Orange Flesh Sweet Potatoes (*Ipomea batatas*) Consumption for Food Diversification and Nutritional Security of Cocoa Producers' Population in Nawa Region, Côte d'Ivoire

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Abstract Cocoa producers' communities are affected by malnutrition due to lake of food diversification. To initiate food diversification program with orange sweet potatoes, households eating habits and staple food composition have been evaluated. An assessment of 91 households' food habits was carried out in 5 localities of Nawa region (Côte d'Ivoire). Anthropometric measurements were performed for children among 6 and 59 months. Dry matter, total sugars, proteins and minerals were determined for the usual staple food and orange sweet potatoes. The results showed that households' food diversity score is 5.2, indicating that diet is less diversified. The major staple food are yams (36.7%), rice (29.6%) and cassava (17.4%). Sweet potatoes are more cultivated and consumed by native immigrant from the North of Côte d'Ivoire. Children nutritional status revealed that global acute malnutrition prevalence is 6.4% (95% Confidence Interval (CI): 3.0, 13.1%), chronic malnutrition prevalence is about 54.3% (95% CI: 44.2, 64.1%) and underweight prevalence is 31.9% (95% CI: 23.4, 41.9%). The staple food nutrients analyses revealed that rice has the most proteins content 5.0%. Orange flesh sweet potatoes have high content in total sugars (78.2 g/100g dry matter (DM)), zinc (3.3 mg/100g DM), magnesium (27.6 mg/100g DM), potassium (558.0 mg/100g DM) and calcium (388.5 mg/100g DM). Yam contains more potassium (730.8 mg/100g DM) and cassava more iron (18.2 mg/100g DM). Orange sweet potatoes which are cultivated by a few producers contain high level of micronutrients. They could be therefore recommended for culture and food diversification and contribute to overcome children malnutrition.

Keywords: sweet potato, Nawa region, cocoa producer, food diversity, nutrients

1. Introduction

The increase of world food prices in 2008 showed the failure of all food security policies undertaken during several decades in sub-Saharan Africa countries [1]. Thus, Côte d'Ivoire, where the agriculture sector is the backbone of the economy, did not escape from this food prices crisis. This country produces several types of crops comprising food and cash crops. Among the cash crops, cocoa contributes about 15 % of the country's Gross Domestic Product [2], 40% of its exports, and supports more than 6 million people, particularly smallholder farmer's households. Indeed, Côte d'Ivoire is the world's largest cocoa producer, with more than a third of the global supply and the NAWA region (in South-West of Côte d'Ivoire) provides 40 % of cocoa production [3]. However, in this agriculturally rich area, chronic malnutrition level is precarious (27.1%) [4]. Moreover, a mapping of malnutrition in the major cocoa producing areas (including Western, Central Eastern, Southern and South-Western parts of the country) revealed stunting rates of 25 to 34% [5]. This is due in part to the fact that, in response to the demand, cocoa productivity and yield have been increased (during the 15 last years) to the detriment of food crops. This phenomenon has caused a food crisis, resulting in the shortage of major food crops on the local markets [6]. But,

several other factors can be also involved in malnutrition e.g. food insecurity, poor health, poor maternal and child-care practices (including inadequate breastfeeding and nutritious complementary feeding for children) and poor food choices meaning lack of food diversification [7].

There is a need to diversify cultures and diet by urging population to grow and consume nutritious food rich in macronutrients and micronutrients. In fact, a previous study has revealed that, among cocoa producers of the Nawa region, staple foods are yam, rice and cassava and foods rich in proteins (meat, beans) and micronutrients (vegetables) are less consumed [8]. However, food practices based on cereals, roots and tubers (sources of starch) consumption without enough proteins and micronutrients can favor nutritional deficiencies [9]. To improve culture and diet, sweet potatoes could be introducing in cropping systems because for this plant, both leaves and tubers are edible. Leaves should contribute to provide minerals and proteins and tubers should provide energy and carotene (vitamin A), particularly the flesh orange varieties. But, this plant is cultivated by a few producers, particularly the immigrants from North Côte d'Ivoire who represent 23.4% of cocoa producers' population [6].

