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MICRO-MINERALS AND VITAMIN C PROFILE OF AFRICAN NIGHTSHADE BASED PREPARATIONS CONSUMED IN THE NORTH WEST REGION OF CAMEROON

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ABSTRACT

Purpose: The aim of this study was to investigate local/traditional recipes of African nightshade and to assess the mineral and vitamin contents of these African nightshade-based preparations among selected ethnic groups from the Northwest Region of Cameroon. The ethnic groups under study were Kom, Tikaris, Wum, Moghamo, and Widikum.

Methodology: This study made use of both survey and experimental designs. A four-section structured questionnaire was administered to 600 households of the Northwest Region. Data obtained from the survey were entered into SPSS version 20 and analysed to obtain 25 local/traditional African nightshade recipes from the region. *Basifhei* is the most consumed African nightshade dish by the Kom people; *Mbas a sekoyn* and *Mbas a mtsong mbi* for the Wum people; *Mbeup Cerie* for the Widikum people while the Moghamos and the Tikaris consume African nightshade prepared in over 15 different ways.

Findings: The mineral analysis for the 25 recipes showed that iron ranged from 0.14mg/100g DW to 24.75mg/100g DW, Zinc 1.71mg/100g DW to 7.56mg/100g DW and copper 5.72mg/100gDW to 26.28mg/100gDW. The vitamin C contents of the 25 recipes ranged from 0.039g/100g DW to 1.84g/100g DW. The results of the study revealed that African nightshade recipes from the Northwest Region of Cameroon are good sources of important nutrients such as the minerals (Iron, zinc, and copper) and vitamins especially vitamin C; with the most popular recipe over the Region being *All–in–one–pot* African nightshade. The high contents of vitamins and minerals make these recipes valuable dietary sources of micronutrients, especially for people with malnutrition illnesses**.**

Recommendation: The study recommends that African night shade cooked by boiling, addition of tomatoes, onions, *egusi* and frying are good sources of vitamins and minerals and should be adopted in households to alleviate micronutrient deficiencies thus African nightshade should be integrated in the Cameroon food systems to alleviate micronutrient deficiencies. However, the quantities of palm oil should be used in moderation**.**

Keywords: *Ethnic groups, Northwest Region, African nightshade, recipes, micronutrients.*

1.0 INTRODUCTION

Vitamin and mineral deficiencies are highly prevalent in Cameroon. Preschool-aged children (39%) and pregnant women (18%) are deficient in vitamin A [1]. Current rates of anemia among preschool-aged children and pregnant women are 68%and 51% respectively, indicating poor health care and malnutrition [1], [2]. About 50% of the anemia in Cameroon is attributable to iron deficiency [3]. Annually, Cameroon loses more than US $ 187 million in the gross domestic product (GDP) to vitamin and mineral deficiencies [4], [5]. One of the causes of malnutrition in Cameroon is the lack of knowledge on the nutritional value of different traditional foods ready for consumption [6]. Because eating habits differ from one region to another in Cameroon, one of the effective approaches to fight against malnutrition is to make an inventory of food ready for consumption in each of the 10 regions of Cameroon.

In Cameroon, especially in the Northwest and West regions, garden huckleberry locally called *jamajama* is one of the most popular vegetables, preferably consumed [7], [8] and to a lesser extent in the Southwest, Littoral and Center regions [9]. The young shoots and leaves of the plant are the main components of the Cameroonian *jamajama* soup. The leaves are used alone or together with okra (*Abelmoschus caillei*), dika nuts (*Irvingia gabonensis*), or *egusi* (some *Cucurbitaceae*) seeds [10] and serve as a complement to most cereals and tubers. Some studies in Cameroon have shown that the leaves of raw garden huckleberry are rich in vitamin A, iron, and magnesium [11]. The methods of production, processing, and preparation of garden huckleberry have a direct bearing on the nutritional composition and bioavailability. These methods vary within and without different ethnic groups.

Cameroon has an extremely heterogeneous population consisting of approximately 250 ethnic groups which include amongst others the Bamouns, the Ewondos, the Bassa, the Nso, the Kom, the Mmocbi, the Bakossi, the Fulanis, the Tikaris, and the Bakas [12]. In Cameroon, there have been limited studies to establish recipes of dishes prepared using the African nightshade vegetable [13]. Moreover, the nutritional value of the vegetable prepared in different forms by different ethnic groups have not been well investigated as these different forms when consumed may affect the quantity and quality of nutrients consumed. In this regard, some works were done on dishes of Littoral, Centre, and West regions of Cameroon [14], [15], [16], [17], [18], [19]. However, data and information on traditional dishes from the Northwest Region of Cameroon are limited. Thus, the current study aims to establish traditional recipes of African nightshade-based preparations consumed in the Northwest Region of Cameroon, their frequency of preparation, and to determine their mineral (Fe, Zn, and Cu) and vitamin C compositions.

2.0 MATERIALS AND METHODS

2.1 Survey and Sampling

A survey was carried out using a questionnaire to identify and establish traditional/local recipes of African nightshade-based preparations in the different ethnic groups of four out of seven randomly selected divisions of the North West Region of Cameroon viz: Momo, Mezam, Boyo, and Menchum divisions. In this light, a three-part structured questionnaire was administered to 600 households: 150 for each division. During the household visits, concise observations and

measurements were made to identify the type and quantity of ingredients as well as the chronology of operations used to prepare the dishes and the time of preparation.

2.2 Samples Pretreatment and Preparation

2.2.1 Ingredients Procurement

The African nightshade used in the preparation of all the recipes identified was purchased from the same farmer at Kedjom Ketingoh in Mezam Division. The groundnuts, fluted pumpkin seeds, and *egusi* were the *country type* purchased from Guzang market in Batibo in Momo Division. Red palm oil was purchased from Widikum in Momo Division and refined vegetable oil (star oil) was purchased from the Bamenda main market in Mezam Division.

