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CONSUMPTION LEVEL AND PROPERTIES ATTRIBUTED TO *SOUMBARA* FROM *NÉRÉ* (*Parkia biglobosa*) AND TO THE LEAVES OF *Moringa oleifera* IN CÔTE D'IVOIRE

Karnon Coulibaly ^{1,*}, Dembélé Syndoux ¹, Cyrille Koffi Tan ² and Fatoumata Camara ²¹ Department of Agro-Industrial Sciences and Technologies, Training and Research Unit for Agriculture, Fisheries Resources and Agro-Industries (ARHAI), University of San Pedro (USP), BP 1800 San Pedro, Côte d'Ivoire.² Laboratory of Nutrition and Food Safety (LNSA), Training and Research Unit for Food Industry Science and Technology, University Nangui Abrogoua, 02 BP 801 Abidjan, Côte d'Ivoire.

* Corresponding Author

ORCID Details

Karnon COULIBALY: <https://orcid.org/0009-0008-4974-3207>Syndoux DEMBELE: <https://orcid.org/0009-0003-6339-0376>

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ABSTRACT

Leafy vegetables, like oilseed plants, are a major dietary source of micronutrients and phytonutrients required to counteract micronutrient deficiencies and metabolic diseases. The aim of this study was to determine the consumption level and to identify the properties attributed to *soumbara* from *nééré* (*Parkia biglobosa*) and to the leaves of *Moringa oleifera*. A structured questionnaire was designed and administered using a cluster sampling method. Results showed that *soumbara* was most widely consumed in Korhogo (97.47%), whereas leaves of *Moringa oleifera* were most consumed in Bouaké (69.74%) and Abidjan (67%). Both *soumbara* and Moringa leaves were mainly consumed as sauce, at 58.62% and 65.86% respectively. Moringa leaves were consumed because they were perceived to prevent disease (47.89%) and to exert a laxative effect (32.46%). In addition, respondents consumed *soumbara* because of the improved digestion it was believed to promote (33.94%) and for its fortifying properties (25.84%). Regarding therapeutic properties, *soumbara* from *nééré* was consumed for its hypotensive properties (33.7%) and Moringa leaves for their antidiabetic properties (31.7%). Overall, *soumbara* and Moringa leaves are consumed for their perceived health benefits.

Keywords: *Moringa oleifera*; *Soumbara*; Diabetes; Arterial Hypertension

1 INTRODUCTION

Food plants are deeply rooted in cultural heritage and are increasingly recognised for their nutritional and functional benefits [1]. Among them are the leaves of *Moringa oleifera* and *Soumbara* (*Parkia biglobosa*). These ingredients play a key role in many African diets and are attracting growing worldwide interest as sustainable sources of plant protein. In

Côte d'Ivoire, *soumbara*, a traditional fermented condiment obtained from the seeds of *Parkia biglobosa* (*nééré*), is used in many recipes to enhance the flavour of dishes [2]. It provides valuable nutritional benefits and is credited with medicinal properties, in particular a lowering of blood pressure, and is used to prevent and/or combat malnutrition and cardiovascular diseases [3], [4]. The leaves of *Moringa oleifera* appear to be among the most promising leafy vegetables in terms of nutrient content, antioxidant activity, phytochemical composition, ease of cultivation and processing, and organoleptic quality.

These plants are widely accepted, available, inexpensive and assumed to have fewer side effects [5]. In Africa, about 80% of the population is thought to depend on traditional medicine for primary health care [6]. WHO encourages the development of standard protocols for ethnobotanical surveys and for the experimental work needed to validate traditional uses. Such plants represent an ideal alternative to conventional drugs, whose cost remains relatively high for populations in developing countries, particularly in rural areas [7]. The interest in plant species is explained by the fact that most plants endowed with therapeutic properties are, first and foremost, food plants [8]. Several studies have been carried out on the leaves of *Moringa oleifera* and on the seeds of *soumbara* (*Parkia biglobosa*). However, few studies have addressed the consumption level and the reasons for consuming the leaves of *Moringa oleifera* and the seeds of *soumbara* (*Parkia biglobosa*). The present study was therefore undertaken to determine the consumption level and to identify the properties attributed to *soumbara* from *nééré* (*Parkia biglobosa*) and to the leaves of *Moringa oleifera* in Côte d'Ivoire.

2 METHODS

2.1 Determination of the sample size

The number of respondents to be surveyed was estimated using the equation proposed by [9]. This equation is expressed by the arithmetic relationship below :

$$n = \frac{t^2 \times p(1-p)}{m^2} \quad (1)$$

- n : required sample size (minimum number of respondents)
- t : 1.96 at a 95% confidence level.
- m : margin of error set at 5%.
- p : estimated population proportion (p being unknown, p = 0.5).

On this arithmetic basis, and after assigning values to the corresponding variables, 1152 individuals were surveyed in 384 households, at a rate of 3 individuals per household. The final sample size was therefore 1152 individuals: 384 respondents in 128 households in Abidjan, 384 respondents in 128 households in Bouaké and 384 respondents in 128 households in Korhogo.

2.2 Inclusion and non-inclusion criteria

The inclusion criterion covered all individuals present at the study site, aged 10 years or over and able to communicate in French or in a local language. The non-inclusion criterion covered all individuals present at the study site, aged 10 years or over, who declined to take part in the study.

2.3 Conduct of the survey

This study was a random cluster survey conducted from 20 September 2021 to 5 November 2021. Respondents were met in their households. Target individuals, i.e. those aged 10 years or over, completed the questionnaire following the survey form. Survey forms were filled in during individual, structured interviews in each selected locality. Interviews were conducted in French. The questionnaire covered the respondent's profile and the knowledge and consumption of *soumbara* and of the leaves of *Moringa oleifera*. The questionnaire also addressed consumption frequencies and the therapeutic properties ascribed to *soumbara* and to the leaves of *Moringa oleifera* with a view to better valorisation.