To achieve this objective, a study was conducted among cocoa producers' communities. Sweet potatoes cultivation and consumption questionnaire and 24 hours recall were administrated to households. Anthropometric measurements were taken to assess children malnutrition prevalence. Usual staple foods and sweet potatoes composition were also analyzed to appreciate the impact of sweet potatoes in food diversification.

2. Material and Methods

2.1. Sampling

The survey was conducted in 5 villages (Petit-Bouaké, Petit-Yamoussoukro, Gnogboyo, Kipiri and Dioulabougou) of the NAWA region localized in South-west Côte d'Ivoire (Figure 1). In these villages a MARS-ICRAF vision for change program (V4C) on cocoa plantation rehabilitation and communities' development is implemented.

The choice criterion was villages' population origin because diet is generally linked to culture. Indeed, Petit-Bouaké and Petit-Yamoussoukro were formed by people native from Center Côte d'Ivoire essentially, Dioulabougou was composed by immigrant from North Côte d'Ivoire and Gnogboyo and Kipiri were mixed villages (native of the region, immigrant from the country and the border country).

A total of 185 cocoa producers' households were enumerated in the 5 villages. Households sample size (91) was calculated in equation (1) according to [10] and with the expected malnutrition prevalence of children cocoa producers (49%) determined in a previous baseline study on children nutritional status conducted in 2014 in 38 villages of the region [8].

$$n = N \times p \qquad (1)$$

n: sample size
N: enumerated households
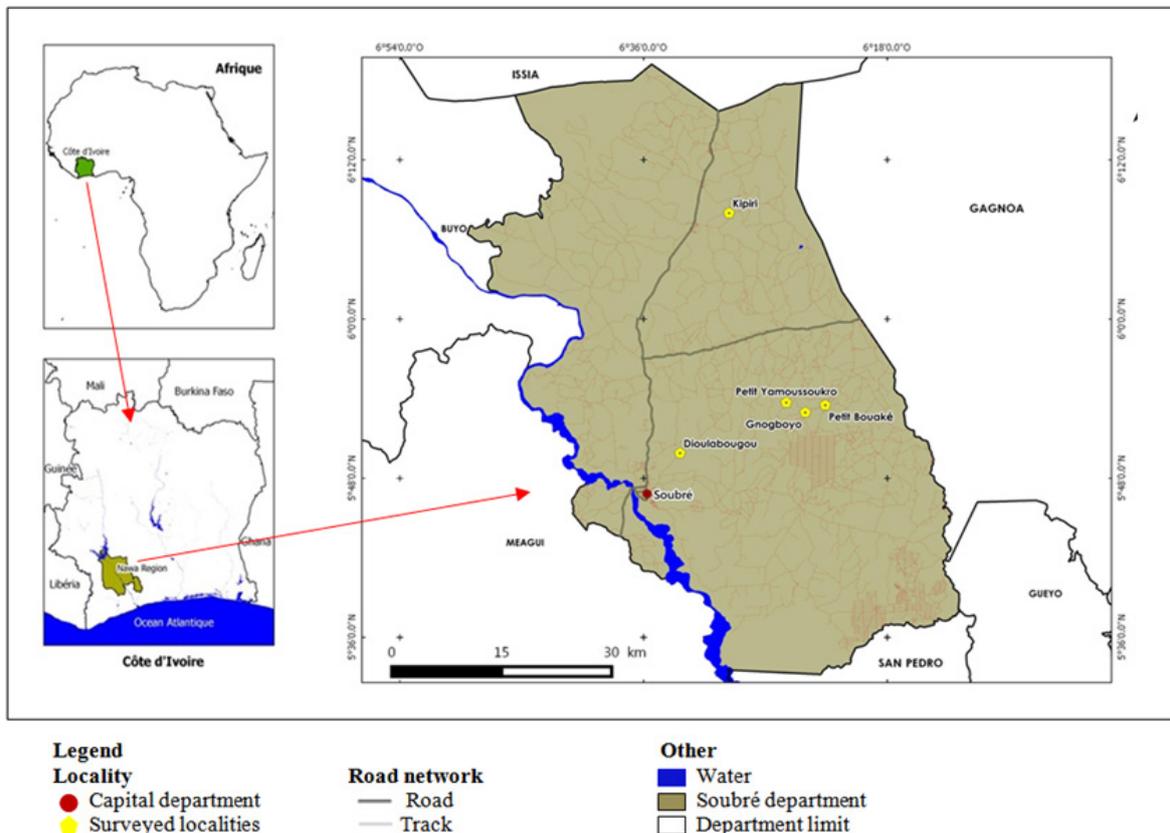p: malnutrition rate of studied population.