2.2.2. Sample Pretreatments

The purchased African nightshade vegetable was de-stalked, and the leaves were washed with distilled water to remove dirt. Exactly 0.5kg of the vegetable sample was weighed and blanched in 1L of boiling water for 2 minutes and immersed in ice-cold water for 2 minutes to minimize premature cooking process.

2.2.3 Preparation of African Nightshade Recipes

Twenty five African nightshade recipes identified from the survey were prepared at the laboratory of Food Science and Technology of the College of Technology, University of Bamenda, Cameroon.

2.3 Chemical Analysis

2.3.1 Determination of Minerals Composition

The mineral contents (Fe, Zn, and Cu) of the 25 nightshade recipes were estimated using the atomic absorption spectrophotometry method as described by [20]. Each sample (0.5 g) was introduced into 8 mL of concentrated nitric acid in Teflon capsules, closed, placed in metal bombs, and heated at 130^{o}C. It was then allowed to cool overnight, the content of the capsules was transferred into a 50 mL standard flask and made up to the mark with deionized water. Total iron, zinc, and copper were determined using a flame atomic absorption spectrometer at 510 nm, 213.86nm, and 589nm, respectively.

2.3.2 Determination of Vitamin C

Vitamin C was estimated by spectrophotometry using methods described by [21], where a solution of 250 mL 2, 6 dichloroindophenol of 50 µmol was prepared by dissolving 50 µmol of 2, 6 dichloroindophenol and adjusted to the 250 mL mark with distilled water. A standard vitamin C solution was prepared by weighing 20 mg of vitamin C and dissolving in 90% acetic acid. The solution was then poured into a 50 mL standard flask and the volume was adjusted to the mark with 90% acetic acid. In test tubes, 2, 6 dichloroindophenol, vitamin C and distilled water were added in different volumes, and these were used to produce a standard calibration curve. A volume of 50 µL of the different filtered samples was transferred into test tubes, 4.5 mL of 2, 6- dichlorophenol indophenols, and 450 µL of distilled water were added and absorbance was taken at 15 seconds and 30 seconds interval at 515nm.

2.4 Statistical Analysis

Chemical analyses of the samples were carried out in triplicate. Data on the micronutrient's composition of the 25 African nightshade recipes were evaluated using a one-way analysis of variance using the statistical package SPSS 20.0. Differences between samples were determined according to the Fischer test and considered to be significant when $P < 0.05$. The principal component analysis was used to determine the relation between the recipes and the micronutrients contents of the foods

3.0 RESULTS AND DISCUSSION

3.1 Ethno African Nightshade Preparations

A survey of the different methods of preparing African nightshade was conducted to identify ethno recipes of African nightshade commonly consumed in the Northwest region of Cameroon. A total of 25 ethno recipes of African nightshade were collected. The ethnic names, common names of the dish, main ingredients, and their proportions as well as the number of households in each ethnic group consuming a said recipe are listed in table 1. The ethnic preparations of African nightshade commonly consumed in the Northwest region of Cameroon are prepared from seeds of *egusi* and fluted pumpkin, tomatoes, onions, groundnuts, crude palm oil, red palm oil, and Irish potatoes.

3.2 Population Under Study

Six hundred households were interviewed from four out of seven randomly selected division of the North West Region of Cameroon viz; 150 in Momo division, 150 in Boyo Division, 150 in Mezam Division, and 150 in Menchum Division in three randomly selected subdivisions of each division viz: Batibo, Mbengwi and Widikum subdivisions for Momo Division; Fundong, Belo and Njinikom subdivisions for Boyo division; Bali, Bafut and Tubah subdivisions for Mezam division and Wum Central, Menchum Valley and Fungom subdivisions for Menchum division. Hence five ethnic groups were visited amongst which 25% were the *Kom* , 25% the *Wum*, 25% the *Tikaris* , 16.7% were the *Moghamos* and 8.3% were the *Widikum* (figure1)

