



### RESEARCH ARTICLE

## EVALUATION OF THE KNOWLEDGE AND CONSUMPTION OF FOOD SUPPLEMENTS IN SIX (06) COMMUNES OF THE DISTRICT OF ABIDJAN: THE CASE OF SPIRULINA (*Arthrospira platensis*) AND MORINGA (*Moringa oleifera*)

Yakoura Karidja Ouattara<sup>1,2</sup>, Kalpy Julien Coulibaly<sup>1</sup>, Zanakoungou Ibrahima Coulibaly<sup>1</sup>, Blé Yatanan Casimir<sup>3</sup>, Vakou N'dri Sabine<sup>1</sup>, André Offianan Touré<sup>1</sup> and Adjéhi Dadié<sup>2</sup>

1. Institut Pasteur of Côte d'Ivoire, 01 BP 490 Abidjan 01, Côte d'Ivoire.
2. Département de Food Sciences and Technologies (STA), Laboratory of Microbiology and Biotechnology, Nangui Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire.
3. Department of Agronomic Forest and Environmental Engineering, University of Man, BP 20 Man, Côte d'Ivoire.

#### Manuscript Info

##### Manuscript History

Received: 15 December 2022  
Final Accepted: 19 January 2023  
Published: February 2023

##### Key words:

Food Supplements, Moringa, Spirulina,  
Knowledge, Consumption, Food use

#### Abstract

Food supplements are playing an increasingly important role in our diet. Moringa and Spirulina are two food supplements produced and marketed in the Ivory Coast. However, very little data exists on the level of consumption of these food supplements. The objective of this study was to assess the level of knowledge and consumption of these two products in six communes of the Abidjan district. To achieve this, a questionnaire was administered to 446 households. The study revealed that 100% of the households surveyed knew about Moringa, while 43.5% knew about Spirulina. 71.75% of the households surveyed had already consumed these products. For 90.4% of the households surveyed, these products are consumed in powder form. And the reasons for consumption were due in 72.84% of cases to health problems. However, 45.40% of household respondents said they had experienced discomfort as a result of consuming Moringa. This study reveals the effectiveness of the dietary use of Moringa and/or Spirulina in the households surveyed. However, the mention of undesirable effects reported should be the subject of further study on the health quality of these supplements, which are becoming increasingly popular.

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#### Introduction:

A food or nutritional supplement is defined, according to Ivorian law (Decree N0 2016-717 of 14 September 2016 regulating the advertising of medicines, other health products and pharmaceutical establishments) "as any foodstuff whose purpose is to supplement a normal diet and which constitutes a concentrated source of nutrients or other substances with a nutritional or physiological effect; presented alone or in combination, marketed in dose form, i.e. forms of presentation such as capsules, tablets, pills and other forms similar to liquid or powder preparations, intended to be taken in measured units of small quantity".

**Corresponding Author: Yakoura Karidja Ouattara**

Address: Institut Pasteur of Côte d'Ivoire, 01 BP 490 Abidjan 01, Côte d'Ivoire.

The marketing of these dietary supplements is booming and has been increasing steadily for the past few years, in terms of turnover but especially in terms of products available on the market [1]. These products are sold freely in pharmacies, parapharmacies, supermarkets, health food shops, gyms, the Internet, markets and at home [2]. The consumer is faced with a large number of products, brands, compositions and cocktails that are widely available through the severy diverse marketing outlets. Indeed, the consumption of these dietary supplements is wide spread in many countries such as the United States [3], Canada [4], Australia [5], in several European countries [6] as well as in Africa [7]. In addition, these products enjoy a high level of confidence regarding their safety of use and as a result their consumption is associated with the notion of health benefits [8]. Consumers are increasingly concerned about their health and are looking for these products as a way to compensate for deficiencies (suspected or proven), which clearly explains this marke tevolution.

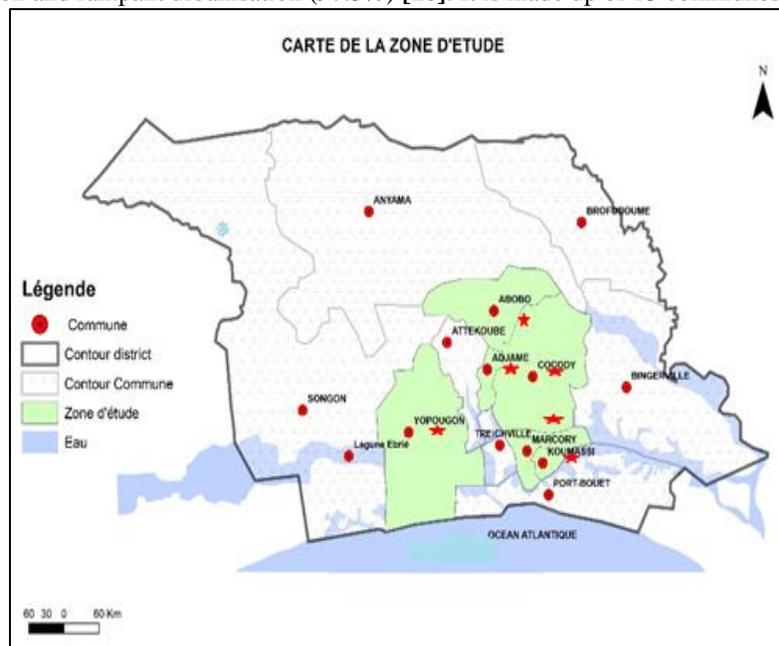
Studies have shown that many plant resources have nutritional potentials that make them good candidates as food or nutritional supplements. For example, Moringa (*Moringa oleifera*) and Spirulina (*Spirulina platensis*) can be used to supplement many foods [9]. Both Moringa and Spirulina have enormous nutritional properties including fat, protein, iron, calcium, vitamin C, and many antioxidants essential for human and even animal nutrition and health [10]. These two food supplements are often used for the prevention and fight against malnutrition in Africa and Asia [11].