Figure 1. Nawa region map and the surveyed localities

The selection of children aged between 6 and 59 months was done in the surveyed households so that, in one household, only one child of the surveyed mother, among those aged between 6 and 59 months, has been considered. The child has been designated by the mother. An exception has been made for households with twins. In this case, both children participated to the survey because they have the same age and it was not interesting to choose one of them as they are twins. Children aged have been got by consulting birth certificate or child Health-Passport. So, a total of 95 children were selected for anthropometric measurements, including 04 twins.

2.2. Selection criteria

2.2.1. Inclusion Criteria

- Cocoa producers' households
- Only one child aged between 6 and 59 months for each household except in four households where twins were considered. This age limit was chosen because it defined the childhood period and because children food diversification begins at 6 months [11]
- Be present during the survey
- Have parents' acceptance

2.2.2. Exclusion criteria

- No cocoa producers' households
- Children 0-5 months aged and children older than 59 months
- Sick children
- Refusal of parents

2.3. Survey questionnaire

The survey data were collected by trained enumerators. Three questionnaires were administrated:
- a 24-hours recall which allowed determining household dietary diversity score [12]
- a food consumption frequency questionnaire [13]
- a questionnaire on sweet potatoes cultivation and consumption.

2.4. Anthropometric measurements

Anthropometric measurements were taken on children by professional caregivers who were trained before data collection. Weight and height were determined using standard measurement tools. The weight of children over 2 years was determined from direct weighing performed on digital weighing scales (SEKA, precision 100g). Children less than 2 years weight was determined by the method of double weighing: mother first and then mother and her child. On the other hand, the height of children over 2 years was measured to the nearest mm using a wall height gauge (graduated in cm) in the standing position. Children less than two years height was measured in the supine position using UNICEF-like fathom wood [14].

Children nutritional status was assessed using the usual index based on combinations of weight, height and age [15].

2.5. Free consent

This study has been approved by the National Ethical and Research Committee of Côte d'Ivoire (030/MSLS/CNER-dkn). In each village, authorities were contacted and informed before enumerators and caregivers' arrival. Free and written informed consent to participate to the survey was obtained from each household head for interviewing mothers and for taking anthropometric measurements on children.

2.6. Food nutritional analysis

After the survey, each household was asked to give a raw portion of their usual staple food (yam, rice, cassava) and sweet potatoes eventually. For sweet potatoes, two cultivars were collected: orange flesh with white skin and orange flesh with red skin.

Before the analysis, each food was cooked with water. For yam, cassava and sweet potato, 4 kg of sample were cooked in 800ml of water and for rice 250g was cooked in 500 ml of water. Cassava, yam and sweet potatoes were sliced in millimeter and all samples (including rice) were dried in an oven at 55 °C for 3 days [16]. Then, the dried samples were ground using an electric crushing (Moulinex). The flours were put in airtight conditioner and stocked in the oven at 45 °C before analysis.

Dry matter and proteins (N x 6.25) content were determined according to AOAC [17]. Total soluble sugars were extracted with ethanol 80% (v/v) and analysed with phenol-sulphuric acid method [18]. Calcium, zinc, potassium, magnesium and iron were determined using Atomic Absorption Spectrophotometer (type 20 VARIAN) at their specified wavelengths (422.7 nm, 213.9 nm, 766.5 nm, 285.2 nm and 248.3 nm) [19].

2.7. Statistical Analysis

Anthropometric data were analyzed using ENA (2011) (Emergency Nutrition Assessment) software. The other data were analyzed with STATISTICA (7.1) software. A one-way ANOVA was performed and when a significant difference was observed, Duncan test was applied ($p \leq 0.05$).