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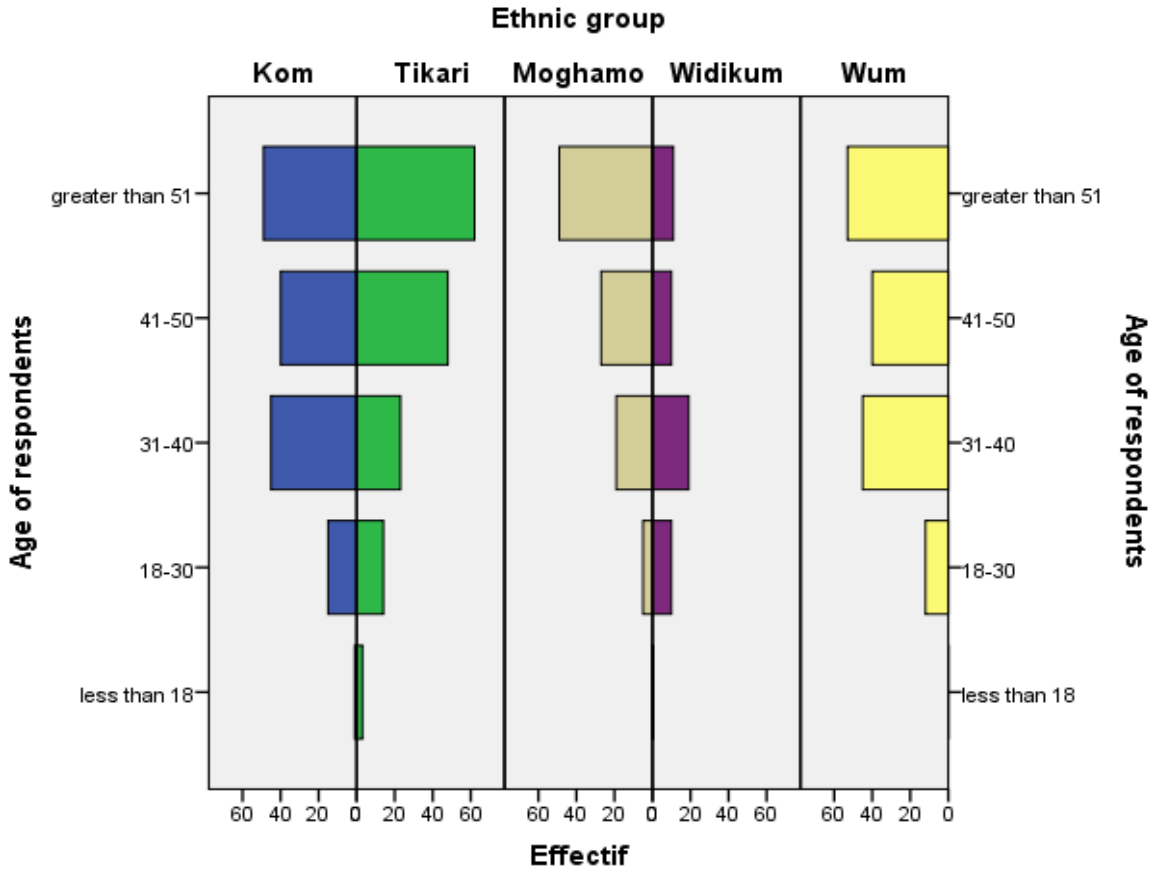

Figure 1: The five Ethnic groups visited, and the age range of the household members interviewed

Table 1: Ethno Recipes of African nightshade-based preparations from five Ethnic group

				Ethnic Group					
				k	W1	T	M	W2	
S/N	**African nightshade Recipes**	**Main ingredients**	**Duration of preparation (min)**	**Number of Households in each Ethnic Group**					**Total**
1	African nightshade stir fried in tomatoes and onions	500g nightshade, onion 75g, tomatoes 100g , Red palm oil 125mL, Water 250mL,2 red fresh pepper corns	30	0	26	59	64	21	**170**
2	*Mbep Tarti*	500g nightshade, red palm oil 31mL, Water 250mL, 2 red fresh pepper corns	30	0	0	0	22	7	**29**

3	*Sautee* Nightshade Leaves	500g nightshade, onion 75g (optional), Red palm oil 62mL, Water 250mL, 2 red fresh pepper corns	25	0	0	39	77	7	**123**
4	All in one pot nightshade	500g nightshade, onion, red palm oil 62mL, Water 125mL, 2 red fresh pepper corns	25	15	123	64	43	5	**250**
5	*mbep woyih*	500g nightshade, red palm oil 31mL, Water 125mL, 2 red fresh pepper corns, salt 10g	25	0	0	0	2	0	**2**
6	Scrubbed nightshade leaves boiled in *egusi*	500g nightshade, red palm oil 31mL, Water 1L, *Egusi* ground 100g, 2 red fresh pepper corns salt 10g	45	0	0	0	7	0	**7**
7	Nightshade leaves boiled with Irish potatoes	500g nightshade, red palm oil 31mL, Water 500mL, Irish potatoes 1 kg, 3 red fresh pepper corns	35	0	0	0	1	0	**1**
8	Raw sliced nightshade leaves cooked in fried onions and ground groundnuts	500g nightshade, red palm oil 31mL, Water 180mL, Onions 60g, Groundnut's ground 100g, 2 red fresh pepper corns	30	0	6	1	2	1	**10**
9	Nightshade leaves in lumpy *egusi*	500g nightshade, red palm oil 31mL, Water 660mL, egusi ground 100g, 2 red fresh pepper corns	40	0	1	4	13	1	**19**
10	Raw sliced nightshade leaves fried in tomatoes	500g nightshade, tomatoes 150g, red palm oil 62mL, Water 1.125 L, 2 red fresh pepper corns	30	0	0	0	3	0	**3**
11	Nightshade leaves in ground fluted	500g nightshade, Fresh fluted pumpkin seeds ground 150g , Red palm oil 62mL, Water 375mL, 2	40	0	0	0	1	0	**1**

	pumpkin seeds	red fresh pepper corns							
12	*Mbep Tarti Gu Nang*	500g nightshade, 1500g cocoyam, red palm oil 125mL, Water 1L, 4 red fresh pepper corns	30	0	0	0	14	0	**14**
13	*Mbeup Cerie*	500g nightshade, red palm oil 31 mL, Water 125 mL, Handful of fresh green pepper corns	30	0	3	3	0	30	**36**
14	*Mpoub*	500g nightshade, red palm oil 31 mL, Water 250 mL, 4 fresh red pepper corns	25	0	39	53	12	5	**109**
15	*Basifhei*	500g nightshade, red palm oil 31 mL, Water 125 mL	25	150	3	1	0	0	**154**
16	*Mbas a sekoyn*	500g nightshade, *Egusi* ground 150g, Water 1L	40	0	77	4	0	0	**81**
17	*Mbas a mtsong mbi*	500g nightshade, Groundnut's ground 150g, Water 1L	40	0	61	0	1	0	**62**
18	Seasoned *Mbas a sekoyn*	500g nightshade, *Egusi* ground 150g, Water 1L, 2 pepper corns	40	0	1	0	0	0	**1**
19	Seasoned *Mbas a mtsong mbi*	500g nightshade, Groundnut ground 150g, Water 1L, 2 pepper corns	40	0	2	0	0	0	**2**
20	*Mbusa*	500g nightshade, Onion 75g, Tomatoes 100g, Red palm oil 125mL, Water 250mL , 2 red fresh pepper corns	20	13	2	11	0	1	**27**
21	*Mborueh*	500g nightshade, red palm oil 31mL (optional), Water 125mL, 2 red fresh pepper corns	25	0	3	19	1	4	**27**
22	*Mbep Tarti ga mowot whow*	500g nightshade, Raw palm oil 31mL, Water 250mL, 3 red fresh pepper corns	25	0	0	0	1	0	**1**

