International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 7 No. 3 Aug. 2014, pp. 1129-1136

http://www.ijias.issr-journals.org/

COMPOSITION OF 13 DIFFERENT TRADITIONAL SAUCES PREPARED FROM MORINGA OLIFERA LEAVES IN THE FAR-NORTH REGION OF CAMEROON

SALIOU MAWOUMA[1-2], ROGER PONKA[3], and CARL MOSES MBOFUNG[1]

[1]Department of Food Science and Nutrition,
The University of Ngaoundere, National School of Agro-industrial Sciences,
PO BOX 455, Ngaoundere, Cameroon

[2]Department of Biological Sciences,
The University of Maroua, Faculty of Science,
PO BOX 814, Maroua, Cameroon

[3]Department of Agriculture, Livestock and By-Products,
The University of Maroua, The Higher Institute of The Sahel,
PO BOX 46, Maroua, Cameroon

ABSTRACT: Micronutrients deficiencies are of great concern in the far north Region of Cameroon and can be fought through the promotion of local food resources. Among them are *Moringa oleifera* leaves which are rich in proteins of good quality, vitamin A, vitamin C, iron and zinc. Our study aims to determine the nutrient composition of local traditional sauces involving Moringa leaves. This was done through the identification of the various recipes, their implementation and the processing of samples prior to biochemical analyses. The contents in moisture, ash, proteins, lipids were determined by standard AOAC methods. Iron and zinc contents were determined by atomic absorption spectrophotometry and vitamin C, phenols and phytate by spectrophotometric methods. The results show pH levels ranging from 7.25 to 8.63, lipid contents varying from 39.00 to 58.30 g/100g DM and proteins content varying from 13.25 to 29.48 g/100g DM. Iron and zinc levels were also important, ranging respectively from 5.86 to 25.47 mg/100g of DM and 0.37 to 3.30 mg/100g of DM. The vitamin C has not been detected in the sauces and the levels of total phenols and phytates were very low (less than 1g/100g of DM). Although the traditional Moringa sauces studied are good sources of nutrients like proteins, iron and zinc, their high pH levels and cooking method that destroy all the vitamin C might compromise the bioavailability of these minerals.

KEYWORDS: Moringa oleifera, traditional recipes, nutrients, antinutrients.

1 INTRODUCTION

The Northern part of Cameroon is characterized by a semi-arid climate which however befits the culture of *Moringa oleifera* (M.O.), a fast growing shrub native of India [1]. The leaves of this plant which are part of the diets of local populations are characterized by a high nutritive value. They are rich in vitamin A, vitamin C, iron and zinc [2], [3]. In addition, they contain high amounts of proteins made up of all the essential amino acids [4]. All these properties make M.O. leaves to be an interesting food for the fight against micronutrients deficiencies in this region where 36.5% of women of childbearing age and 63.5% of children under 5 years have a deficient iron status [5].

Anemia from iron deficiency results in adults with reduced physical capacity and productivity [6]. In pregnant women, severe anemia is responsible of 20% of maternal deaths and increases the risk of morbidity and fetal and neonatal mortality

[7]. Anemic children are intellectually less efficient, have behavioral troubles and a slow growth [8]. Zinc deficiency in turn has a negative impact on the immune system and is associated with a higher risk of infectious diseases [9], [10].

Previous studies showed that sauces made with leafy vegetables are good sources of micronutrients [11], [12]. In Senegal, Ndong et al. showed that the fortification of traditional meals with the powder of M.O. leaves increases significantly their protein and iron contents [13]. Other studies on Cameroonian vegetables put emphasis on their nutritive value without considering the effects of cooking techniques on the level of nutrients in cooked products [14], [15]. In addition, no study has been carried out on the nutrient value of the various recipes involving Moringa leaves in the far north Cameroon. Therefore our study aims to determine the composition of the different traditional Moringa sauces that are consumed in that Region.

2 MATERIALS AND METHODS

2.1 IDENTIFICATION OF THE RECIPES

The recipes of 13 Moringa sauces were written down based on data collected during a survey conducted in January 2012 in 243 households belonging to rural and urban areas of the far-north Region of Cameroon. During home visits to 04 different women in Maroua, details concerning the types and quantities of ingredients used were noted, along with the preparation procedure.