3. Results

3.1. Socio-demographic characteristic and households' food diversity score

Cocoa producers' population is dominated by immigrant's native from the other parts of the country and from the border countries. Around 6.7% of them grow sweet potatoes, localized as follow: 20% in Dioulabougou and in Petit-Yamoussoukro and 60% in Gnogboyo (Table 1). Generally, potatoes are cultivated by women both for household consumption and for income generation by selling them in market. The average households' food diversity score is 5.2, varying from 2 to 9. About 36.0% of households reached a high level of food diversity score while 36.7% have an acceptable level and 27.3% a low level (Table 2). The most consumed staple foods are yams (36.7%), rice (29.6%) and cassava (17.4%). Sweet potatoes are rarely consumed (1.02%) (Figure 2).

3.2. Children overall nutritional status

Global acute malnutrition prevalence are 6.4% (95% CI : 3.0, 13.1%). The moderate form is 3.2% (95% CI: 1.1, 9.0%) and the severe form is 3.2% (95% CI: 1.1, 9.0%).

The distribution curve of children is below the reference curve and the average index is 6.1 ± 1.6 (Figure 3). Acute malnutrition according to MUAC is 2.1% (95% CI: 0.6, 7.4%). There is any severe form. Children global chronic malnutrition prevalence is about 54.3% (95% CI: 44.2, 64.1%) with 13% (95% CI: 7.6, 21.4%) for the moderate form and 41.3% (95% CI: 31.8, 51.5%) for the severe form. The distribution curve of children height-for-age index is offset from the reference curve and the average index is -2.5 ± 2.1 z-scores (Figure 4). Children global underweight prevalence is 31.9% (95% CI: 23.4, 41.9%). The moderate form is 21.3% (95% CI: 14.2, 30.6%) and the severe form is 10.6% (95% CI: 5.9, 18.5%). The distribution curve of children weight-for-age index is offset from the reference curve and the average index is -1.3 ± 1.4 z-scores (Figure 5).

Table 1. Villages' population origin and repartition of sweet potatoes farmers

Villages	Natives (%)	Internal Imm. (%)	Imm. from border country (%)	Sweet potato Producers (%)	Sweet potatoes Producers origin
Dioulabou- gou	0	86.7	13.3	20.0	Imm. from North CI
Petit-Bouake	0	75.9	24.1	0	
Petit-Yakro	0	100.0	0	20.0	Imm. from Center CI
Gnogboyo	33.3	33.3	33.3	60.0	Imm. from North, Center and countries border CI
Kipiri	47.1	20.0	32.9	0	

Imm.: Immigrants
CI: Côte d'Ivoire

Table 2. Food diversity score

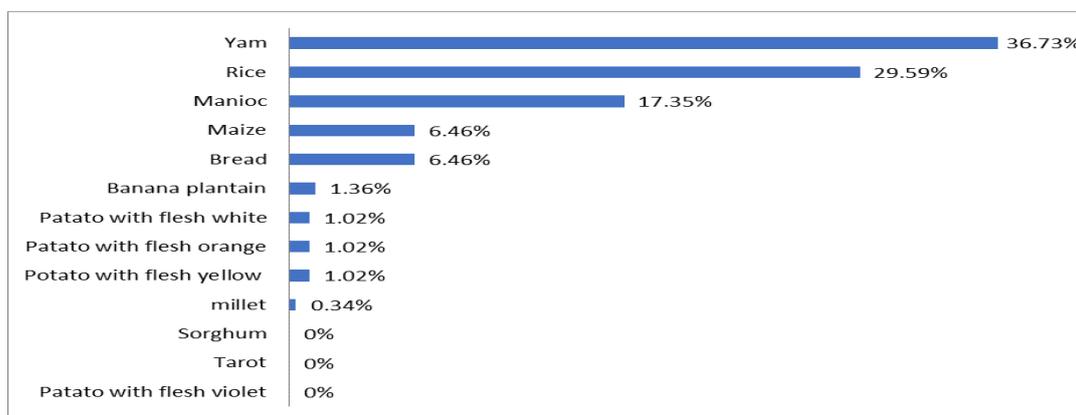| Score level	Households rate (%)	Food groups
Low dietary diversity score (< 5)	27.3	Cereals, Spices, condiments, drinks
Average dietary diversity score (= 5)	36.7	Cereals, Vegetables, Fish Oils, Spices, condiments, drinks
High dietary diversity score (> 5)	36.0	Cereals, Roots and tubers Vegetables, Poisson, Milk and dairy products, Oils, Sugar, Spices, condiments, drinks