Thus, due to their rich nutritional composition, these food supplements are increasingly popularized through certain media, websites, scientific conferences, word-of-mouth testimonies, etc. [12]. In view of this popularisation, studies conducted in Cameroon [7], Benin [13] and Chad [14] reveal information on the knowledge, importance and use of Moringa and Spirulina by the populations. However, in Côte d'Ivoire, there is very little scientific data highlighting the level of use and knowledge of these food supplements. This study is therefore important because its objective is to evaluate the level of knowledge and consumption of these food supplements in six communes in the district of Abidjan.

## Materials and Methods:

### StudyArea

The study was conducted in the district of Abidjan located in the south of Côte d'Ivoire, bordering the Atlantic Ocean (Gulf of Guinea) and covering an area of 2119 km<sup>2</sup> (0.6% of the country) with a population density of 1475 inhabitants/km<sup>2</sup>. According to the National Institute of Statistics (INS), Abidjan has an estimated population of 4.707.000, which represents 20.7% of the total population with a growth rate of 3.7% per year [15]. Considered the cultural crossroads of West Africa, the Abidjan agglomerationis experiencing perpetual growth characterised by strong industrialisation and rampant urbanisation (97.3%) [16]. It is made up of 13 communes (**Figure 1**).



**Figure 1:** Map of the city of Abidjan showing the sites used for the study.

### Size of Households Surveyed

A survey in the 13 communes of the Abidjan district made it possible to determine the level of supply and sales of these food supplements in the various markets. From this survey, six (6) communes (Abobo, Adjamé, Cocody, Koumassi, Marcory, Yopougon) with a high rate of supply and sales were selected for investigation. The size of the households to be interviewed was determined using the formula of [17] based on data from the 2014 General Census of Population and Housing [15].

Formula **Dagnelieet al. (1998)**.

$$n = \frac{U_{1-\frac{\alpha}{2}}^2 \times p(1-p)}{d^2}$$

**n**: minimum size of the survey population

**p**: prevalence of dietary supplement consumption

**U<sub>1- $\alpha$ /2</sub>**: 1.96 with  $\alpha = 5\%$  precision level

**d**: margin of error set at 0.05

Given the absence of data on the rate of consumption of these food supplements at the national level for this study, a prevalence of  $p=50\%$  was used to estimate the size of the households. A total of 446 households were surveyed in the Abidjan district. A proportional distribution according to total household size in each locality was made (**Table 1**).

**Table 1:** Number of households in the surveyed communes.

Municipalities	Household Size	Number of households surveyed
Abobo	116.750	113
Adjamé	51.076	49
Yopougon	130.457	126
Koumassi	70.295	68
Cocody	52.751	51
Marcory	40.215	39
<b>TOTAL</b>	<b>461.546</b>	<b>446</b>

Source : [15]

### Conduct of the Survey

From September to November 2019, the household survey was conducted randomly in different concessions in the six selected communes. In concessions with multiple households, a single household was randomly selected. The questionnaire designed for this purpose was structured around sections on the level of knowledge and consumption of food supplements such as Moringa and Spirulina. Information on the consumers' perception of the benefits of these food supplements and the reasons for their consumption was collected. Consumption pattern, amount and frequency of consumption, history and severity of discomfort following the consumption of these dietary supplements were taken into account. Basic demographic information such as age, education level was also collected.

### Data analysis

The responses to the questionnaire were coded and recorded using IBM SPSS Statistics version 22. The method of flat sorting the data allowed us to determine the frequency of the modalities for each variable studied. The results were expressed in terms of percentage and the comparison of the different frequencies observed according to the place of residence of the household was carried out by applying the Pearson Chi-square test. A  $p$ -value  $< 0.05$  was considered statistically significant.

## Results:

### Socio-demographic Characteristics of Household Respondents

The socio-demographic profile of the surveyed population indicated that 52.5% of the respondents in the households were men and 47.5% were women. Taking into account the level of education, 52.2% of the surveyed population had a higher level of education. In addition, the most represented age group was over 45 years old (**Table 2**).