3 RESULTS

3.1 Sociodemographic profile of respondents

The survey showed that 44.10% of respondents were male and 55.90% female. Respondents were aged between 10 and 75 years, the predominant age classes being 25-50 years (52.17%) and 15-25 years (23.96%) (**Table 1**). Most respondents worked in the informal sector (27.78%) (**Table 2**). The ethnic groups encountered were diverse, the Mandé group being the most represented (27.35%). Educational attainment varied within the sample: 18.07% had no

formal schooling, 19.96% had primary education, 26.04% secondary education and 35.93% tertiary education (**Table 3**).

Table 1: Profile of respondents by sex and age class

Cities	Sex		Age class			
	M	F	10-15 years	15-25 years	25-50 years	50-75 years
Abidjan	14.06	19.27	1.04	7.9	17.88	6.51
Bouaké	15.19	18.14	0.95	6.6	16.75	8.25
Korhogo	14.85	18.49	1.65	9.46	17.54	5.47
Total (%)	44.10	55.90	3.64	23.96	52.17	20.23

F: female; M: male

Table 2: Profile of respondents by locality and occupation

Cities	Occupation					
	Pupil	Student	Civil servant	Private-sector worker	Informal-sector worker	Unemployed
Abidjan	3.47	6.42	2.78	5.03	9.81	5.82
Bouaké	3.65	5.99	2.52	6.17	10.42	4.60
Korhogo	4.25	9.72	3.73	3.99	7.55	4.08
Total (%)	11.37	22.13	9.03	15.19	27.78	14.5

Table 3: Profile of respondents by locality, ethnic group and educational level

Cities	Ethnic group					Educational level			
	Akan	Gur	Mandé	Kru	Other	No sch	Prim	Sec	Tert
Abidjan	6.86	5.81	9.98	3.38	7.29	7.20	6.68	8.07	11.37
Bouaké	6.79	4.95	9.47	2.6	9.80	6.77	7.73	8.86	9.98
Korhogo	6.68	12.5	7.9	1.30	4.69	4.1	5.55	9.11	14.58
Total (%)	20.33	23.26	27.35	7.28	21.78	18.07	19.96	26.04	35.93

No sch: no formal schooling; Prim: primary; Sec: secondary; Tert: tertiary

3.2 Source of supply of *soumbara* and of leaves of *Moringa oleifera*

Table 4 shows the source of supply of *soumbara* from *nééré* and of *Moringa* leaves. Most consumers obtained *Moringa* leaves from a garden or a field in Abidjan (22.66%), Bouaké (25.83%) and Korhogo (28.85%). However, 13.75% of consumers in Abidjan bought *Moringa* leaves at the market. For *soumbara*, the market was the main source of supply in Abidjan (25.29%), Bouaké (35.05%) and Korhogo (37.46%).

Table 4: Source of supply of *soumbara* and of leaves of *Moringa oleifera*

Cities	Leaves of <i>Moringa oleifera</i>		<i>soumbara</i> from <i>nééré</i>	
	At the market	In the field / garden	At the market	Other
Abidjan	13.75	22.66	25.29	0
Bouaké	6.19	25.83	35.05	0.73
Korhogo	2.72	28.85	37.46	1.47

3.3 Purchase price of *soumbara* and of leaf powder of *Moringa oleifera*

Table 5 presents the cost of the leaves of *Moringa* and of *soumbara* in the three cities. *Soumbara* was purchased at 2000 XOF per kilogram in Abidjan. In Bouaké and Korhogo, the purchase price of *soumbara* was 1700 XOF and 1500 XOF per kilogram, respectively. *Moringa* leaf powder was purchased at 8000 XOF per kilogram in Abidjan and 10 000 XOF per kilogram in Bouaké and Korhogo.

Table 5: Purchase price and quantities of *soumbara* and of leaves of *Moringa* by locality

Cities	<i>Soumbara</i>	Leaf powder of <i>Moringa</i>
	1 kg / XOF	1 kg / XOF
Abidjan	≥ 2000	8000
Bouaké	1700	10 000
Korhogo	1500	10 000

3.4 Level of knowledge of *soumbara* from *nééré* and of leaves of *Moringa oleifera*

All respondents were familiar with *soumbara* from *nééré* (100%) in the three (3) cities. The leaves of *Moringa oleifera* were mainly known in Abidjan (92.13%) and Bouaké (88.15%) (**Figure 1**).