2.2 PREPARATION OF THE SAUCES

Fresh leaves were collected from the same field located in the outskirt of Maroua. The other ingredients were purchased at the main food market of the town (marché abattoir) and stored at 4°C. The different sauces were prepared as shown in figure 1, in the kitchen facilities of the laboratory of Biosciences of the Higher Institute of the Sahel, Maroua, Cameroon. After cooling, the sauces were then homogenized using a domestic blender (Super Master Blender SMB-2898) and each sample was divided into three aliquots. The first aliquot was used to determine the pH using of a digital electronic pH meter (pHep HI 98107). The second aliquot was dried in hot air oven at 45 ± 2^0C until moisture free, homogenized again using pestle and mortar, packed in polyethylene pouches and stored at -20°C till further analysis. The third aliquot was used for proximate analysis.

Each dish was prepared in triplicates and care was taken to prevent mineral contamination at every stage.

2.3 THE PROXIMATE ANALYSIS

The moisture content was determined by drying fresh sample in an oven at 105°C until constant weight, ash by incineration in a muffle furnace at 550°C for 48 h, protein by the Kjeldahl technique with total proteins calculated by applying the factor 6.25 to the nitrogen values, and lipids by extraction using the standard Soxhlet procedure [16].

2.4 MICRONUTRIENTS ANALYSIS

Total iron and zinc contents were determined by Flame Atomic Absorption Spectrometry [17]. Vitamin C were measured by the redox reaction using N- Bromosuccinimide [18].

2.5 ANTINUTRIENTS ANALYSIS

Phytates were determine by spectrophotometric method according to Ali et al., [19], and total phenols using the Folin-Ciocalteu reagent [20].

2.6 STATISTICAL ANALYSIS

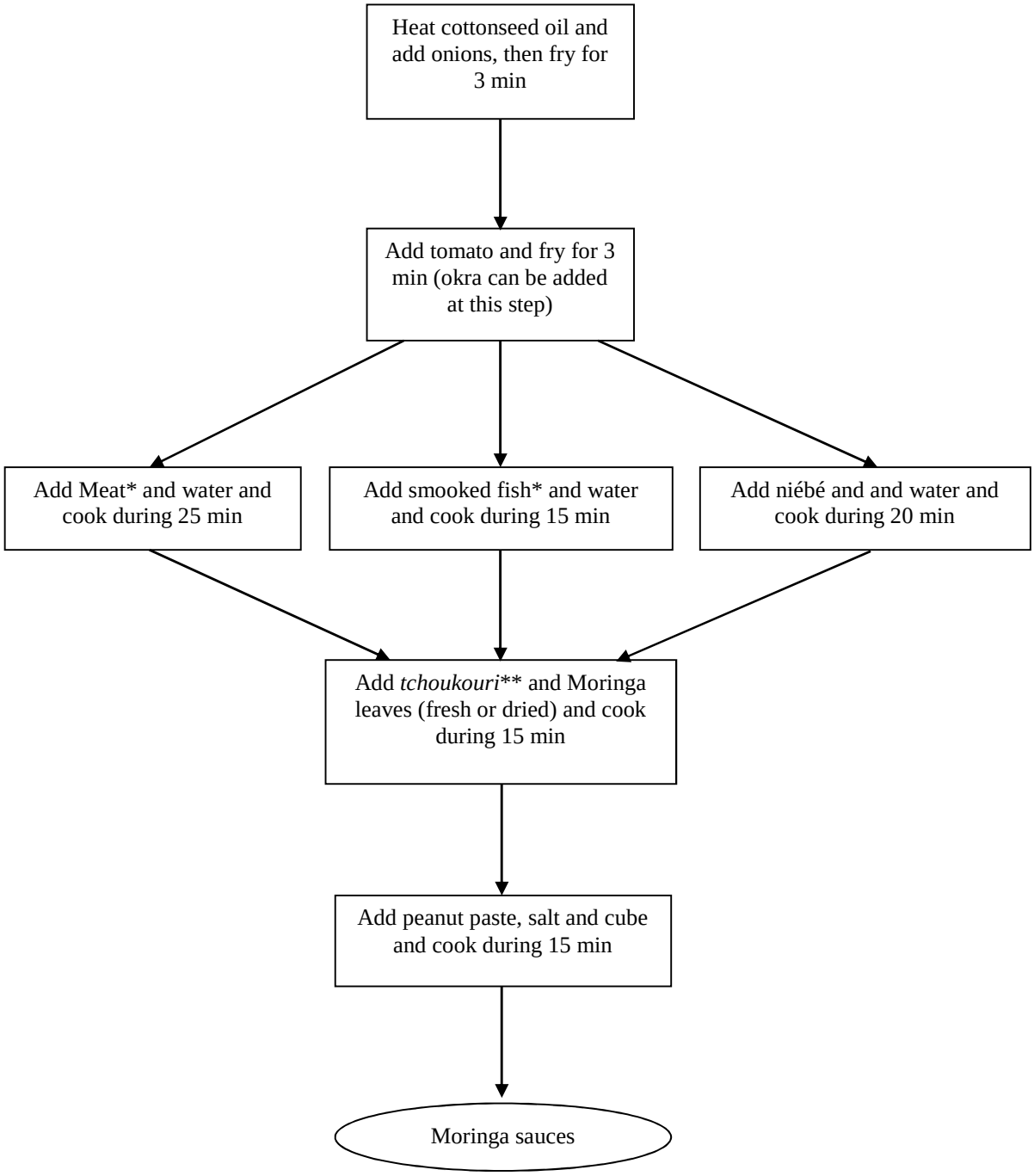
The statistical analysis of data was done by one way Analysis of Variance (ANOVA) using the software IBM SPSS Statistics version 19.0.1. Differences between means were tested using the Duncan Multiple Range Test with 5% level of significance.