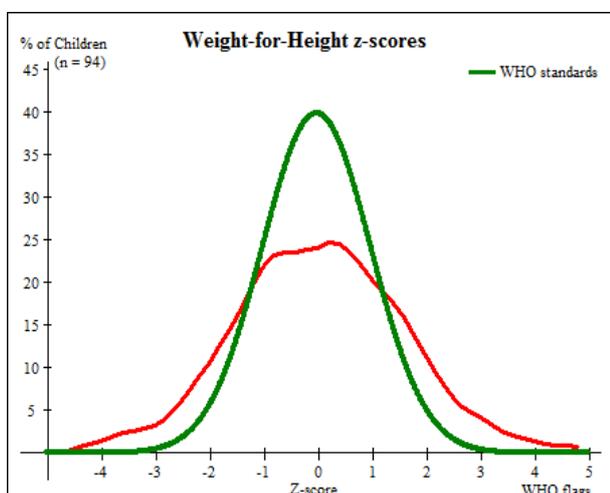**Figure 2.** Food consumption frequency

Figure 3. Distribution of Weight-for-Height index regarding population reference WHO 2006
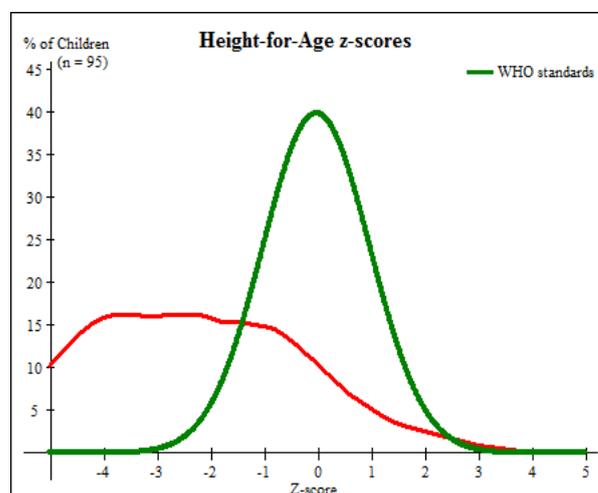

Figure 4. Distribution of Height-for-Age index regarding population reference WHO 2006
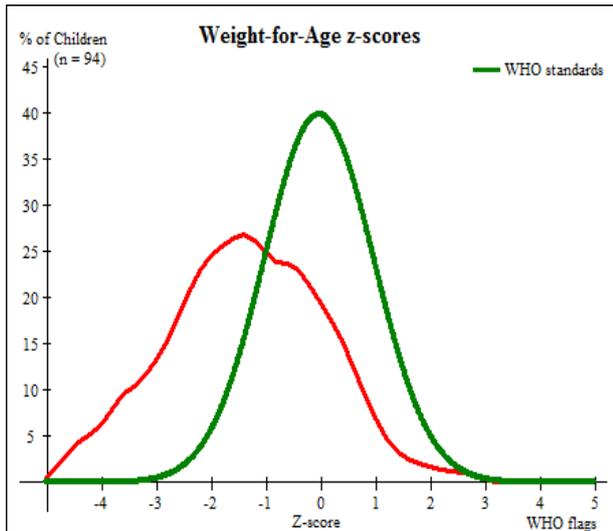
Figure 5. Distribution of Weight-for-Age index regarding population reference WHO 2006