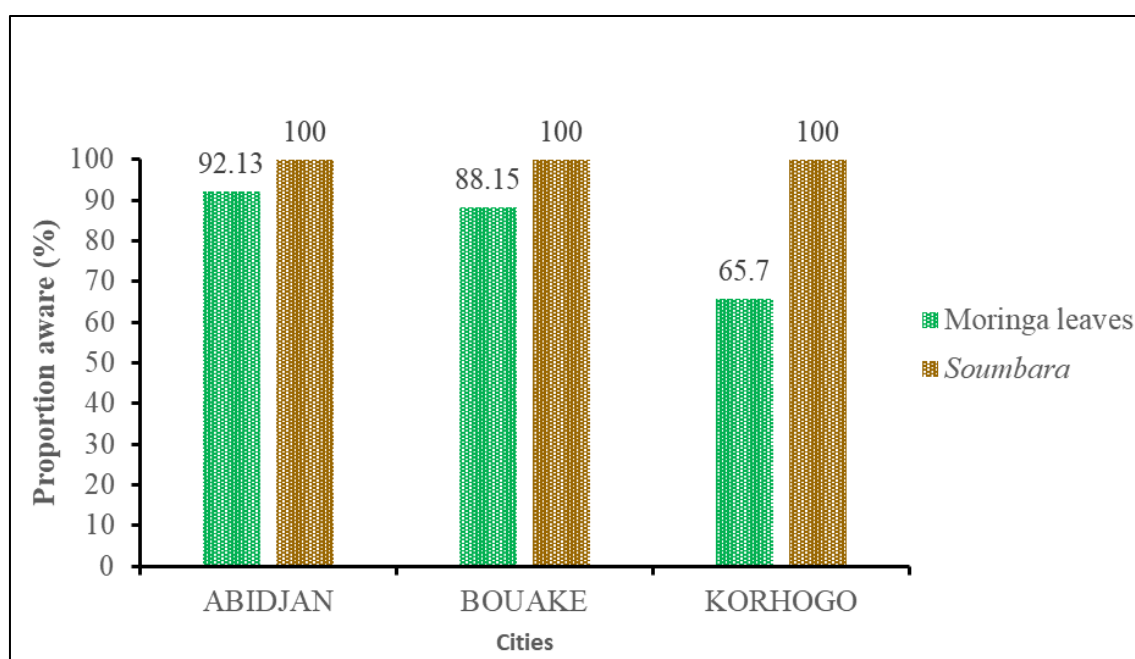


Figure 1: Level of knowledge of *soumbara* from *nééré* and of leaves of *Moringa oleifera*

3.5 Consumption level of *soumbara* from *nééré* and of leaves of *Moringa oleifera*

Figure 2 shows that *soumbara* was widely consumed in all surveyed localities. Korhogo recorded the highest proportion (97.47%), while Bouaké and Abidjan recorded 92.64% and 90.23%, respectively. The leaves of *Moringa oleifera* were more consumed in Bouaké (69.74%) and Abidjan (67%). The lowest consumption was recorded in Korhogo (37.48%).

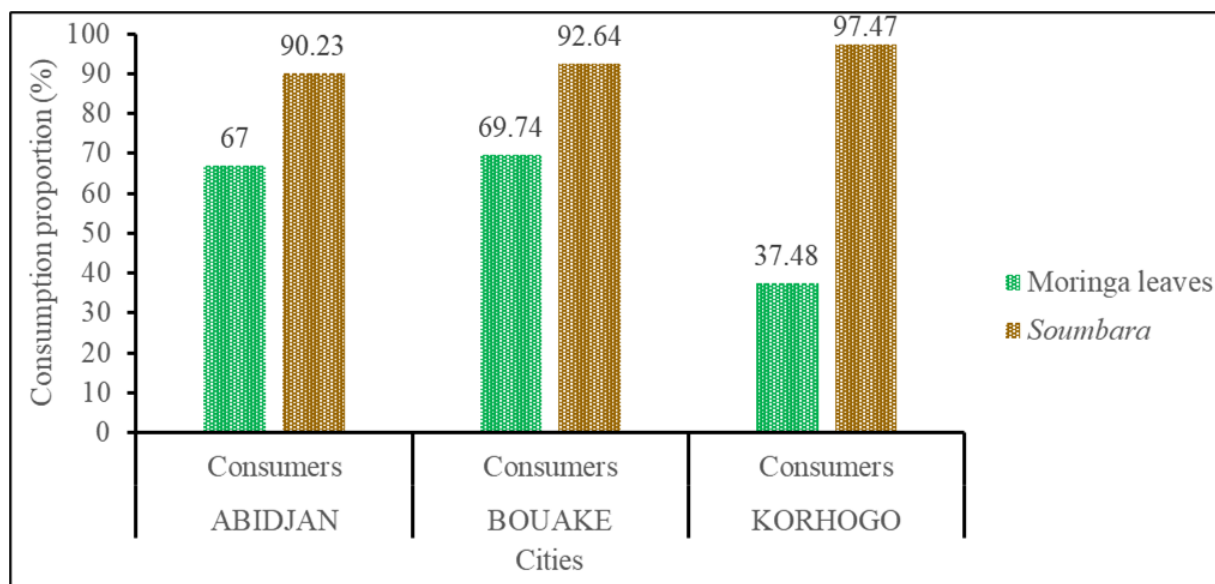


Figure 2: Consumption of *soumbara* from *nééré* and of leaves of *Moringa oleifera*

3.6 Chi-square test between the consumption of leaves of *Moringa oleifera*, of *soumbara* and locality

The chi-square test (χ^2) revealed a relationship between locality and the consumption level of leaves of *Moringa oleifera* since the observed chi-square (χ^2_{obs}) (26.28) was higher than the theoretical chi-square (5.99). However, the chi-square test (χ^2) revealed no apparent relationship between locality and the consumption level of *soumbara* since the observed chi-square (χ^2_{obs}) (4.4) was lower than the theoretical chi-square (5.99) (**Table 6**).

Table 6: Chi-square test between the consumption of leaves of *Moringa oleifera*, of *soumbara* and locality

	Chi-square parameters (χ^2)			
	Df	(χ^2_{obs})	(χ^2_{theo})	P
Moringa leaves	2	26.28	5.99	< 0.05
<i>Soumbara</i>	2	4.4	5.99	> 0.05

χ^2_{obs} : observed chi-square; χ^2_{theo} : theoretical chi-square; P: probability; df: degrees of freedom.

3.7 Consumption frequency of *soumbara* from *nééré* and of leaves of *Moringa oleifera*

Figure 3 highlights the consumption frequency of *soumbara* and of the leaves of *Moringa*. It appears that 77.64% of consumers of *soumbara* in Korhogo consumed it 1 to 2 times per week, whereas in Abidjan (52.30%) and Bouaké (57.09%) the consumption frequency was 1 to 2 times per month. The leaves of *Moringa* were rarely consumed in Abidjan (49.85%), Bouaké (45.64%) and Korhogo (59.60%).