23	unsqueezed nightshade fried in tomatoes	500g nightshade, Tomatoes 100g, red palm oil 31mL, Water 250mL, 2 red fresh pepper corns	35	23	0	1	0	0	**24**
24	English style with *egusi*	500g nightshade, Tomatoes 150g, Onion 50g, Refined palm oil 31mL, Ground *egusi* 100g, Water 250mL, 2 red fresh pepper corns	40	0	0	0	6	0	**6**
25	English style with groundnuts	500g nightshade, Tomatoes 150g ,Onion 50g, Refined palm oil 31mL, Ground groundnut 100g, Water 250mL, 2 red fresh pepper corns	50	0	0	0	6	0	**6**

T= Takari W1= Wum M= Moghamo K= Kom W2= Widikum

Recipe 1: African nightshade stir-fried in tomatoes and onions

Recipe 1 is African nightshade fried in heated red palm oil with tomatoes and onions. This was known as the *western style* in all the ethnic groups (Wum, Moghamo, Tikaris, and Widikum) who prepared it except the Kom people. This recipe was most common with the Tikaris (59) and the Moghamo (64).

Recipe 2: *Mbep Tarti*

Recipe 2 is nightshade that is boiled, squeezed, sliced, and mixed in unheated red palm oil in a wooden mortar using the fingers. This recipe is specific to the Moghamos (22) and Widikum (7).

Recipe 3: *Sauteed* Nightshade Leaves

Recipe 3 is boiled nightshade stir-fried with onions in heated red palm oil. This is otherwise known as sautéed nightshade dish. This recipe is specific to the Moghamos (77), some Widikum (7), and some Tikaris people (39) even though other recipes are prepared by them (table 1). This recipe is like the one described by [13] which was common to the *Bamiléké* ethnic group from the west region of Cameroon in a meal commonly known as *Kwa'Ndzap.*

Recipe 4: All in one pot African nightshade

Recipe 4 is nightshade sorted washed and cooked in red palm oil. Also known as *all in one pot* because it is not squeezed nor removed from the pot after boiling. This recipe is specific to all the ethnic groups and was the most popular recipe (table 1) in all the 600 households interviewed (250).

Recipe 5: *Mbep Woyih*

Recipe 5 is nightshade scrubbed with the palms before boiling all in one pot in red palm oil. This recipe was specific to only one household in the Moghamo ethnic group.

Recipe 6: Scrubbed Nightshade Leaves Boiled in *Egusi*

Recipe 6 is one in which the nightshade is first scrubbed with salt, rinsed, and squeezed, and then subsequently fried in ground egusi in heated red palm oil. This recipe is specific to only seven households in the Moghamo ethnic group.

Recipe 7: Nightshade leaves boiled with Irish potatoes

Recipe 7 is nightshade cooked together with peeled Irish potatoes in red palm oil. This recipe was specific only to one household in the Moghamo ethnic group.

Recipe 8: Raw sliced nightshade leaves cooked in fried onions and ground groundnuts

Recipe 8 is one in which the nightshade is first of all sliced raw and then cooked in fried onions and ground groundnuts in heated red palm oil. Few households in Tikari (1), Wum (6) Widikum (1), and Moghamo (2) prepared this recipe amongst other recipes (table 1)

Recipe 9: Nightshade leaves in lumpy *egusi*

Recipe 9 is one in which boiled, squeezed, and sliced nightshade is cooked in boiling ground egusi that has formed lumps. This recipe was specific to a few households of the Tikaris (4), Wum (1), Widikum (1), and some Moghamos (13).

Recipe 10: Raw sliced nightshade leaves fried in tomatoes

Recipe 10 is one in which the nightshade is sliced raw and then blanched after which it is fried in tomatoes in heated red palm oil. Only three households in Moghamo prepared this recipe amongst other recipes

Recipe 11: Nightshade leaves in ground fluted pumpkin seeds

Nightshade boiled, squeezed, and sliced is cooked in boiling ground fluted pumpkin seeds in red palm oil. This recipe was specific to only one household in the Moghamo ethnic group.

Recipe 12: *Mbep Tarti Gu Nang*

Recipe 12 is one in which the nightshade vegetable is cooked by steam from boiling cocoyam lined with plantain leaves. The vegetable is squeezed, sliced, and mixed with fingers with red palm oil in a wooden mortar in ground pepper, salt and Maggi. Fourteen households in the Moghamo ethnic group prepare this recipe amongst other recipes (table 1)

Recipe 13: *Mbeup Cerie*

The nightshade vegetable is sliced raw just like eru and cooked in very little water in red palm oil. The dish is served with pepper made separately with a variety of spices. This recipe is otherwise known as the *Widikum country style.* 30 households in widikum and very few households (3) in Tikari prepare this recipe amongst other recipes

Recipe 14: *Mpoub*

Pepper is cut into halves and thrown on the washed non-sliced nightshade vegetable which is then boiled in a pot in red palm oil with all seasonings and stirred occasionally only with a wooden spoon. Some households in all the ethnic groups except Kom prepare this recipe.