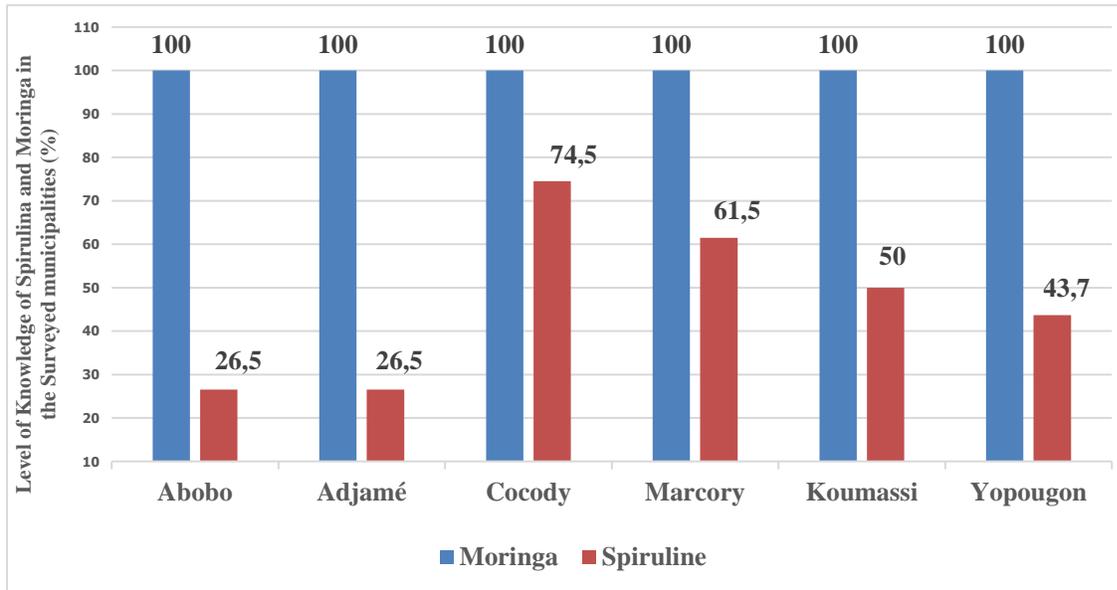
**Table 2:** Socio-demographic characteristics of household respondents.

Characteristics	Respondents	Effectif (N=446)	Proportion (%)
<b>Gender</b>	Male	234	52,5%
	Woman	212	47,5%
<b>Level of Study</b>	Illiterate	21	4,7%
	KoranicSchool	33	7,4%
	Primary	89	19,9%
	Secondary	70	15,7%
	Higher	233	52,2%
<b>Age</b>	≤ 18 Yearsold	16	3,6%
	18-45Yearsold	190	42,6%
	More than 45Yearsold	240	53,8%

### Level of Knowledge of Moringa and Spirulina

The study showed that the entire population surveyed (100%) knew about *Moringa oleifera*, but not about Spirulina. The level of knowledge of Spirulina varied from one commune to another. Spirulina was known in the communes of Cocody (74.4%), Marcory (61.5%), and Koumassi (50%) (**Figure 2**).

The results of the study also revealed that 56.4% of male respondents knew about Moringa and Spirulina and 43.6% knew about Moringa but not Spirulina. In contrast, 29.2% of female respondents knew about Moringa and Spirulina and 70.7% knew about Moringa but not Spirulina (**Figure 3**). Statistical analyses showed that the level of knowledge of these food supplements varied according to the sex of the respondents ( $p < 0.05$ ).