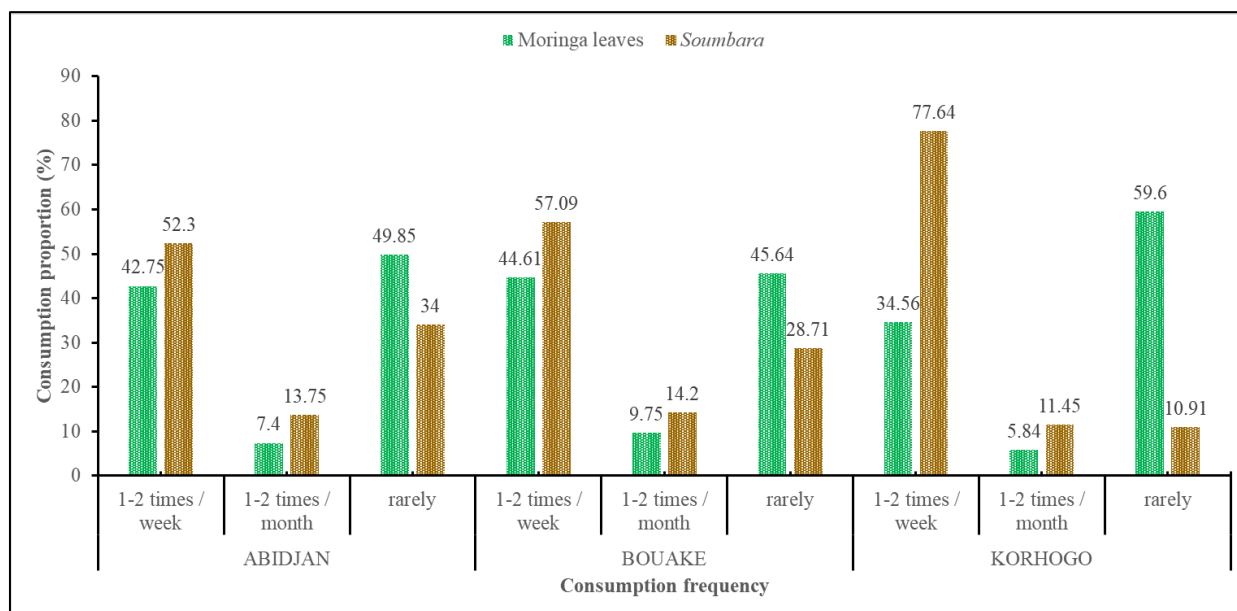


Figure 3: Consumption frequencies of *soumbara* from *néré* and of leaves of *Moringa oleifera*

3.8 Time of consumption of *soumbara* from *néré* and of leaves of *Moringa oleifera*

The results showed that *soumbara* from *néré* was mainly consumed at dinner (30.08%), whereas the leaves of *Moringa oleifera* were consumed at any time of day (35.86%).

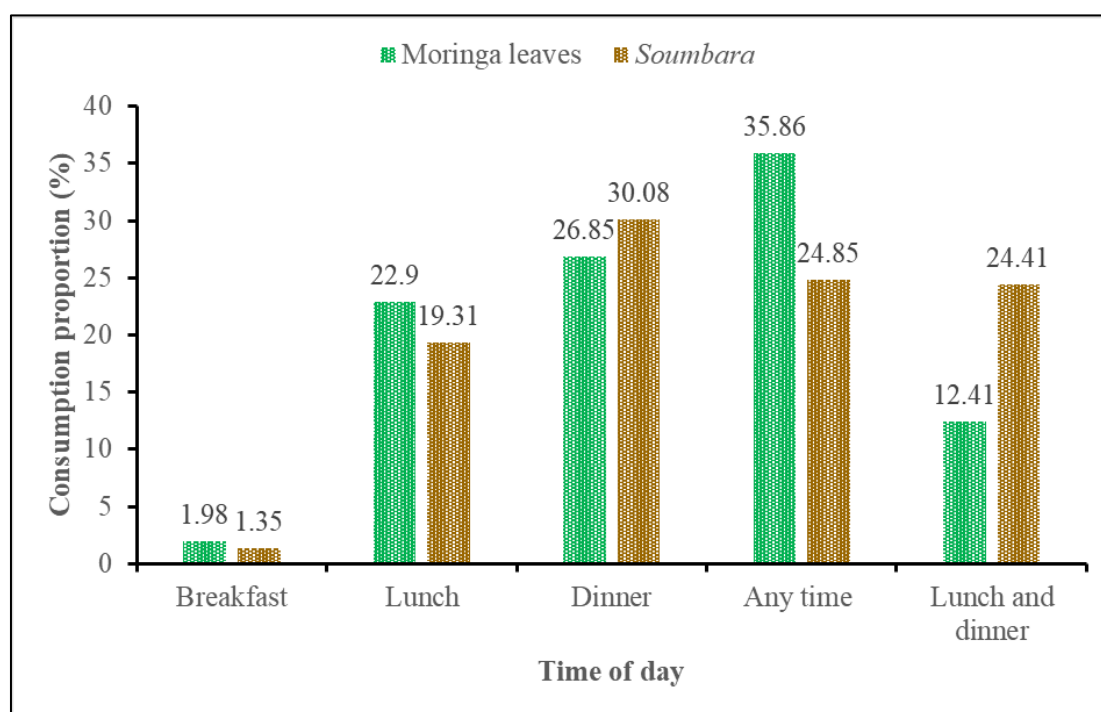


Figure 4: Time of consumption of *soumbara* from *néré* and of leaves of *Moringa oleifera*

3.9 Form of consumption of *soumbara* from *néré*

Figure 5 shows the forms of consumption of *soumbara*. The survey revealed that *soumbara* was mostly consumed in sauces (41.52%). In addition, 16.19% of consumers of *soumbara* used it as a spice. Furthermore, some consumers (24.36%) sprinkled the powdered *soumbara* over food, and 17.91% consumed it as a soup.