3 RESULTS AND DISCUSSION

Table 1 describes the 13 Moringa sauces studied. From this table, it appears that the percentages of incorporation of Moringa leaves vary from 14.9 to 16% for recipes using fresh leaves and from 4,3 to 4,6% for recipes using dried leaves. The values observed are lower than those obtained by Madhu for Indian sauces involving fenugreek (30%) and spinach leaves (40%) [21]. The lower percentages obtained in our study are due to the presence of other ingredients, and also to large quantities of water added during preparation. Although the percentages of incorporation of dried leaves were lower, we noticed that the consistence of the sauces obtained was similar to the ones containing fresh leaves. This can be explained by the reabsorption of water by the dried leaves during cooking.

The proximate composition of *M. oleifera* sauces are shown in Table 2. The moisture content of the different sauces analyzed does not vary ($p < 0.05$). The high values of moisture observed are due to large quantities of water added during preparation of the sauces and to the important water content of the ingredients like the M. oleifera leaves, tomato, onion, fresh meat [22]. All the sauces had varied amounts of pH, ash, lipids, and proteins contents. The pH of the sauces range from 7.25 ± 0,07 to 8.63 ± 0,61 and are higher than those observed by Madhu with Indian green leafy vegetable based products (from 5.09 to 7.43) [21]. The presence of extract of wood ash (*tchoukouri*) which is of alkaline nature among ingredients may explain these high values. Alkaline pH has been reported to be and inhibiting factor of the Nonheme Iron Absorption because it drastically reduce the solubility of ferric ions [23]. The total ash content of the sauces ranged from 5.46 ± 0,11 to 10.44 ± 0.37 g/100g DM. These values are similar to those reported by Ponka et al. in dishes consumed in Ngali II region of Cameroon, but higher than those reported by Kayode et al. on selected indigenous soups in Nigeria [24], [25]. The variations in ash are the function of ingredients and their in situ ash content. The lipid contents of the sauces vary from 39.00 ± 1.13 to 58.30 ± 2.12 g/100g DM. These values are higher than those found by Domngang et al. in dishes consumed in some rural areas of the West Province of Cameroon, with values ranging from 15.08 - 35.3 g/100g DM [26]. Cottonseed oil and peanut paste are the main contributors to these high lipids contents of the sauces. The values of the proteins content range from 13.25 ± 0.27 to 29.48 ± 0.36 g/100g DM and are higher than those observed by Teugwa et al. on dishes consumed in a rural area of the Far North Region of Cameroon [27]. M.O. leaves have interesting amount of protein along side with other ingredients like meat, fish and peanut paste which are also good sources of proteins. The recipe having the lowest protein content is the one using okra (very poor in proteins) as one of the major ingredient in the weight basis.

