the average daily consumption of vegetables was below the recommended minimum quantity of vegetables in the Benin dietary guidelines (approximately 200g/day, https://wiredhealthresources.net/presentations/82/story_content/external_files/Benin.pdf). This could potentially lead to insufficient intake of micronutrients. The promotion of vegetables by the AMSANA program did not result in sufficient vegetable consumption by the women. This outcome could be attributed to the program's focus on promoting diversity in food without specifically emphasizing increased vegetable quantities. Most reports describing dietary consumption in the study area rarely emphasize the quantities of consumed foods. Programs relying on such reports are often designed to improve dietary diversity without detailed attention to consumed quantities. However, it is known from the literature that improvements in production do not necessarily lead to dietary improvements. Consumption and dietary habits are also influenced by cultural practices. A woman who experiences an increase in vegetable production may not significantly modify the quantities of vegetables in her meals; she might instead focus on traditional preparation methods. Such culinary practices are unlikely to influence the quantities of vegetables consumed. On the other hand, increased production could improve the availability of vegetables in households over time. The analysis of vegetable consumption trends between FAPs revealed that vegetables, including leafy greens and other varieties, were consumed most during the Intermediate FAP (September) and the decreased FAP (July). In September, harvests contribute to increased availability of various vegetables, including tomatoes, okra, chili peppers, sorrel, and eggplants. These vegetables are less available during the increased FAP, and those that are available come from off-season harvests, which are less common in the study area (PAM, 2017). In the decreased FAP, the first rains promote the growth of young shoots of plants, some of which are used for food. This is the case with baobab leaves, sorrel leaves, sesame leaves, and other leaves collected from the wild. These findings align with previous studies that reported increased fruit and vegetable consumption during the decreased FAP (Ategbo, 1993; Mitchikpè *et al.,* 2008; Arsenault *et al.,* 2014; Kombienou, 2017). The consumption of fruits and animal products remained low in all FAPs. Egg consumption was less than 5g regardless of the FAP; dairy product consumption was less than 40g, and the meat, poultry, and fish group consumption ranged from 31g to 69g. All these animal product quantities are lower than the recommended average quantities for women of reproductive age in the Benin dietary guidelines.

As observed, the dietary consumption of women of reproductive age remained low and unstable between FAPs, except for cereals. The dietary consumption trends were similar to those described in previous studies in the study area, even those conducted decades ago (Ategbo, 1993). This suggests a limited effect of the AMSANA program in ensuring sustainable quality nutrition for women of reproductive age. This could be attributed to the program's limited focus on promoting cereal (maize) and vegetable production and consumption. Although the program aimed to promote dietary diversity, it did not support the production of animal products, fruits, and legumes. Yet, these food items have long been identified as deficient in household diets and a source of micronutrient deficiencies (Atégbo, 1993; Mitchikpè, 2007; Savy *et al.,* 2006; Martin-Prevel *et al.,* 2013). Additionally, increased beneficiary knowledge does not necessarily lead to improved practices. Another program implemented in the study area found high proportions of women who had better knowledge of diversified meals but very few had improved their dietary diversity (GIZ, 2021). The dietary consumption discussed above consequently resulted in insufficient and unstable nutritional intakes between FAPs. Energy intakes varied from 5750 KJ (July in the decreased FAP) to 8920 KJ (March in the Intermediate FAP). These intakes are lower than those reported by Ategbo (1993) in the same study area, ranging from 5.3 MJ to 5.5 MJ per day. The decreased FAP presented the lowest energy intake, which is typically described in the study area. The decreased FAP is known to be a period when energy intake is lower, leading to an increase in the number of children and women suffering from acute malnutrition or thinness. Energy intake was not the only nutritional intake that was consistently low throughout the year. Vitamin intakes (A and C) were also low, except during the Intermediate FAP (March) when a significant increase in intake was observed. This increase in vitamin intake is linked to the higher consumption of available and accessible mangoes during this period. Mangoes are an important source of vitamin A and vitamin C (Vincent et al., 2020). Like energy intake, iron intake was lower compared to previous studies by Ategbo in the same study area about three decades ago (Ategbo, 1993). However, vitamin A intakes during the increased FAP (November and January) and in March during the Intermediate FAP were higher than those reported by Ategbo (1993). During the decreased FAP, vitamin A intake was lower than that reported by the same author for the same period. Nevertheless, our results align with those of Arsenault et al. (2014) in Burkina Faso and Waswa et al. (2021) in Kenya, who also found that iron and zinc intakes of women of reproductive age were higher during the decreased FAP compared to the other food availability periods.