**Figure 2:** Level of knowledge of Moringa and Spirulina according to locality.

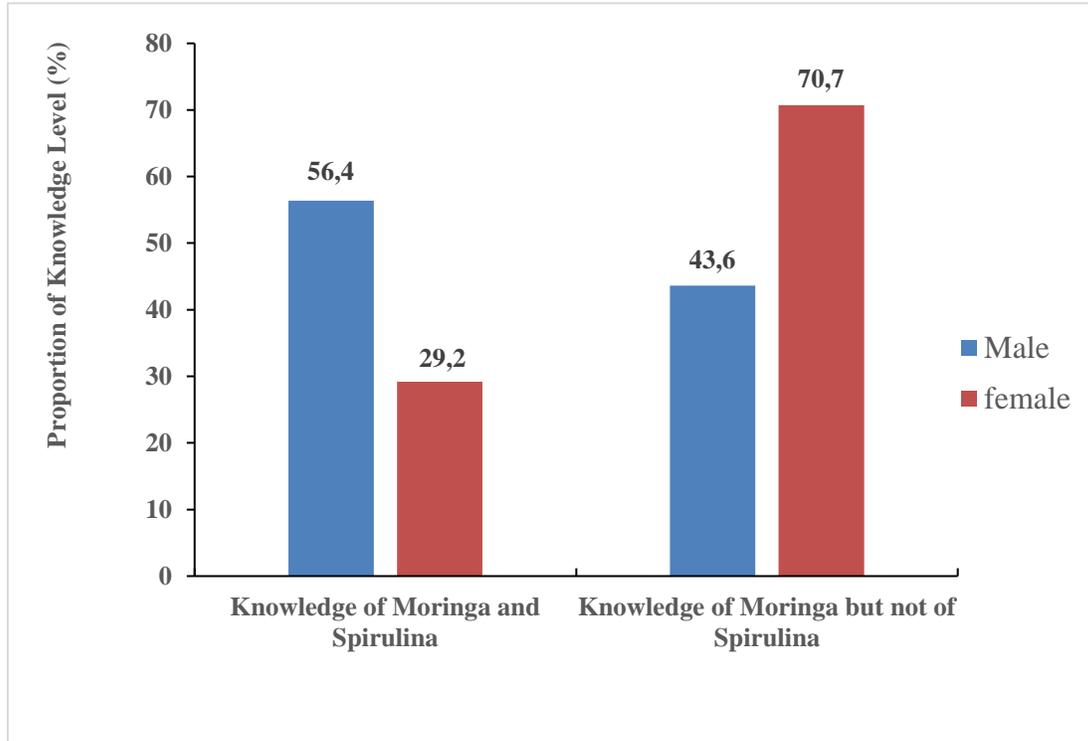


Figure 3: Level of knowledge of Moringa and Spirulina according to locality.

**Reasons for consuming Moringa and Spirulina**

Of the 320 people surveyed in households that had already consumed Moringa and/or Spirulina, 313 (97.8%) continue to consume these products and 7 households (2.2%) have stopped consuming them either because of problems with taste or because the product is expensive. However, the reasons for consuming these food supplements revealed essentially two factors, namely the nutritional and therapeutic virtues associated with Moringa and Spirulina through testimonies of people who have consumed them and advertisements on certain websites. The survey revealed that 72.8% of households consume these products for health problems and 27.2% consume them simply out of curiosity in order to observe the beneficial effects that these food supplements can provide (Table 3).

Table 3: Reasons for consumption of Spirulina and Moringa according to municipalities.

Municipalities	Effectif	Reasons for consumption	
		Health	Curiosity
Abobo	81	79%	17 (21%)
Adjamé	27	74,1%	7 25,9%
Yopougon	101	66,3%	33,7%
Koumassi	48	77,1%	22,9%
Marcory	28	75%	25%
Cocody	28	67,9%	32,1%
<b>TOTAL</b>	313 (97,8%)	228 (78,2%)	85 (27,2%)

**Supposed beneficial effects of Moringa and Spirulina consumption**

The study found that 286 or 91.4% of household respondents observed beneficial effects from consuming Moringa and/or Spirulina. However, 1.6% of respondents did not observe any beneficial effects and 7% had no idea of the beneficial effects of consuming these food supplements (Table 4).

**Table 4:** Proportion of households that observed beneficial effects.

Observation of beneficial effects	Effectif	Prevalence (%)
Yes	286	91,4%
No	5	1,6%
Don't know	22	7,0%
<b>TOTAL</b>	<b>313</b>	<b>100%</b>

**Form of consumption of Spirulina and/or Moringa**

According to the survey results, Moringa and Spirulina are consumed in households in different forms (powder, leaves, grains, tablet, capsules). Among the 313 households that continue to consume these supplements, the powdered form is the most consumed overall. Moringa leaf powder was the form most consumed in households in the communes of Abobo and Yopougon, with rates of 76.5% and 57.4% respectively. More over, among households that consume both Spirulina and Moringa, the powdered form was the most consumed overall, at 26.8%. Consumption of Spirulina in powder form was observed in 10.7% of households surveyed in the commune of Cocody (**Table 5**).

**Table 5:** Forms of food supplements consumed by municipality.

Commune	Moringa+ Spiruline	Form consumed				Spiruline			Total
		Moringa Powder	Leaves	Grain	Powder+grains	Powder	Tablets	Capsules	
Abobo	12 (14,8%)	62 (76,5%)	0 (0%)	4 (4,9%)	2 (2,5%)	1 (1,2%)	0 (0%)	0 (0%)	<b>81</b>
Adjamé	6 (22,2%)	17 (62,9%)	0 (0%)	3 (11,1%)	1 (3,7%)	0 (0%)	0 (0%)	0 (0%)	<b>27</b>
Cocody	10 (35,7%)	14 (50%)	1 (3,6%)	0 (0%)	0 (0%)	3 (10,7%)	0 (0%)	0 (0%)	<b>28</b>
Koumassi	14 (29,2%)	28 (58,3%)	0 (0%)	3 (6,3%)	0 (0%)	0 (0%)	3 (6,3%)	0 (0%)	<b>48</b>
Marcory	11 (39,3%)	15 (53,6%)	0 (0%)	0 (0%)	0 (0%)	1 (3,6%)	1 (3,6%)	0 (0%)	<b>28</b>
Yopougon	31 (30,7%)	58 (57,4%)	0 (0%)	7 (6,9%)	2 (2%)	0 (0%)	1 (1%)	2 (2%)	<b>101</b>
<b>Total</b>	<b>84 (26,8%)</b>	<b>194 (62%)</b>	<b>1 (0,3%)</b>	<b>17 (5,4%)</b>	<b>5 (1,6%)</b>	<b>5 (1,6%)</b>	<b>5 (1,6%)</b>	<b>2 (0,6%)</b>	<b>313</b>

**Mode and frequency of consumption of Spirulina and Moringa**

The mode of consumption reported by the majority of consumers of these products was mixing Moringa and/or Spirulina with plain water in 73.2% of households surveyed. Moringa powder was consumed mixed with plain water and before meals by 84.7% of households. Consumption of these products mixed with tea or coffee was observed in 9.6% of households surveyed. 17.3% of households consume Moringa and/or Spirulina mixed with their daily meal. Among households that consume both Spirulina powder and Moringa, 88.9% and 13.1% of these households consume these products during the meal and mixed with plain water respectively. 56.7% of Moringa bean consumers and 16.7% of Spirulina tablet consumers consume these products mixed with tea or coffee. 9.3% of households consume Spirulina powder during meals (**Table 6**).