The micronutrient and anti-nutrient contents of the sauces varied ($P < 0.05$). Iron levels, range from 5.86 ± 0.84 to 25.47 ± 0.33 mg/100g of DM. They are similar to the values obtained by Randrianatoandro et al. with dishes prepared from green-leafy vegetables in an urban district of Antananarivo (Madagascar), and higher than those observed by Ndong et al. in traditional Senegalese sauces enriched with the powder of M.O. leaves [13], [28]. The Highest value is observed in the sauce containing okra which is nevertheless reported to have low quantities of iron compare to other ingredients. This paradoxal result may be explained by a contamination during the processing of the sauces. Zinc content also vary ($P < 0.05$) from 0.37 ± 0.03 to 3.30 ± 0.01 mg/100g of DM. This result is similar to what have been reported in other African leaf sauces (baobab, spinach, amaranths) [12], [29], [30]. Higher zinc levels are observed with sauces containing cowpea. Ingredients like of M.O. leaves, meat, fish and cowpea may explain these appreciable values since they are reported to be rich in minerals like iron and zinc [22]. The antinutritional factors levels observed varied and were low (less than 0.1 g /100g of DM for total phenols and less than 1g /100g of DM for phytates. Cooking has been reported to reduce anti-nutrients of plant products [31], [32]. This result is of nutritional interest as antinutrients bind dietary minerals giving insoluble complexes that are not absorbed in the human gut. Vitamin C has not been detected in the sauces. It has been probably destroyed during the preparation of the sauces, since Moringa leaves and other ingredients containing vitamin C have been cooked in boiling water for at least 30 minutes. Bioavailability of minerals like iron might be affected since vitamin C is the most potent enhancer of iron absorption [33].



**Meat and smooked fish can be added along with niébé*
***tchoukouri: extract of wood ash*

Figure 1: Flow shart of the preparation procedures of Moringa oleifera sauces

Table 1: Description of traditional Moringa sauces consumed in the Far-North region of Cameroon.

Sauce code	Type of leaves used	Other ingredients	Weight of the sauce (g)	% incorporated (Moringa leaves)
1	Fresh (100g)	Cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (700g).	622	16.1
2	Fresh (100g)	Okra (100g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (700g).	672	14.9
3	Fresh (100g)	Meat (80g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	662	15.1
4	Fresh (100g)	Smoked fish (60g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (700g).	652	15.3
5	Fresh (100g)	Cowpea (40g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	637	15.7
6	Fresh (100g)	Meat (80g), cowpea (40g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	677	14.7
7	Fresh (100g)	Smoked fish (60g), cowpea (40g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	667	14.9
8	Dry (30g)	Cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	650	4.6
9	Dry (30g)	Meat (80g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	675	4.4
10	Dry (30g)	Smoked fish (60g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	660	4.5
11	Dry (30g)	Cowpea (40g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	675	4.4
12	Dry (30g)	Meat (80g), cowpea (40g), cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	700	4.3
13	Dry (30g)	Smoked fish (60g), cowpea (40g), Cottonseed oil (50g), onion (45g), peanut paste (70g), tomato (70g), salt (1,5g), cube (4g), *tchoukouri* (4g), water (800g).	680	4.4

Table 2: The pH and proximate composition of Moringa oleifera sauces

Sauce code	pH	Moisture (%)	Ash (g/100g DM)	Lipids (g/100g DM)	Proteins (g/100g DM)
1	7.83 ± 0.25^{abcde}	67.92 ± 5.48^{a}	10.44 ± 0.37^{h}	50.10 ± 0.14^{d}	18.38 ± 0.26^{de}
2	8.15 ± 0.35^{cdef}	71.15 ± 0.91^{a}	8.41 ± 0.30^{d}	50.40 ± 2.26^{d}	13.25 ± 0.27^{ab}
3	8.63 ± 0.61^{f}	70.47 ± 1.95^{a}	9.33 ± 0.45^{ef}	43.80 ± 0.84^{b}	29.75 ± 0.32^{h}
4	8.60 ± 0.26^{ef}	71.41 ± 1.85^{a}	8.41 ± 0.30^{d}	44.50 ± 0.42^{bc}	22.29 ± 0.24^{f}
5	8.03 ± 0.57^{bcdef}	67.59 ± 5.90^{a}	5.46 ± 0.11^{a}	39.00 ± 1.13^{a}	19.22 ± 0.28^{e}
6	7.33 ± 0.30^{ab}	68.33 ± 0.26^{a}	7.56 ± 0.13^{c}	43.80 ± 0.84^{b}	11.96 ± 0.03^{a}
7	7.66 ± 0.20^{abcd}	68.57 ± 1.25^{a}	6.63 ± 0.35^{b}	39.70 ± 0.14^{a}	15.58 ± 0.11^{c}
8	8.33 ± 0.20^{def}	72.58 ± 5.10^{a}	8.25 ± 0.26^{d}	58.30 ± 2.12^{f}	14.66 ± 0.34^{bc}
9	8.33 ± 0.64^{def}	74.21 ± 1.44^{a}	9.98 ± 0.05^{h}	45.80 ± 0.84^{bc}	24.29 ± 0.40^{g}
10	7.76 ± 0.58^{abcd}	70.36 ± 1.52^{a}	9.53 ± 0.40^{fg}	47.20 ± 0.28^{c}	29.48 ± 0.36^{h}
11	8.40 ± 0.28^{def}	70.10 ± 4.60^{a}	7.69 ± 0.38^{c}	45.70 ± 1.27^{bc}	17.43 ± 0.06^{d}
12	7.40 ± 0.34^{abc}	70.43 ± 1.04^{a}	7.21 ± 0.14^{c}	51.90 ± 0.70^{d}	17.47 ± 0.14^{d}
13	7.25 ± 0.07^{ab}	72.97 ± 1.03^{a}	8.23 ± 0.21^{d}	38.80 ± 1.13^{a}	15.71 ± 3.46^{c}