Recipe 15: *Basifhei*

Sorted and washed nightshade is cooked in little water and little red palm oil with no salt, no Maggi, and no pepper. This is typical of the Kom people and is known as the *Kom country style.* All the households (150) in Kom prepare this recipe (table 1).

Recipe 16: *Mbas a sekoyn*

Recipe 16 is one in which the nightshade vegetable is boiled with ground-soaked egusi on different portions of the vegetable with no seasonings. This is typical of the Wum culture.77 households in the Wum ethnic group and 4 households in the tikari ethnic group prepare this recipe amongst other recipes.

Recipe 17: *Mbas a mtsong mbi*

Recipe 17 is one in which the nightshade vegetable is boiled with ground soaked groundnuts on different portions of the vegetable with no seasonings. This is typical of the Wum culture. 61 households in the Wum ethnic group and one household in the Tikari ethnic group prepare this recipe amongst other recipes

Recipe 18: Seasoned *Mbas a sekoyn*

Recipes 18 is one in which the nightshade vegetable is boiled with ground-soaked egusi on different portions of the vegetable with seasonings. Only one household in the Wum ethnic group prepare this recipe amongst other recipes (table 1)

Recipe 19: Seasoned *Mbas a mtsong*

Recipes 19 is one in which the nightshade vegetable is boiled with ground-soaked groundnuts and on different portions of the vegetable with seasonings. Only two households in the Wum ethnic group prepare this recipe amongst other recipes.

Recipe 20: *Mbusa*

Recipe 20 is sorted, and washed nightshade vegetables cooked all in one pot with sliced tomatoes and onions with seasonings and red palm oil. This recipe was common among the Tikari people. Eleven households in the Tikari ethnic group,13 households in the Kom ethnic group,1 household in the Widikum ethnic group, and 2 households in the Wum ethnic group prepare this recipe amongst other recipes.

Recipe 21: *Mborueh*

Recipe 21 is one in which the nightshade vegetable is boiled to be partially ready and then strained and seasoned with salt and maggi. Red palm oil may or may not be added and served with A*chu*. This is the *Bafut country style.*

Recipe 22: Mbep Tarti ga mowot whow

The vegetable is boiled and seasoned with ground pepper, salt, and Maggi in a wooden mortar and mixed in crude palm oil using fingers. Only one household in the Moghamo ethnic group prepares this recipe amongst other recipes.

Recipe 23: unsqueezed nightshade fried in tomatoes

The nightshade vegetable is boiled but not squeezed and fried in tomatoes in heated red palm oil.10 households in the Kom ethnic group and one household in widikum prepare this recipe amongst other recipes

Recipe 24: English style with *egusi*

Recipes 24 is one in which the nightshade vegetable is boiled, squeezed, sliced, and then fried in tomatoes in heated vegetable oil with ground egusi. Six households in the Moghamo ethnic group solely prepare these recipes.

Recipe 25: English style with groundnuts

Recipes 25 is one in which the nightshade vegetable is boiled, squeezed, sliced, and then fried in tomatoes in heated vegetable oil with ground groundnuts. Six households in the Moghamo ethnic group solely prepare these recipes. This dish was similar to the *Woulahada* dish from the Far North Region of Cameroon [22].

3.3 Mineral Composition of the African Nightshade Preparations

3.3.1 Zinc Levels of the African Nightshade Recipes

The zinc content of the recipes ranged from 1.71mg/100g DW to 7.56mg/100g DW (Table 2). There were no significant differences ($p<0.05$) in the zinc contents of recipes 1, 20 and 25; 10, 12 and 13; 2, 3, 4, 11 and 21; and 5, 8 and 15 respectively. The zinc contents of raw (fresh) African nightshade ranged from 1.2mg/100g to 24.3 mg/100g [11], [23], [24], [25]. There is generally a low level of zinc in all the recipes probably due to losses during cooking. The trend shows that there has been an increase in the Zinc contents of the recipes compared to the raw (fresh) state (1.2mg/100g). This is because cooking increases the bioavailability of nutrients (Djuikwo *et al*., 2015). Recipe 22 which is *Mbep Tarti ga mowot whow* recorded the least amount of Zinc (1.71mg/100g DW). Recipe 16 which is *Mbas a sekoyn* recorded the highest amount of Zinc (7.65mg/100g DW). Recipe 16 is one in which the nightshade vegetable is boiled with ground-soaked *egusi* (*citrillus lanatus*) on different portions of the vegetable with no seasonings and no palm oil. The high Zinc content of recipe 16 could be attributed to the fact that; first, no palm oil was used and secondly due to the presence of the egusi (figure 4) which is rich in zinc (21.05g/100g), [26]. Zinc is part of many enzymes; needed for making protein and genetic material; has a function in taste perception, normal fetal development, and production of sperm, normal growth and sexual maturation, immune system health. It is required for protein synthesis and DNA and RNA synthesis in body cells. Zinc accelerates the process of healing wounds [27]. The values of zinc in the 25 recipes in this study agree closely with the values (3.38-9.13 mg/100g and 3.73 – 4.24mg/100g) obtained by [28] in their work on ferementation and unfermentation of eleven African indigenous vegetables including African nightshade and [24] on the effects of different cooking methods on the nutritional value of some African

indigenous leafy vegetables; African night shade (*Solanum nigrum*), spider plant (Gynandropsis *gynandra*) and vegetable Amaranth (*Amaranthus hybridus)* in Kenya. The RDA for zinc is 11 mg/100g [29] thus the consumption of these recipes can significantly contribute to the RDA for zinc.