With regard to frequency of consumption, 57.5% and 34.5% of household respondents consume Spirulina and/or Moringa twice a day and once a day respectively. Among the households consuming Moringa powder, 77.3% and 63.3% had a consumption frequency of once and twice a day respectively. Consumption frequencies of two and three times a week were observed in 3.8% and 4.2% of households respectively (**Table 7**).

Statistical analysis revealed that the frequency of consumption of Spirulina and Moringa differed significantly by reason for consumption ( $p < 0.05$ ). In some households where these food supplements are consumed for health reasons, the frequency of consumption was twice a day and once a day. In contrast, in some households where these food supplements are consumed for simple curiosity, the frequency of consumption is relatively low, with a frequency of consumption of two or three times a week.

**Table 6:** Consumption pattern of Spirulina and Moringa

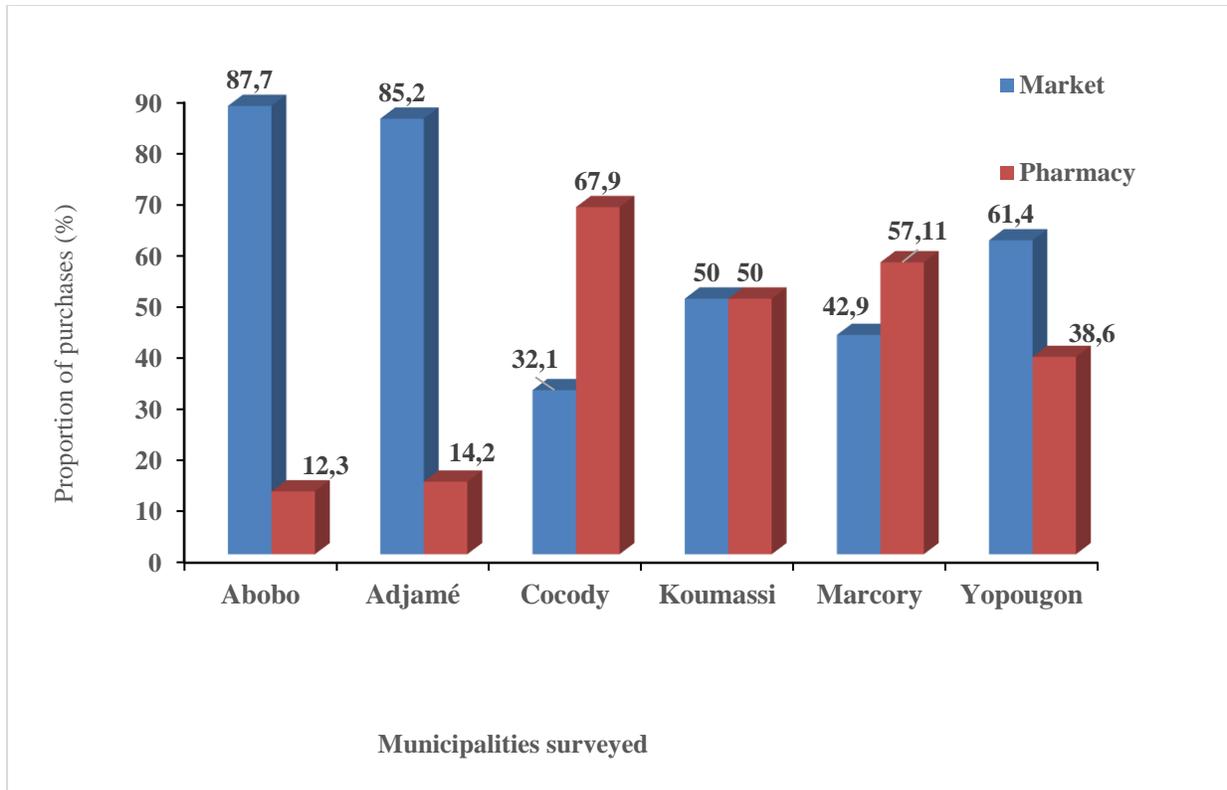
Mode of consumption	Moringa+ Spiruline	Moringa				Spiruline			Total
	Powder	Powder	Leaves	Grain	Powder +grains	Powder	Tablets	Capsules	
Mix with tea or coffee	6 (20%)	0 (0%)	0 (0%)	17 (56,7%)	0 (0%)	0 (0%)	5 (16,7%)	2 (6,7%)	<b>30</b> <b>(9,6%)</b>
Mix with plain water before a meal	30 (13,1%)	194 (84,7%)	0 (0%)	0 (0%)	5 (2,2%)	0 (0%)	0 (0%)	0 (0%)	<b>229</b> <b>(73,2%)</b>
During the meal	48 (88,9%)	0 (0%)	1 (1,9%)	0 (0%)	0 (0%)	5 (9,3%)	0 (0%)	0 (0%)	<b>54</b> <b>(17,3%)</b>
After the meal	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	<b>0</b> <b>(0%)</b>
<b>Total</b>	<b>84</b>	<b>194</b>	<b>1</b>	<b>17</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>2</b>	<b>313</b>