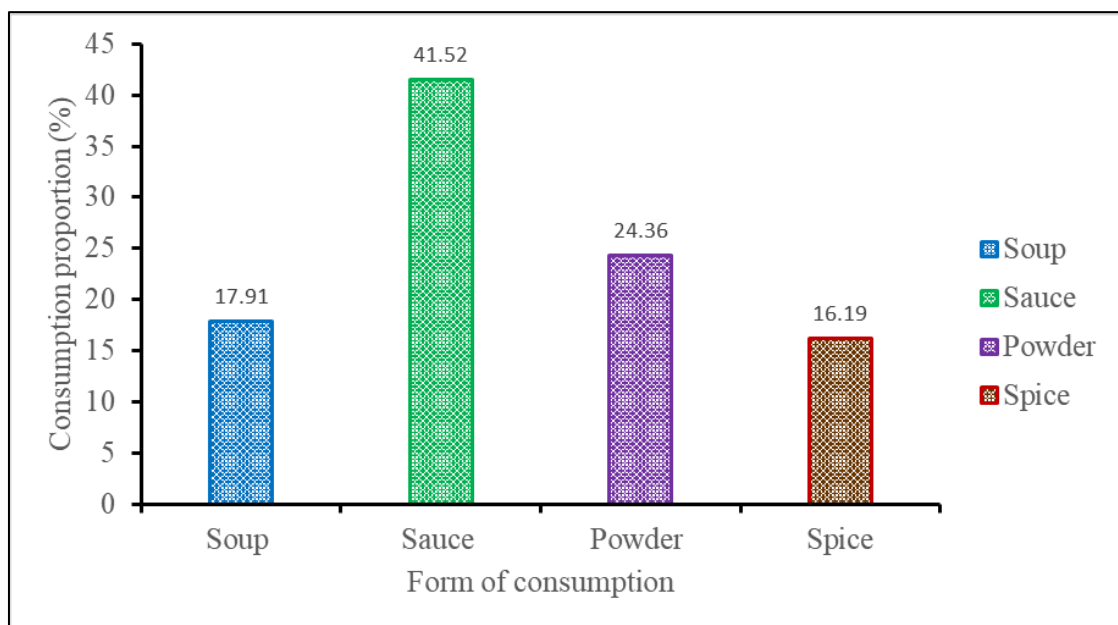


Figure 5: Form of consumption of *soumbara* from *néré*

3.10 Form of consumption of leaves of *Moringa oleifera*

Figure 6 presents the forms of consumption of the leaves of Moringa. The results showed that Moringa leaves were mainly used to prepare leaf sauces (65.86%). In addition, 14.94% of consumers used Moringa leaves to prepare herbal infusions.

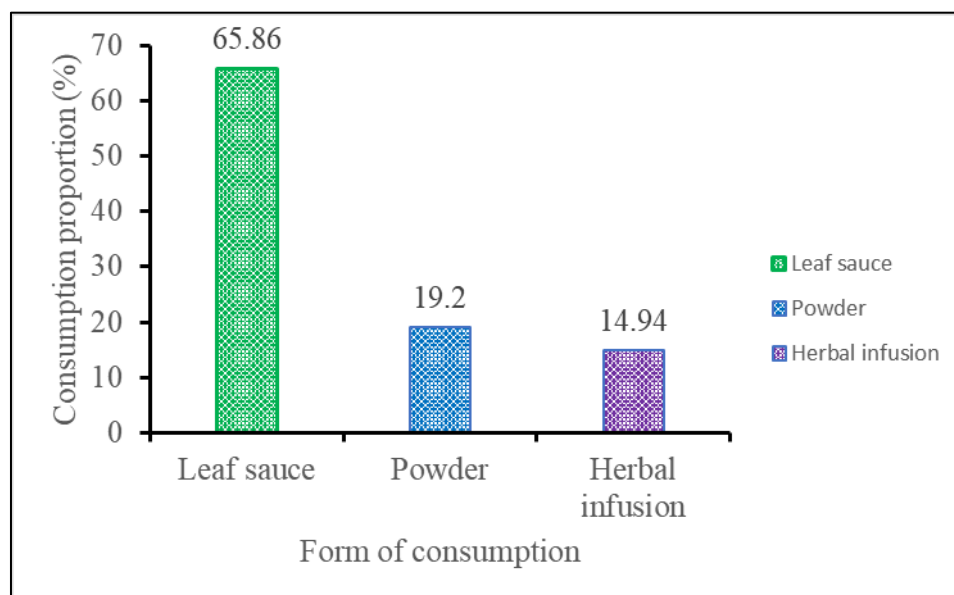


Figure 6: Form of consumption of leaves of *Moringa oleifera*

3.11 Reasons for consuming the leaves of *Moringa oleifera* and of *soumbara* from *néré*

A clear pattern emerged regarding the reasons why respondents consumed *soumbara* from *néré* and the leaves of Moringa. As shown in Figure 7, respondents consumed the leaves of Moringa not only because they were perceived to prevent disease (47.89%), but also for their laxative action (32.46%). In addition, respondents consumed *soumbara* because of the improved digestion it was believed to promote (33.94%) and for its fortifying properties (25.84%).