3.3. Staple food nutritional composition

Staple food dry matter varied between 28.1 % (potato with orange flesh and white skin) and 37.4 % (rice) and differed significantly at the threshold of 0.05% (Table 3). There is also a significant difference between foods for total sugar contents. Orange sweet potatoes have the highest rate (78.2 and 60.1 g/100g DM), rice and yam the lowest one (29.4 and 30.4 g/100g DM respectively). Proteins rate is not elevated in rice (5.0%) but this value is higher than that of orange flesh potatoes with white skin (2.9%), cassava (0.9%) and orange flesh potatoes with red skin (1.0%). Minerals content is indicated in Table 4. Zinc rate is high in orange sweet potatoes with white skin (3.3 mg/100g DM) and low in orange sweet potatoes with red skin (1.2 mg/100 g DM). Iron is high in cassava (18.2 mg/100g DM) and low in orange sweet potatoes with red skin (1.4 mg/100 g DM). Magnesium and potassium are high in yam (36.3 and 730.8 mg/100g DM respectively). The rates in sweet potatoes are also elevated with 27.6 mg/100g DM (magnesium) and 558.0 mg/100g DM (potassium) in orange sweet potatoes with white skin and 23.7mg/100g DM (magnesium) and 423.6mg/100g DM (potassium) in orange sweet potatoes with red skin. Calcium is very low in cassava (6.0 mg/100g DM) but high in orange sweet potatoes with white skin (388.5 mg/100g DM), in orange sweet potatoes with red skin (339.6mg/100g DM) and in yam (444.1 mg/100g DM).

Table 3. Staple food dry matter, total sugars and proteins contents

Samples	Dry Matter (%)	Total sugar (g/100 g)	Proteins (%)
Rice	37.39 ± 0.73^c	29.37 ± 0.06^a	5.03 ± 0.07^d
Yam	35.76 ± 0.16^c	30.43 ± 0.01^a	1.89 ± 0.21^b
Cassava	36.63 ± 0.20^{cd}	35.75 ± 0.87^b	0.91 ± 0.05^a
PO/WS	28.08 ± 0.31^a	78.16 ± 0.52^d	2.96 ± 0.36^c
PO/RS	29.34 ± 0.08^b	60.12 ± 0.09^c	0.90 ± 0.05^a

PO/WS: Sweet potato with orange flesh and white skin
PO/RS: Sweet potato with orange flesh and red skin
In row, values with different letter differ statistically (Duncan test, $p \leq 0.05$).

Table 4. Staple food minerals contents in mg / 100 g DM

Samples	Zinc	Iron	Magnesium	Potassium	Calcium
Rice	1.7 ± 0.0^b	10.6 ± 0.2^b	11.3 ± 0.6^a	42.9 ± 0.6^b	139.5 ± 0.9^b
Yam	1.8 ± 0.1^b	12.1 ± 0.2^c	36.3 ± 0.4^e	730.8 ± 0.0^e	444.1 ± 62.5^d
Cassava	2.5 ± 0.3^c	18.2 ± 0.2^e	25.2 ± 0.3^c	10.5 ± 0.3^a	6.0 ± 0.1^a
PO/WS	3.3 ± 0.4^d	1.4 ± 0.3^a	27.6 ± 0.4^d	558.0 ± 1.1^d	388.5 ± 17.6^c
PO/RS	1.2 ± 0.0^a	13.0 ± 0.0^d	23.7 ± 0.6^b	423.6 ± 19.2^c	339.6 ± 2.2^c

PO/WS: Sweet potato with orange flesh and white skin
PO/RS: Sweet potato with orange flesh and red skin
In row, values with different letter differ statistically (Duncan test, $p \leq 0.05$).

4. Discussion

Sweet potatoes used to be cultivated by migrant's native from North and from countries border Côte d'Ivoire essentially. This is because this culture is more developed in North Côte d'Ivoire which offered an appropriate climate [20]. However, the plant is well known by South-West population, but it is not in their eating habits. Indeed, sweet potatoes are rarely consumed and only 6.7% of women grow this crop. Yams are the most consumed as staple food. Indeed, cocoa producers' population is in majority native from the central region of Côte d'Ivoire where yams are the main staple food [21]. Sweet potatoes could contribute to crops and food diversification in the region during lean season. Thus, it could improve the diet and the resilience of women farmers.