Table 2: Zinc Content of the 25 African nightshade-based Preparations

S/N	African nightshade Recipes	Zn (mg/100gDW)
1	African nightshade stir fried in tomatoes and onions	2.69 ± 0.24^{bc}
2	*Mbep Tarti*	3.77 ± 0.52^{ef}
3	*Sautee* Nightshade Leaves	3.61 ± 0.11^{ef}
4	All in one pot nightshade	3.75 ± 0.19^{ef}
5	*Mbep woyih*	3.82 ± 0.65^{efg}
6	Scrubbed nightshade leaves boiled in *egusi*	5.41 ± 0.32^{hi}
7	Nightshade leaves boiled with Irish potatoes	2.15 ± 0.39^{bc}
8	Raw sliced nightshade leaves cooked in fried onions and ground groundnuts	3.93 ± 0.42^{efg}
9	Nightshade leaves in lumpy *egusi*	5.92 ± 0.63^{ij}
10	Raw sliced nightshade leaves fried in tomatoes	2.86 ± 0.60^{cd}
11	Nightshade leaves in ground fluted pumpkin seeds	3.70 ± 0.12^{ef}
12	*Mbep Tarti Gu Nang*	2.89 ± 0.23^{cd}
13	*Mbeup Cerie*	2.84 ± 0.39^{cd}
14	*Mpoub*	3.99 ± 0.12^{fg}
15	*Basifhei*	3.85 ± 0.24^{efg}
16	*Mbas a sekoyn*	7.56 ± 0.57^{i}
17	*Mbas a mtsong mbi*	5.13 ± 0.58^{h}
18	Seasoned *Mbas a sekoyn*	6.39 ± 0.10^{jk}
19	Seasoned *Mbas a mtsong mbi*	4.41 ± 0.12^{g}
20	*Mbusa*	2.47 ± 0.10^{bc}
21	*Mborueh*	3.68 ± 0.25^{ef}
22	*Mbep Tarti ga mowot whow*	1.71 ± 0.13^{a}
23	Unsqueezed nightshade fried in tomatoes	3.36 ± 0.23^{de}
24	English style with *egusi*	6.55 ± 0.42^{k}
25	English style with groundnuts	2.71 ± 0.18^{bc}

Mean±SE values within the same column followed by the same superscripts are not significantly different at α=0.05, one-way ANOVA, 95% confidence level, Fischer LSD.

3.3.2 Iron Levels of the African nightshade Recipes

The Iron levels of the recipes ranged from 0.14mg/100g DW to 24.75mg/100g DW (Table 3). There were no significant differences ($p<0.05$) in the iron contents of recipes 9 and 25; 6, 7 and 20; 5, 11, 15 and 22; 14 and 21 and 8, 12 and 23 respectively (Table 3). Studies carried out by [30] and [31] indicated that raw (fresh) nightshade contains 8.90 mg/g and 17.3mg/g of iron respectively. The recommended daily intake (RDI) for iron content is between 10 to 8 mg [32], [33]. Amongst these African nightshade recipes, 17 could significantly contribute to the recommended daily intake of iron. There were generally lower levels of iron in recipes that were boiled while there were generally higher levels of iron in recipes that were fried especially with tomatoes. This observation is in conformity with the works of [24], [31]. Recipe 10 which is raw sliced nightshade leaves fried in tomatoes recorded the highest iron content (24.75mg/100g). This recipe included frying the vegetable in heated palm oil for 5 min. Frying significantly ($P < 0.05$) increased iron solubility; this could be attributed to the increased cooking time and also more iron could have been generated from the tomatoes used during frying which is known to contain 1.99 mg/100g of iron [34]. The mean levels of iron in the 25 African nightshade recipes in this study slightly differ from the levels found in a study by [24], [31], [35]. This could be due to the differences in the type of ingredients used (figure 4) and place (soil) where the vegetables were cultivated [3]. The RDA for iron is 10 mg/100g [29], thus; majority of the recipes can significantly contribute to the RDA of iron when consumed.

Table 3: Iron content of the 25 African Nightshade- based Preparation

S/N	African nightshade Recipes	Fe (mg/100gDW)
1	African nightshade stir fried in tomatoes and onions	9.70 ± 2.21^{def}
2	*Mbep Tarti*	8.35 ± 3.96^{cde}
3	*Sautee* Nightshade Leaves	16.82 ± 3.70^{ghi}
4	All in one pot nightshade	22.57 ± 3.59^{ij}
5	*Mbep woyih*	14.34 ± 5.57^{efgh}
6	Scrubbed nightshade leaves boiled in *egusi*	4.16 ± 3.67^{abcd}
7	Nightshade leaves boiled with Irish potatoes	4.11 ± 6.42^{abcd}
8	Raw sliced nightshade leaves cooked in fried onions and ground groundnuts	15.94 ± 4.58^{fghi}
9	Nightshade leaves in lumpy *egusi*	0.73 ± 1.27^{ab}
10	Raw sliced nightshade leaves fried in tomatoes	24.75 ± 8.45^{j}
11	Nightshade leaves in ground fluted pumpkin seeds	14.65 ± 6.71^{efgh}
12	*Mbep Tarti Gu Nang*	15.92 ± 4.82^{fghi}
13	*Mbeup Cerie*	17.66 ± 1.02^{hi}
14	*Mpoub*	20.68 ± 0.55^{hij}

15	*Basifhei*	14.33±4.27^{efgh}
16	*Mbas a sekoyn*	10.42±1.91^{defg}
17	*Mbas a mtsong mbi*	7.26±3.94^{bcd}
18	Seasoned *Mbas a sekoyn*	8.32±3.80^{cde}
19	Seasoned *Mbas a mtsong mbi*	2.15±2.80^{abc}
20	*Mbusa*	5.92±5.92^{abcd}
21	*Mborueh*	18.76±0.78^{hij}
22	*Mbep Tarti ga mowot whow*	14.73±3.84^{efgh}
23	Unsqueezed nightshade fried in tomatoes	15.80±5.60^{fghi}
24	English style with *egusi*	0.14±0.00^{a}
25	English style with groundnuts	1.14±1.71^{ab}

Mean±SE values within the same column followed by the same superscripts are not significantly different at α=0.05, one-way ANOVA, 95% confidence level, Fischer LSD.