DM: Dry matter.

The values are given as mean ± standard deviation.

Different superscripts in the same line indicate significant differences (P < 0.05)

Table 3: Micronutrient and anti-nutrient contents of Moringa oleifera sauces.

Sauce code	Iron (mg/100g DM)	Zinc (mg/100g DM)	Vitamin C (mg/100g DM)	Total phenols (mg/100g DM)	Phytates (mg/100g DM)
1	14.50 ± 0.13^{k}	0.44 ± 0.02^{ab}	ND	19.05 ± 0.50^{d}	119.40 ± 0.98^{b}
2	15.46 ± 0.33^{m}	0.37 ± 0.03^{a}	ND	31.05 ± 0.07^{j}	173.55 ± 23.54^{c}
3	10.87 ± 0.07^{e}	1.60 ± 0.04^{d}	ND	24.15 ± 0.07^{h}	110.20 ± 1.27^{ab}
4	16.01 ± 0.17^{l}	1.62 ± 0.01^{d}	ND	20.60 ± 0.56^{e}	113.35 ± 4.73^{b}
5	10.11 ± 0.13^{d}	1.98 ± 0.06^{e}	ND	20.30 ± 0.14^{e}	267.80 ± 2.26^{d}
6	6.78 ± 0.09^{c}	2.85 ± 0.08^{g}	ND	15.35 ± 0.21^{b}	116.15 ± 13.78^{b}
7	5.86 ± 0.08^{a}	2.42 ± 0.03^{f}	ND	16.50 ± 0.98^{c}	125.45 ± 7.28^{b}
8	14.13 ± 0.49^{i}	0.46 ± 0.01^{b}	ND	20.00 ± 0.28^{e}	113.60 ± 10.74^{b}
9	11.34 ± 0.17^{f}	1.64 ± 0.03^{d}	ND	24.95 ± 0.07^{h}	165.95 ± 0.35^{c}
10	13.71 ± 0.14^{h}	1.63 ± 0.01^{d}	ND	21.15 ± 0.21^{f}	180.75 ± 11.52^{c}
11	13.29 ± 0.13^{g}	1.95 ± 0.03^{e}	ND	17.25 ± 0.21^{c}	274.50 ± 0.70^{d}
12	6.30 ± 0.09^{b}	3.30 ± 0.01^{h}	ND	23.15 ± 0.49^{g}	128.95 ± 3.60^{b}
13	14.37 ± 0.23^{jk}	2.41 ± 0.06^{f}	ND	15.35 ± 0.21^{b}	119.45 ± 2.89^{b}

DM: Dry matter.

The values are given as mean ± standard deviation.

Different superscripts in the same line indicate significant differences (P < 0.05)

ND: Not detected (< 0.01 mg/100g DM)

4 CONCLUSION

Traditional Moringa sauces are good sources of lipids and proteins in the diet of local populations of the Far-north Cameroon. Although the incorporation of the *M.oleifera* leaves in the sauces is low, their appreciable levels of iron and zinc and low antinutrient content make the consumption of that sauces to be a potential solution to micronutrients deficiencies in that region. However, the high pH levels of the sauces and the cooking method that destroy all the vitamin C might be serious shackles to the bioavailability of these minerals.