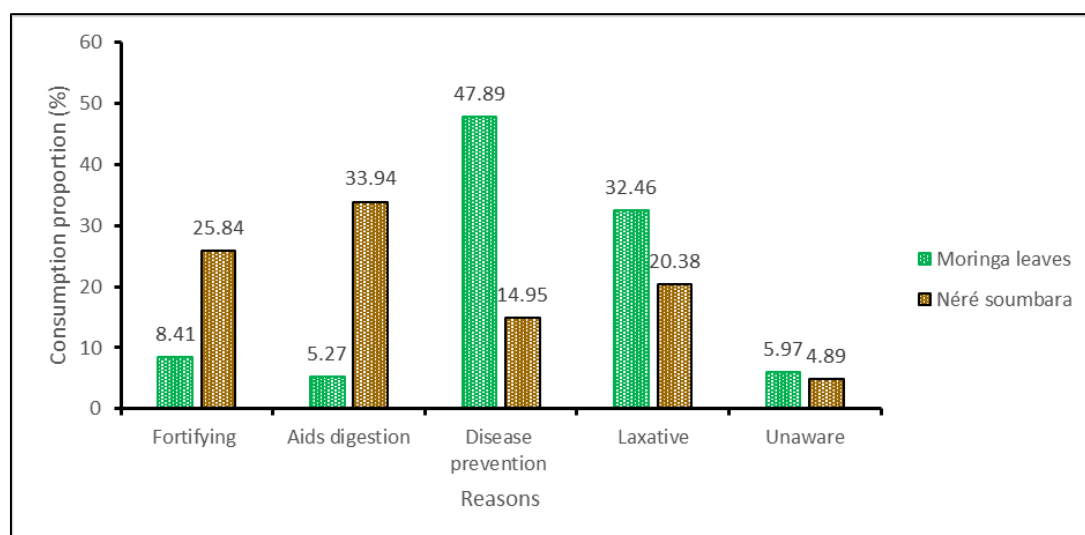


Figure 7: Reasons for consuming the leaves of *Moringa oleifera* and of *soumbara* from *nééré*

3.12 Therapeutic properties attributed to the leaves of *Moringa oleifera* and to *soumbara* from *nééré*

The health benefits of local products are an important issue for the population. **Figure 8** presents the therapeutic properties of *soumbara* and of the leaves of *Moringa* as reported by consumers. Thus, 31.78% of respondents consumed the leaves of *Moringa* for the prevention and management of diabetes, while 23.24% were unaware of their health properties. Furthermore, 33.78% of respondents consumed *soumbara* from *nééré* to counter arterial hypertension and 22.49% to counter diabetes.

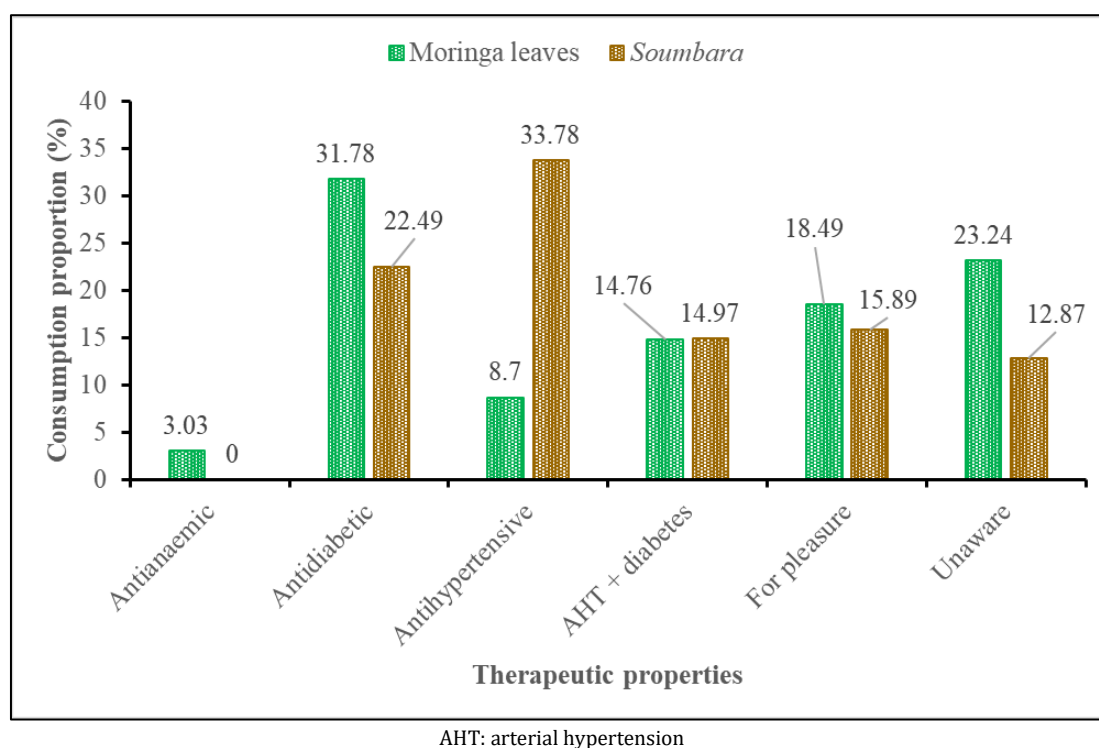


Figure 8: Therapeutic properties attributed to the leaves of *Moringa oleifera* and to *soumbara* from *nééré*

3.13 Consumption of *soumbara* from *nééré* and of leaves of *Moringa oleifera* according to educational level

The results reported in **Figure 9** show that consumers of leaves of *Moringa* were predominantly individuals with no formal schooling (76.07%). In contrast, most consumers of *soumbara* had primary education (94.30%) and 91.70% tertiary education. The chi-square test (χ^2) revealed a relationship between educational level and the consumption of leaves of *Moringa* since the observed chi-square (χ^2_{obs}) (353.6) was higher than the theoretical chi-square (7.81). In contrast, the chi-square test (χ^2) showed no relationship between educational level and the consumption of *soumbara* since the observed chi-square (χ^2_{obs}) (1.38) was lower than the theoretical chi-square (7.81) (**Table 7**).