3.3.3 Copper Levels of the African nightshade Recipes

The mean copper levels of the 25 African nightshade recipes ranged from 5.72mg/100g to 26.28mg/100g (table 4). There were no significant differences ($p<0.05$) in the copper levels of recipes 1 and 2; 4 and 5; 20 and 21; 19 and 24 and 11, 12, 15, 16, 18, 22, and 25 respectively. Raw (fresh) African nightshade has been shown to contain 0.44mg/g copper [35] These results indicate that cooking increase copper content in all (25) of the recipes (table 2); these results concur with the experimental findings of [35] which showed an increase in copper in some African indigenous vegetables (African nightshade inclusive) after cooking by boiling and frying with and without traditional salt. These differences can be attributed to different ingredients used in the recipes such as tomatoes, onions, groundnut (*Arachis hypogeal*), egusi powder (*Citrullus lanatus*), and the different ways of preparation (figure 2). Recipe 1 which is African nightshade fried in heated red palm oil with tomatoes and onions recorded the least amount (5.72mg/100g) of copper. This is largely due to the presence of palm oil which significantly reduces copper levels by dilution. Recipe 18 (*Mbas a mtsong mbi***)** in which the nightshade vegetable is boiled with ground-soaked groundnuts on different portions of the vegetable with no seasonings, recorded the highest amount (26.28mg/100g) of copper which may be partly due to the presence of ground groundnut paste (figure 4). RDA for copper is 2-3mg [36], table 4, indicates that all the 25 recipes can significantly contribute to the RDA of copper if more than 0.5g is consumed.

Table 4: Copper Content of the 25 African Nightshade – based Preparations

S/N	African nightshade Recipes	Cu (mg/100gDW)
1	African nightshade stir fried in tomatoes and onions	5.72 ± 2.32^{a}
2	*Mbep Tarti*	6.95 ± 0.89^{a}
3	*Sautee* Nightshade Leaves	9.98 ± 1.30^{ab}
4	All in one pot nightshade	12.38 ± 3.63^{bc}
5	*Mbep woyih*	11.28 ± 2.15^{bc}
6	Scrubbed nightshade leaves boiled in *egusi*	15.32 ± 0.21^{cde}
7	Nightshade leaves boiled with Irish potatoes	14.38 ± 1.50^{cd}
8	Raw sliced nightshade leaves cooked in fried onions and ground groundnuts	18.42 ± 0.70^{defgh}
9	Nightshade leaves in lumpy *egusi*	17.38 ± 0.91^{def}
10	Raw sliced nightshade leaves fried in tomatoes	18.08 ± 2.23^{defg}
11	Nightshade leaves in ground fluted pumpkin seeds	20.95 ± 1.15^{fghij}
12	*Mbep Tarti Gu Nang*	20.75 ± 4.35^{fghij}
13	*Mbeup Cerie*	22.52 ± 0.32^{hijk}
14	*Mpoub*	19.02 ± 4.89^{efghi}
15	*Basifhei*	21.38 ± 1.56^{fghij}
16	*Mbas a sekoyn*	21.22 ± 0.97^{fghij}
17	*Mbas a mtsong mbi*	$26.28\pm3,77^{k}$
18	Seasoned *Mbas a sekoyn*	20.62 ± 2.03^{fghij}
19	Seasoned *Mbas a mtsong mbi*	23.65 ± 2.07^{jk}
20	*Mbusa*	22.85 ± 1.06^{ijk}
21	*Mborueh*	23.25 ± 1.31^{ijk}
22	*Mbep Tarti ga mowot whow*	20.25 ± 2.91^{fghij}
23	Unsqueezed nightshade fried in tomatoes	21.68 ± 0.84^{ghij}
24	English style with *egusi*	23.88 ± 4.38^{jk}
25	English style with groundnuts	20.52 ± 5.86^{fghij}

Mean±SE values within the same column followed by the same superscripts are not significantly different at α=0.05, one-way ANOVA, 95% confidence level, Fischer LSD.

3.3.4 Vitamin C Composition of the African Nightshade Recipes

The vitamin C levels of the recipes ranged from 0.039g/100g DW to 1.84g/100g DW (Table 5). There were no significant differences ($p<0.05$) in the vitamin C contents of recipes 1, 13, and 15; 5, 10, 21, and 22; 2, 11, and 14; and 8 and 9 respectively. Recipe 12 recorded the least vitamin C value (0.039g/100g). This can be attributed to the method of cooking because the vegetable was cooked from steam from boiling cocoyam for 30 min and later squeezed and mixed with ground salt and pepper. It has been reported that longer cooking times of above 10 min, squeezing, and addition of salt significantly lowers vitamin C content [37], [38], [39]. Recipe 25 recorded the highest vitamin C value (1.84g/100g). Recipe 25 is nightshade fried in ground groundnuts in tomatoes and onions in vegetable oil. The high vitamin C can be attributed to the cooking method (frying), time used, and the ingredients tomatoes and onions used (figure 4). These attributions are in agreement with the works of [34], [38] who confirmed that onions and tomatoes tend to increase the vitamin content of recipes that are known to contain (11mg/100g and 10 mg/100g) of vitamin C respectively. However the vitamin C contents of all the recipes were generally higher compared to values obtained by [28] (0.18 mg/100g to 5.37 mg/100g) and [38] (5.7mg/g to 6.9mg/g), [40], (1968) (24mg/100g), [41], (20mg/100g) but were similar to values obtained by [24] (425.04mg/100g DW to 684.23mg/100g DW). The RDA of vitamin C is 50mg/100g [29]. The reported mean levels in the 25 African nightshade recipes were by far higher than the RDA except recipe 12. Hence the consumption of these recipes can contribute significantly to the RDA of vitamin C.