REFERENCES

[1] M. Arbonnier, Arbres, arbustes et lianes des zones sèches d'Afrique de l'Ouest. CIRAD-MNHN-UICN, 2000.

[2] L. P. Sena, D. J. Vanderjagt, C. Rivera, A. T. Tsin, I. Muhamadu, O. Mahamadou, M. Millson, A. Pastuszyn, R. H. Glew, "Analysis of nutritional components of eight famine foods of the Republic of Niger," Plant Foods for Human Nutrition, vol.52, no. 1, pp.17-30, 1998.

[3] Yang, R. Y., Tsou, S. C. S. Lee, T., Chang, C. L., Kuo, G., and Lai, P. Y., Moringa, a novel plant rich in antioxidants, bioavailable iron, and nutrients, In: C. T. Ho, (Eds.) Challenges in Chemistry and Biology of Herbs, American Chemical Society, Washington, D.C. pp. 224-239. 2006.

[4] M. Broin, Composition nutritionnelle des feuilles de Moringa oleifera. PROPAGE, Centre Technique de Coopération Agricole, 2006.

[5] Institut National de la Statistique, Ministère de la Planification, de la Programmation du Développent et de l'Aménagement du Territoire, Enquête Démographique et de Santé: Cameroun 2004. Calverton, MD, ORC Macro, 2005.

[6] S. Basta, M. Soekirman, K. Karryadi, N. Scrimshaw, "Iron deficiency anemia and the productivity of adult males in Indonesia," American Journal of Clinical Nutrition, vol. 3, pp. 916-25. 1979.

[7] L. H. Allen, N. Ahluwalia, Improving iron status through diet: The application of knowledge concerning dietary iron bioavailability in human populations. USAID/OMNI, Washington, DC, 1997.

[8] S. J. Fairweather-Tait, "Iron deficiency in infancy: easy to prevent - or is it?" European Jounal of Clinical Nutrition, vol. 46 (Suppl 4):S9-S 14, 1992.

[9] K. Simmer, S. Khanum, L. Carlsson, R. P. H. Thompson, "Nutritional rehabilitation in Bangladesh – The importance of zinc," American Journal of Clinical Nutrition, vol. 47, pp.1036-1040, 1988.

[10] M. M. Black, "Zinc deficiency and child development," American Journal of Clinical Nutrition, vol. 68, pp. 464S-508S, 1998.

[11] R. H. Glew, D. J. VanderJagt, C. Lockett, L. E. Grivetti, G. C. Smith, A. Pastuszyn, M. Millson, "Amino acid, fatty acid, and mineral composition of 24 indigenous plants of Burkina-Faso," Journal of Food Composition and Analysis, vol. 10, pp. 205–217, 1997.

[12] S. Avallone, T. W. E. Tiemtore, C. Mouquet-Rivier, S. Trèche, "Nutritional value of six multi-ingredient sauces from Burkina Faso," Journal of Food Composition and Analysis, vol. 21, pp. 553–558, 2008.

[13] M. Ndong, S. Wade, N. Dossou, A. T. Guiro and D. R. Gning, "Valeur nutritionnelle du Moringa oleifera, étude de la biodisponibilité du fer, effet de l'enrichissement de divers plats traditionnels sénégalais avec la poudre des feuilles," African Journal of Food, Agriculture Nutrition and Development, vol. 7, pp. 1-17, 2007.

[14] E. Fokou et F. Domngang, "Etude des potentialités nutritionnelles de quelques légume-feuilles consommés au Cameroun (2): Evaluation de la fraction protidique," Annales de la Faculté des Sciences, Biologie-Biochimie, vol. 1, no. 4, pp. 97-110. 1987.

[15] O. U. Eka, F. Domngang et E. Fokou, "Nutrient content of some leafy green vegetables eaten in Cameroon: Chemical analysis of sugars, crude fat, minerals and oxalic acid," Nigerian Journal of Nutritional Sciences, vol. 92, pp. 97-103, 1987.

[16] AOAC, Official Methods of Analysis of the Association of Official Analytical Chemistry. AOAC: Washington, DC, 1990.

[17] I. Novozamsky, V. J. G. Houba and W. Van Vark "A novel digestion technique for multi-element plant analysis," Communication in Soil Science and Plant Analysis, vol. 14, pp. 239–248, 1983.