Most households have an unsatisfactory food diversification level (64%). This could happen because foods are less available in the region. Indeed, since the 15 last years, food crops production has decreased in favor to cocoa production [6]. Consequently, most households are in a situation of food insecurity and vulnerability with a prevalence rate of 21.5% [22]. These results are closed to those reported in rural region of Ouagadougou [23] which indicated that 61.7% of households have an unsatisfactory food diversification level. However, our results are in contrast with those of a study conducted in Haiti that found a good level of food diversity of households (62%) with only 38% for unsatisfactory one [24]. All these differences could be explained by the fact that the studies were conducted in different countries where the populations have different food habits and different resources.

Global acute malnutrition rate (6.4%) is precarious as it is between 5 and 10% [15]. This is materialized by the distribution curve which is under the reference curve, indicating little variation among children of our study and those of the reference. This prevalence is like that of the Nawa region prevalence (6.4%) [25]. Children could be affected by acute malnutrition because of infectious diseases and/or because of insufficient food intake [26]. Height-for-age index showed a chronic malnutrition (stunting) rate of 54.3%. This prevalence is critical according to WHO [15] scale, as it is greater than 40%. Stunting is strongly marked in the region and could indicated inadequate dietary intake and episodes of infection periods during children growth. This prevalence level found in this study is higher than 27.1%, 29% and 48.7%, the reported stunting rates of previous studies conducted in the Nawa region [25] and in cocoa producing communities

[5,9] respectively. These differences could be explained by sample sizes which are more important in the evocated studies (564 [25] and 1475 [9]) than in ours (95 children). There are also socio-economic, environment and cultural factors and children age groups which can be implicated [27]. Indeed, if the proportion of children aged from 30 to 59 months is less important than that of children aged from 6 to 29 months, chronic malnutrition could be under estimated [28]. Global underweight prevalence is also critical because it is higher than 30%. This prevalence revealed growth retardation among children because of poor diets or recurrent infections and illness [29]. Underweight prevalence is high than 14.4% the Nawa region value [25] and closed to 28.8%, cocoa producers' communities' value [8]. This is because, generally, rural population (mothers) were not aware of infant nutrition such as food diversification stage when during weaning period [30].

Nutritional composition indicated that total sugar content of sweet potato is higher than in the other staple food crops. This confirms previous findings [31] which indicated that sweet potatoes contain 78.4 g/100g of total sugars. These sugars are complex. Sweet potatoes, thus, could be recommended to children in growth and any person having an intense physical activity. In addition, sweet potatoes have been successfully tested in weaning process and in children oral rehydration therapy of diarrhea [32] in Mauritania. Rice has the highest proteins content while orange flesh sweet potatoes contain only 2.9 % of proteins. This rate is lower than that indicated in three studies [33,34,35] with respectively 5.0%, 4.8% and 6.3% of proteins. All the studied foods contain minerals such as zinc, iron, magnesium, potassium and calcium. Potassium, calcium and magnesium are important in sweet potatoes which also contain high level of zinc, an important mineral for children. This makes sweet potato with orange flesh an interesting food for children and for pregnant and wet nurse women. According to Food Institute of Technology [32], the valorization of sweet potatoes should contribute to improve the nutritional status of populations particularly children and women.

5. Conclusion

This study assessed the food habits, the nutritional status and the importance of sweet potatoes in the diet of cocoa producers' populations of the Nawa region. Cocoa producers' community staple food is yam, followed by rice and cassava. Sweet potato is a marginalized crop except for immigrants' population. However, this plant contains nutrients such as complex sugar, minerals and carotene which are useful for human well-being. Sweet potatoes production and consumption should be extended to all the sub-groups (native, immigrants and aliens) as stunting rate is elevated. The diffusion of orange flesh sweet potatoes varieties will contribute to overcome malnutrition and to ameliorate food security.

Acknowledgements

Statement of Competing Interests

The authors have no competing interest in relation to their work.

List of Abbreviations

CI: Confidence Interval
DM: Dry matter
PO/WS: Sweet potato with orange flesh and white skin
PO/RS: Sweet potato with orange flesh and red skin

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