**Table 7:** Frequency of consumption of Spirulina and Moringa.

Frequency of consumption	Moringa+ Spiruline	Moringa				Spiruline			Total
	Powder	Powder	Leaves	Grain	Powder+ grain	Powder	Tablets	Capsules	
Once a day	31 (28,7%)	77 (77,3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	108 (34,5%)
Twice a day	44 (24,4%)	114 (63,3%)	0 (0%)	11 (6,1%)	0 (0%)	4 (2,2%)	5 (2,8%)	2 (1,1%)	180 (57,5%)
Twice a week	4 (33,3%)	0 (0%)	1 (8,3%)	6 (50%)	0 (0%)	1 (8,3%)	0 (0%)	0 (0%)	12 (3,8%)
Three times a week	5 (38,5%)	3 (23,1%)	0 (0%)	0 (0%)	5 (38,5%)	0 (0%)	0 (0%)	0 (0%)	13 (4,2%)
<b>Total</b>	<b>84</b>	<b>194</b>	<b>1</b>	<b>17</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>2</b>	<b>313</b>

#### Mode of supply

The Moringa and Spirulina consumption survey revealed that the supply of these food supplements in the households surveyed was done either in local markets or in pharmacies. The majority of households surveyed in the communes of Abobo, Adjamé and Yopougon said they bought Moringa and Spirulina in local markets with proportions of 87.7%, 85.2% and 61.4% respectively. On the other hand, 57.1%, 50% and 67.9% of households surveyed in the communes of Marcory, Koumassi and Cocody respectively said they bought these food supplements in pharmacies (**Figure 4**).



**Figure 4:** Proportion of place of purchase of food supplements by municipality.

#### Discomfort Related to the Consumption of Moringa and Spirulina

Several consumers (91.4%) claimed to have experienced discomfort (diarrhoea, abdominal pain, fever, vomiting and nausea) following the consumption of Moringa and/or Spirulina. Of these consumers, 93.5% reported having experienced discomfort after consuming Moringa, 66.7% of Spirulina consumers also reported having experienced discomfort after consuming this food supplement. Further more, among households that consume both Spirulina and Moringa, 89.3% reported having observed the same adverse effects. On the other hand, 12.7% said they had not experienced any discomfort following the consumption of these products (**Figure 5**).

The symptoms most often reported by consumers were diarrhoea, observed in 66.9% of households, nausea/vomiting in 27% and abdominal pain in 6.1% of households. It should be noted that these symptoms were mild and disappeared after one day (**Figure 6**).

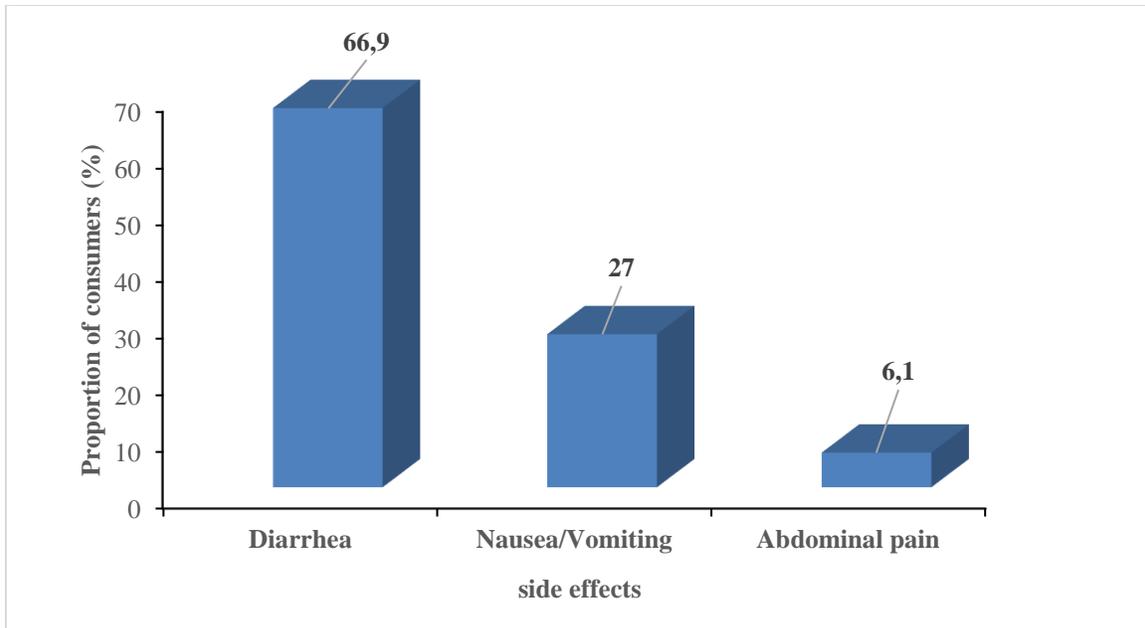


Figure 5: Proportion of consumers who experienced discomfort according to the food supplement consumed.