[18] D. F. Evered, "Determination of ascorbic acid in highly coloured solutions with N bromosuccinimide," J. Analyst, vol. 85, pp. 515-517, 1960.

[19] M. I. Ali, A. J. Perera, and Y. S. Hafez, "New chromophore method for phytic acid determination," Cereal Chemistry, vol. 63, pp. 475–478, 1986.

[20] G. Marigo, "Méthode de fractionnement et d'estimation des composés phénoliques chez les végétaux," Analysis, vol. 2, no. 2, pp. 106-110, 1973.

[21] V. P. Madhu, Bioaccessibility of iron and zinc from green leafy vegetable based products. M.H.Sc. Thesis, University of Agricultural Sciences, Dharwad, 2010.
[22] B. Stadlmayr, U. R. Charrondiere, V. N. Enujiugha, R. G. Bayili, E. G. Fagbohoun, B. Samb, P. Addy, I. Barikmo, F. Ouattara, A. Oshaug, I. Akinyele, G. A. Annor, K. Bomfeh, H. Ene-Obong, I. F. Smith, I. Thiam, B. Burlingame, West African Food Composition Table. FAO. Rome, 2012.
[23] M. N. Garcia-Casal, M. Layrisse, L. Solano, M. A. Baron, F. Arguello, D. Llovera, J. Ramirez, I. Leets and E. Tropper "Vitamin A and b-Carotene Can Improve Nonheme Iron Absorption from Rice, Wheat and Corn by Humans," Journal of Nutrition, vol. 128, pp. 646–650. 1998.
[24] R. Ponka, E. Fokou, R. Leke, M. Fotso, J. Souopgui, M. Achu Bih, F. M. Tchouanguep, "Methods of preparation and nutritional evaluation of dishes consumed in a malaria endemic zone in Cameroon (Ngali II)," African Journal of Biotechnology, vol. 4, no. 3, pp. 273-278, 2005.
[25] O. F. Kayode, A. U. Ozumba, S. Ojeniyi, D. O. Adetuyi, and O. L. Erukainure, "Micro Nutrient Content of Selected Indigenous Soups in Nigeria," Pakistan Journal of Nutrition, vol. 9, no. 10, pp. 962-965, 2010.
[26] F. Domngang, C. Teugwa, E. Fokou, J. Tchuinmogne, "Etude nutritive de quelques plats alimentaires consommés dans certaines zones rurales de l'Ouest – Cameroun," Annales de la Faculté des Sciences, Biologie-Biochimie, vol. 2, pp. 35 – 45, 1989.
[27] C. Teugwa, F. Mbiapo, E. Fokou et M. Fotso "Composition chimique de quelques plats traditionnels de l'Extême–Nord Cameroun: Gniri/ Follere, Gniri/Lalo et Gniri/Tasba," Cameroon Journal of Biololgical et Biochemical Sciences, vol. 4, no. 3, pp. 77 – 89, 1992.
[28] V. A. Randrianatoandro, S. Avallone, C. Ralison, C. Picq, S. Trèche, "Recipes and nutritional values of dishes consumed in urban districts in Madagascar," International Journal of Food Science and Nutrition, vol. 61, no. 4, pp. 404–416, 2010.
[29] O. O. Onabanjo, C. R. B. Oguntona "Iron, zinc, copper and phytate content of standardized Nigerian dishes," Journal of Food Composition and Analysis, vol. 16, pp. 669–676, 2003.
[30] R. Ponka, E. Fokou, M. Fotso, F. M. Tchouanguep, R. Leke, J. Souopgui, M. A. Bih, "Composition of dishes consumed in Cameroon," International journal of Food Science and Technology, vol. 41, pp. 361–365, 2006.
[31] Duke, J. A., and Atchley A. A., Proximate analysis. In: B. R. Christie (Ed.), The handbook of plant science in agriculture. CRS press Inc., Boca Raton, FL. 1984.
[32] O. C. Enechi, and I. Odonwodu "An assessment of the phytochemical and nutrient composition of the pulverized root of Cissus quadrangularis," International Bioresearch, vol. 1, pp. 63-68, 2003.
[33] J. R. Hunt, S. K. Gallagher, L. K. Johnson, "Effect of ascorbic acid on apparent iron absorption by women with low iron stores," American Journal of Clinical Nutrition, vol. 59, pp.1381-85, 1994.