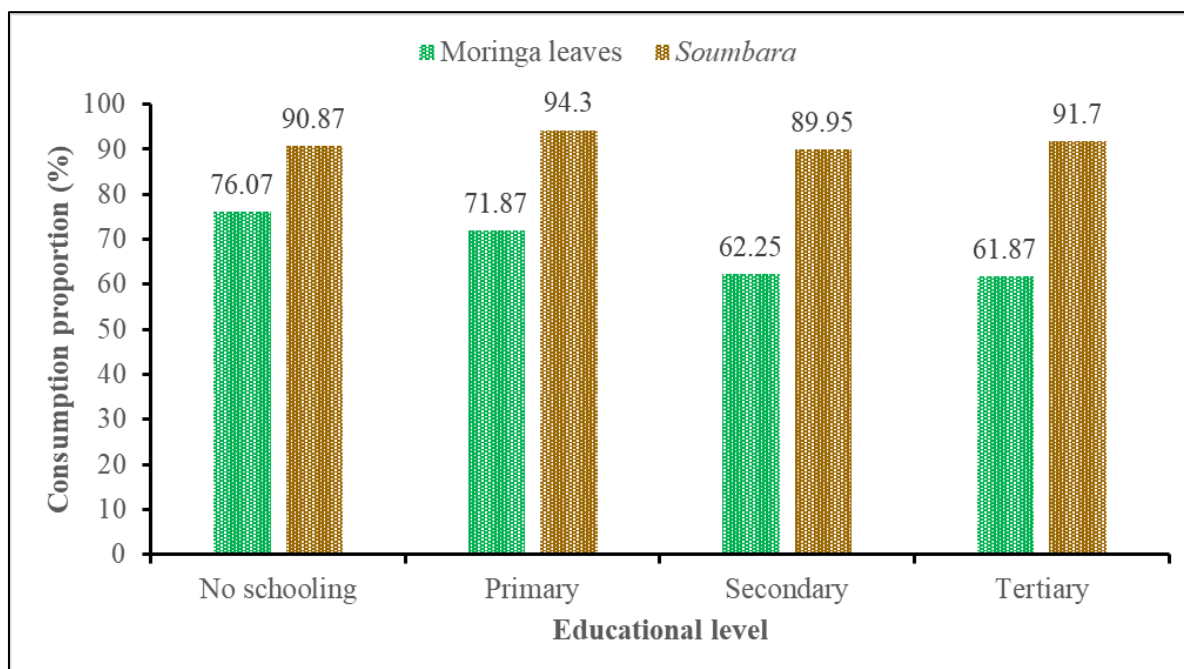


Figure 9: Consumption of *soumbara* from *néré* and of the leaves of *Moringa oleifera* according to educational level

Table 7: Chi-square test between the consumption of leaves of *Moringa*, of *soumbara* and educational level

	Chi-square parameters (χ^2)			
	Df	(χ^2_{obs})	(χ^2_{theo})	P
Moringa leaves	3	1.38	7.81	> 0.05
<i>Soumbara</i>	3	353.6	7.81	< 0.05

χ^2_{obs} : observed chi-square; χ^2_{theo} : theoretical chi-square; P: probability; df: degrees of freedom.

3.14 Consumption of *soumbara* and of leaves of *Moringa oleifera* according to sex

The results presented in **Figure 10** showed that women consumed more leaves of *Moringa* (71.95%) and more *soumbara* (94.05%) than men. However, the chi-square test (χ^2) showed no relationship between sex and the consumption level of *soumbara* since the observed chi-square (χ^2_{obs}) (3.02) was lower than the theoretical chi-square (3.84). The same applied to the leaves of *Moringa* since the observed chi-square (χ^2_{obs}) (1.91) was lower than the theoretical chi-square (3.84) (**Table 8**).

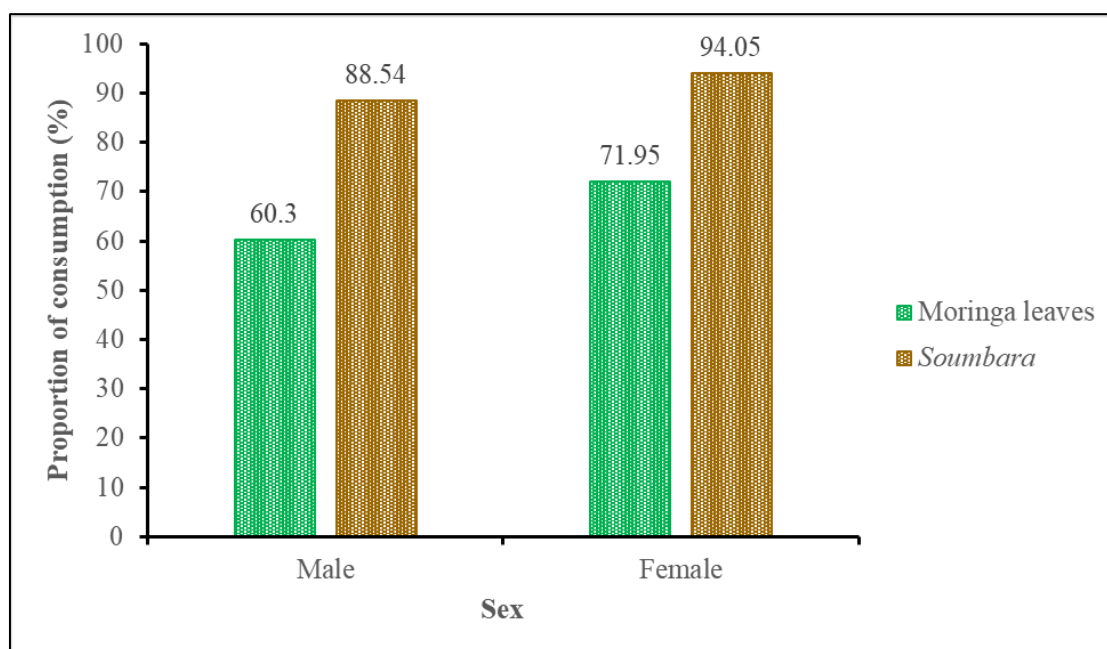


Figure 10: Consumption of soumbara from *néré* and of leaves of *Moringa oleifera* according to sex

Table 8: Chi-square test between the consumption level of Moringa leaves, of soumbara and sex

	Chi-square parameters (χ^2)			
	Df	(χ^2_{obs})	(χ^2_{theo})	P
Moringa leaves	1	1.91	3.84	> 0.05
Soumbara	1	3.02	3.84	> 0.05

χ^2_{obs} : observed chi-square; χ^2_{theo} : theoretical chi-square; P: probability; df: degrees of freedom.