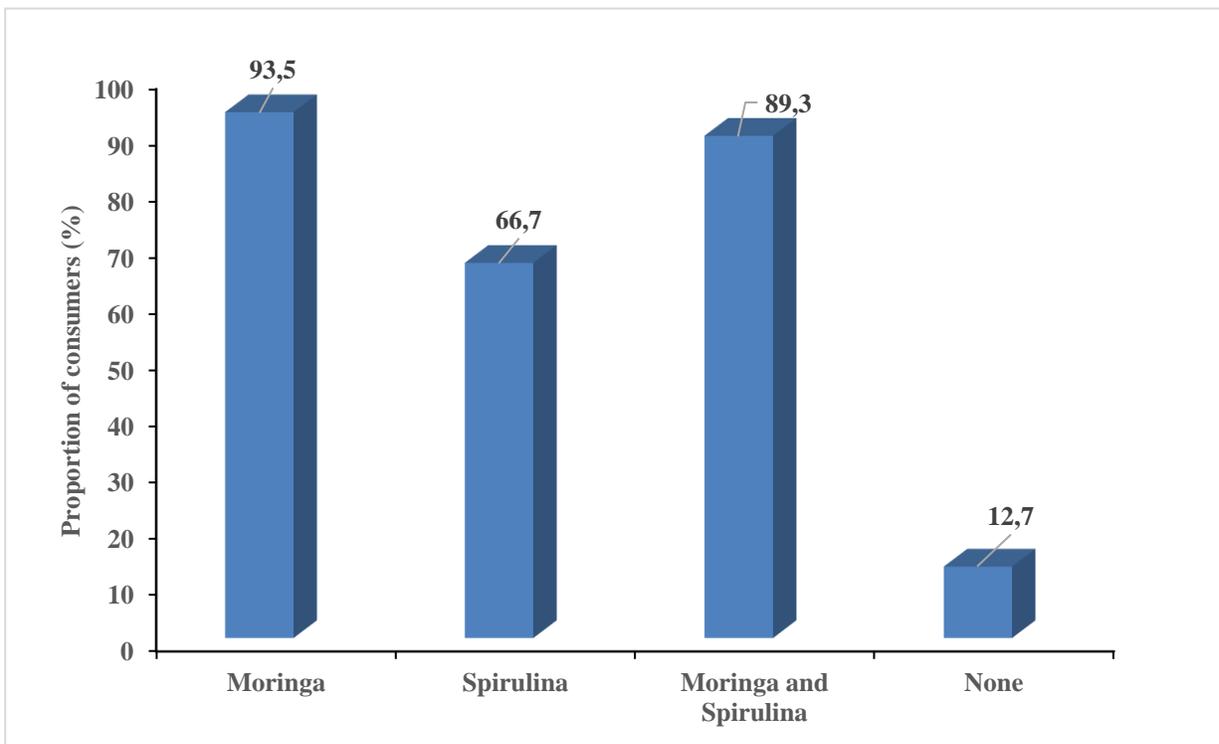


Figure 6: Proportion of consumers who reported symptoms after consumption of Spirulina and/or Moringa.

**Discussion:**

In Côte d'Ivoire, studies on the consumption of food supplements are generally rare. However, they provide a better understanding of the use of these food products and their consumption environment, whether at home or in the field of modern or traditional medicine. All the people surveyed in the households have knowledge of Moringa in all the communes surveyed, which is not the case for Spirulina, which is known by only 43.5% of respondents. The results observed on the level of knowledge of Moringa are similar to those observed in the North of Cameroon in the town

of Maroua by [7]. Indeed, the work carried out by these authors revealed that 95% of the respondents in Maroua had knowledge about Moringa. The results of this study are also similar to those carried out by [18] in the far north of Cameroon who observed that the households surveyed (100%) in both rural and urban areas knew about Moringa oleifera.

The level of knowledge of Moringa could be explained by the fact that Moringa is an acclimatised plant in almost all tropical regions [13]. More over, this plant is part of the local flora of the household surveyed, which makes it (if not perfectly mastered) known and familiar. As for Spirulina, it is less known in the communes of Abobo, Adjamé and Yopougon, unlike the communes of Cocody, Marcory and Koumassi. This variation in the level of knowledge of Spirulina from one commune to another could be explained by the fact that Spirulina is less accessible because of its purchase price and people who have knowledge of this food supplement have a high level of education. In addition, people with a middle level of education are not interested in Spirulina because they do not have information about the therapeutic and nutritional values of its consumption. According to a mission report of the RONGEAD/ASF-CI project (European NGO Network on Agriculture, Trade, Environment and Development / Amitié Sans Frontière Côte d'Ivoire Office) carried out in 2011, 6% of people living in Côte d'Ivoire have heard of spirulina.