The adequacy rates of vitamins (A and C) and minerals (iron and zinc) were higher during the Intermediate FAP compared to the other food availability periods ($p<0.05$). The highest adequacy rates for vitamins (A and C) and minerals (iron and zinc) were found in March and September during the Intermediate FAP. However, during the decreased FAP in July, the adequacy rates for minerals and vitamins (except vitamin A) were lower than those of the other food availability periods. Furthermore, most women (>50%) did not have adequate intakes of iron, zinc, vitamin A, and vitamin C during all food availability periods, except for vitamins during the Intermediate FAP (Vitamin C in September and March; vitamin A in March). Iron, zinc, vitamin A, and iodine intakes are often deficient and constitute a public health problem in developing countries (Latham, 2001; Gibson and Ferguson, 2008). It is evident that, despite benefiting from the AMSANA program intervention, most women did not meet the recommended minimum intakes. However, other studies in the study area had previously revealed acceptable access to food for at least 90% of households (Nagassi *et al.,* 2023) and at least 50% of women achieving minimum dietary diversity during the months of March in the Intermediate FAP and May and July in the decreased FAP (Nagassi *et al.,* 2021). Other multisectoral interventions have also not found a positive impact on the dietary quality of women of reproductive age, even if the household's access to food has improved. This was the case in Malawi with the "Integrating Nutrition in Value Chains Project (INVC)" implemented from 2012 to 2016, where the intervention did not impact the consumption of micronutrient-rich foods (Feed The Future, 2015; USAID Malawi, 2015).). In Guatemala, the intervention did not improve underweight among women of reproductive age. In contrast, other programs in Burkina Faso and Bangladesh had an impact on underweight, anemia, and energy deficiency among women of reproductive age at the end of the intervention. These programs had in common the promotion of production and consumption of specific micronutrient-rich foods (Olney *et al.,* 2015; Sekander *et al.,* 2018). Therefore, it can be assumed that the limited coverage of nutritional requirement may be associated with the absence of a specific focus on promoting specific micronutrient-rich foods. This could potentially contribute to the increasing trend of anemia in the study area (from 41% in 2012 to 58% in 2018) despite various interventions (INSAE and ICF., 2019). Interventions must focus on improving dietary diversity to prioritize the enhancement of nutritional adequacy for beneficiaries. It is crucial to improve the availability and access to high-nutrient-value foods, such as animal products, vitamin A-rich fruits, and iron-rich vegetables**.**

Conclusion

In conclusion, this study has demonstrated that the AMSANA program intervention did not ensure that women had sufficient and consistent dietary and nutritional intake across food availability periods. In almost all periods, women did not meet their requirements for iron, zinc, vitamin A, and Vitamin C. The dietary pattern of women remained unchanged compared to the one previously described despite the AMSANA program intervention. There was a low consumption of high-nutrient-value foods such as animal products and fruits. This limited influence of the AMSANA intervention on women's dietary and nutritional intake may explain the persistence of malnutrition among women in the Atacora department. Multisectoral interventions could be designed to integrate the production and consumption of these locally deficient nutrient-rich foods. This integration could be achieved through an assessment of existing nutrient-rich foods, followed by promoting their production to enhance their availability. Examples of nutrient-rich foods, such as mung beans (green lentils) and orange-fleshed sweet potatoes, which have been promoted by various programs, could serve as models to follow. It is crucial to strengthen multisectoral interventions with a focus on improving the availability of nutrient-rich foods. Considering the results obtained for women, a study examining the effect of food availability seasonality on nutritional intakes of other vulnerable members, particularly children under 5 years old, would complement the analysis of the impact of multisectoral interventions on nutrition improvement in the northwest of Benin.

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