4 DISCUSSION

This part of the work was devoted to the sociodemographic characteristics of the consumption of *soumbara* from *néré* and of leaves of *Moringa*. The aim of this study was to determine the consumption level of *soumbara* from *néré* and of leaves of *Moringa oleifera*. The results showed that *soumbara* was a widely known product (100%), consumed by 91.62% of respondents. This high consumption of *soumbara* is likely to be associated with the culture and dietary habits of the populations. In addition to this main reason, health preservation and the sensory pleasure provided by *soumbara* from *néré* were also reported. Moreover, the survey revealed that *soumbara* was consumed by all respondents irrespective of educational level. A similar study by [10] showed that *soumbara*, a genuine local product, remains very popular and is consumed by all, regardless of social class or income. A survey by [11] reported the same trends: 95% of respondents had a good opinion of *soumbara*, 2% a moderately good opinion, and 3% did not appreciate *soumbara*.

According to the information collected, *soumbara* was consumed after cooking, as sauces (41.52%) or soups (17.91%), as powder (24.36%) and in spiced preparations (16.19%). These results reflect the use of *soumbara* as a seasoning condiment in the preparation of many dishes. This observation was also made by [12] who reported that *soumbara* contains free amino acids (glutamic and aspartic acids) that act as flavour enhancers and are highly sought after in aroma formulation.

The survey also revealed that *soumbara* was more consumed by the populations of Korhogo (97.47%) and Bouaké (92.64%) than by those of Abidjan (90.23%). The consumption frequency of *soumbara* was also higher in the north than in other regions of Côte d'Ivoire. This result may be explained by the local production of *soumbara* from *néré* in the north (Korhogo) and by the proximity of this region to major producing countries such as Burkina Faso, Guinea and Mali.

The survey showed that respondents consumed *soumbara* for its antihypertensive (33.78%) and antidiabetic (22.49%) properties. These therapeutic properties were reported by [13], who states that the seed of *nééré* is used as a blood-pressure regulator. Particular attention is thus paid to *soumbara* by consumers insofar as it may regulate arterial blood pressure. Moreover, it may supply vitamins and elements necessary for the proper functioning of the organism, and it is one of the main condiments used to season sauces in households [14]. These results indicate that *soumbara* is well appreciated by consumers.

At the end of the consumption survey on the leaves of Moringa, it emerged that 72.54% of respondents were familiar with the leaves of Moringa and 63.31% consumed them. These results are close to those of [15], who reported, in their study on the level of knowledge and consumption of food supplements, that 71.7% of the households surveyed consumed Moringa leaves. The high consumption level of Moringa leaves may be explained both by the fact that the leaves of Moringa are commonly present in the diets of many populations and by the cultural intermixing of the population [16]. Furthermore, indigenous knowledge of leafy vegetables is preserved and transmitted from generation to generation, and thereby constitutes a factor in the maintenance of biological resources [17].

The consumption of leaves of Moringa at least once a month reflects the year-round availability of these leafy vegetables. They thus contribute to the food security of urban populations, especially the poorest [18]. This result is in agreement with that of [19]. These authors further reported that leafy vegetables do not hold a prominent place in dietary habits in Côte d'Ivoire.

The diversity observed in the consumption frequency of the leaves of Moringa is consistent with the work of [16] on the contribution of leafy vegetables to the nutrition of urban populations in Côte d'Ivoire. This diversity may be due to inter-ethnic intermixing and/or to the cultural identity of respondents, all the more so as the surveyed cities (Korhogo, Bouaké and Abidjan) are cosmopolitan [20].

Moreover, the main preferred forms of the leaves of Moringa among respondents were: leaf sauce (65.86%), powder (19.2%) and herbal infusion (14.94%). These observations suggest that the consumption of these leaves is region-specific [21].

Subjects with no formal schooling (71.87%) consumed the leaves of Moringa more than subjects with tertiary education (61.87%). Educational level thus appears to influence the consumption of leafy vegetables. According to [22], people with low or no schooling remain more attached to their cultural values, whereas those with a high standard of living tend to adopt Western lifestyles [23].

The survey results showed that the leaves of Moringa were consumed with a view to preserving health. Accordingly, 31.78% of respondents consumed the leaves of Moringa for the prevention and management of diabetes, while 23.24% were unaware of their health properties. These results suggest a perceived health benefit provided by the leaves of Moringa to their consumers. In addition, numerous therapeutic properties are attributed to *Moringa oleifera* [24], which is used in traditional medicine for the treatment of metabolic diseases [25].

5 CONCLUSION

In summary, the survey results revealed that the leaves of Moringa and *soumbara* are well known and consumed by the population. The leaves of Moringa, are consumed mainly by individuals with no formal schooling, in the form of leaf sauce, powder and herbal infusion. As for *soumbara* from *nééré*, it is consumed irrespective of educational level and sex, in the form of sauce, powder and spice. Regarding the reasons for consumption, *soumbara* is consumed for its antihypertensive properties and for the flavour it imparts to dishes, whereas the leaves of Moringa are consumed for their antidiabetic properties.

However, the properties attributed to *soumbara* (hypotensive, antidiabetic) and to Moringa leaves (antidiabetic, laxative) rest exclusively on the perceptions and beliefs of the respondents. Clinical or biological studies are therefore needed to confirm or refute these claims.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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