Regarding the level of consumption of Moringa and Spirulina, 71.7% of households surveyed have already consumed Moringa and/or Spirulina and 70.2% continue to consume these products. However, Moringa is the most consumed and this could be explained by the fact that it is more accessible to households, due to its low purchase price, unlike Spirulina which is relatively more expensive. In general, Moringa has, it is cheap and affordable for all social strata, compared to Spirulina. A study conducted by [7] in Cameroon on the use and socio-economic importance of Moringa revealed that 93.4% of households use Moringa in their diet Furthermore, the predominance of men among consumers in this study could be related to the way the survey was conducted. Indeed, the methodological approach during the survey was to submit the questionnaire randomly to the target population. At the time of the survey, the persons most often present in the households were either the head of the household or a male person who was usually designated by other family members to answer the questionnaires on behalf of the family. Therefore, men represented about 58% of the respondents.

More over, the study found that 72.8% of the respondents consume Moringa and/or Spirulina for health problems. This could be due to the promotion of the therapeutic values of these products. In addition, the sales strategies used by the people in charge of selling these products are very focused on the therapeutic virtues linked to the use of Moringa and/or Spirulina. Indeed, to attract more customers, these street vendors promote these food supplements by emphasising the nutritional therapeutic virtues assigned to these products. These results are close to those obtained by [19] who mentioned that 58.1% of respondents in their study on supplementation and consumption of probiotics in patients used dietary supplements for health problems. The work of [18] carried out in Cameroon on the dietary uses of *Moringa oleifera* in the Far North region of Cameroon also reported that 41.5% of households surveyed in the urban area of Cameroon used Moringa exclusively as a medicine for their health problems.

Regarding the mode of consumption of Moringa and/or Spirulina, the results showed that 73.2% of consumers consume these products in powder form. This could be due to the fact that these dietary supplements are more sold in this form and more appreciated by consumers because consumption is easier and more pleasant. The results of this study are similar to those observed by [13] in Benin who revealed that leaves processed into powder and incorporated into food represent a practice conducted by 68.7% of the respondents.

In this study, statistical analyses showed that the places of purchase of Spirulina and/or Moringa are linked to the commune. The majority of households interviewed in the communes of Abobo, Adjamé and Yopougon buy these products in local markets. In contrast, the majority of households interviewed in the communes of Cocody, Marcory and Koumassi buy their supplies from pharmacies. This finding could be explained by consumer purchasing power. Low-income households buy their supplies mainly in local markets from vendors, while high-income households buy their supplies in large stores such as pharmacies. The study also shows that 57.5% of households consume these food supplements for health problems. In parallel, a high frequency of consumption was observed among the latter, in contrast to those who consume these products out of curiosity.

The study revealed that 91.4% of consumers claimed to have experienced discomfort (adverse reactions) following the consumption of these products. The high rate of consumers experiencing adverse reactions could be due to the consumer overdosing on the product in order to observe the beneficial effects and virtues that may come from its use

as soon as possible. This could also be due to the manufacturing process of the Moringa leaf powder which is still done in an artisanal way and in the non-respect of good hygiene practices. These poor practices could lead to the proliferation of certain infectious agents that could cause undesirable effects following consumption of the product. The observation of undesirable effects following the consumption of Moringa powder has already been observed by [20] during their work in Burkina Faso on the nutritional value of *Moringa Oleifera*. These results are similar to those observed by [21] whose work focused on the use and effect of herbal medicines in hepatic patients hospitalised at the Department of Medicine and Hepato Gastroenterology of the Centre Hospitalier Universitaire (CHU) of Cocody in Côte d'Ivoire. Their study revealed the occurrence of adverse effects reported by 31.2% of the patients who used therapeutic plants to treat themselves.

### Conclusion:

The survey carried out as part of this study has provided new data on the consumption of food supplements such as Spirulina and Moringa in the district of Abidjan in Côte d'Ivoire. It gives a precise and detailed vision of the consumption of these food supplements since very few data are currently available at the national level on the consumption of food supplements. This study revealed that all the people interviewed in the households were aware of Moringa, unlike spirulina, where the level of awareness varied from one commune to another. A high rate of consumption of these food supplements was observed. Of the 446 households surveyed, 320 (71.75%) had already consumed moringa and/or spirulina and 313 (70.2%) were still consuming these products. The reasons for consuming these products were mainly related to health problems, given the medicinal and therapeutic virtues attributed to these food supplements. This justifies the high frequency of consumption of Moringa and/or Spirulina. The majority of households surveyed consume Moringa and/or spirulina once or twice a day. These food supplements are sold in various forms, but the most commonly consumed form was powder. Adverse effects were also observed and reported by most consumers. Further detailed studies are therefore needed to highlight any possible risks to consumers of these increasingly popular food supplements.

### Acknowledgements:

We would like to thank all the people and in particular the consumers of Moringa powder and Spirulina who agreed to participate in this survey in the various communes of the Abidjan district.

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