Table 5: Vitamin C content of the 25 African Nightshade- based Preparations

S/N	African nightshade Recipes	Vit C (g/100gDW)
1	African nightshade stir fried in tomatoes and onions	0.055 ± 0.039^{ab}
2	*Mbep Tarti*	0.687 ± 0.118^{de}
3	*Sautee* Nightshade Leaves	0.297 ± 0.000^{bc}
4	All in one pot nightshade	0.315 ± 0.070^{c}
5	*Mbep woyih*	0.250 ± 0.015^{abc}
6	Scrubbed nightshade leaves boiled in *egusi*	0.647 ± 0.235^{d}
7	Nightshade leaves boiled with Irish potatoes	1.149 ± 0.080^{g}
8	Raw sliced nightshade leaves cooked in fried onions and ground groundnuts	0.876 ± 0.148^{ef}
9	Nightshade leaves in lumpy *egusi*	0.880 ± 0.056^{ef}
10	Raw sliced nightshade leaves fried in tomatoes	0.228 ± 0.099^{abc}
11	Nightshade leaves in ground fluted pumpkin seeds	0.755 ± 0.161^{de}
12	*Mbep Tarti Gu Nang*	0.039 ± 0.018^{a}
13	*Mbeup Cerie*	0.079 ± 0.092^{ab}

14	*Mpoub*	0.716±0.194^{de}
15	*Basifhei*	0.079±0.053^{ab}
16	*Mbas a sekoyn*	1.078±0.026^{fg}
17	*Mbas a mtsong mbi*	1.457±0.094^{hi}
18	Seasoned *Mbas a sekoyn*	1.520±0.056^{ij}
19	Seasoned *Mbas a mtsong mbi*	1.818±0.096^{k}
20	*Mbusa*	0.866±0.027^{e}
21	*Mborueh*	0.185±0.079^{abc}
22	*Mbep Tarti ga mowot whow*	0.253±0.235^{abc}
23	Unsqueezed nightshade fried in tomatoes	1.252±0.175^{gh}
24	English style with *egusi*	1.721±0.147^{jk}
25	English style with groundnuts	1.834±0.186^{k}

Mean±SE values within the same column followed by the same superscripts are not significantly different at α=0.05, one-way ANOVA, 95% confidence level, Fischer LSD.

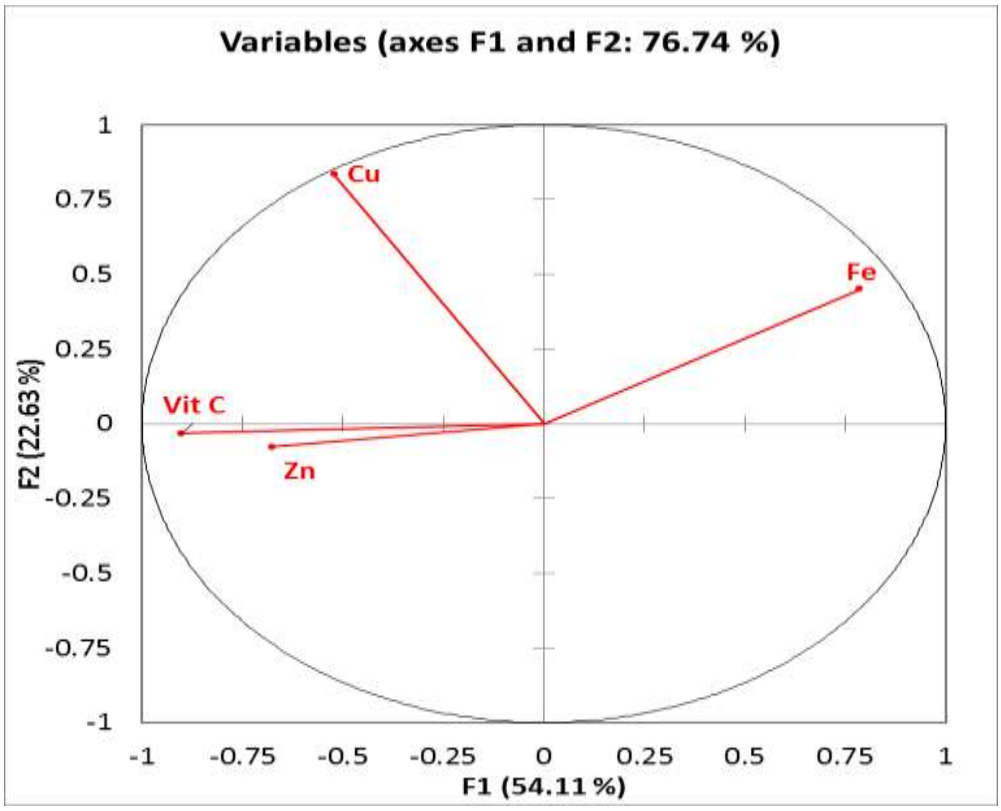

Figure 2: Correlation Circle of the Different Micronutrients in the Different Recipes

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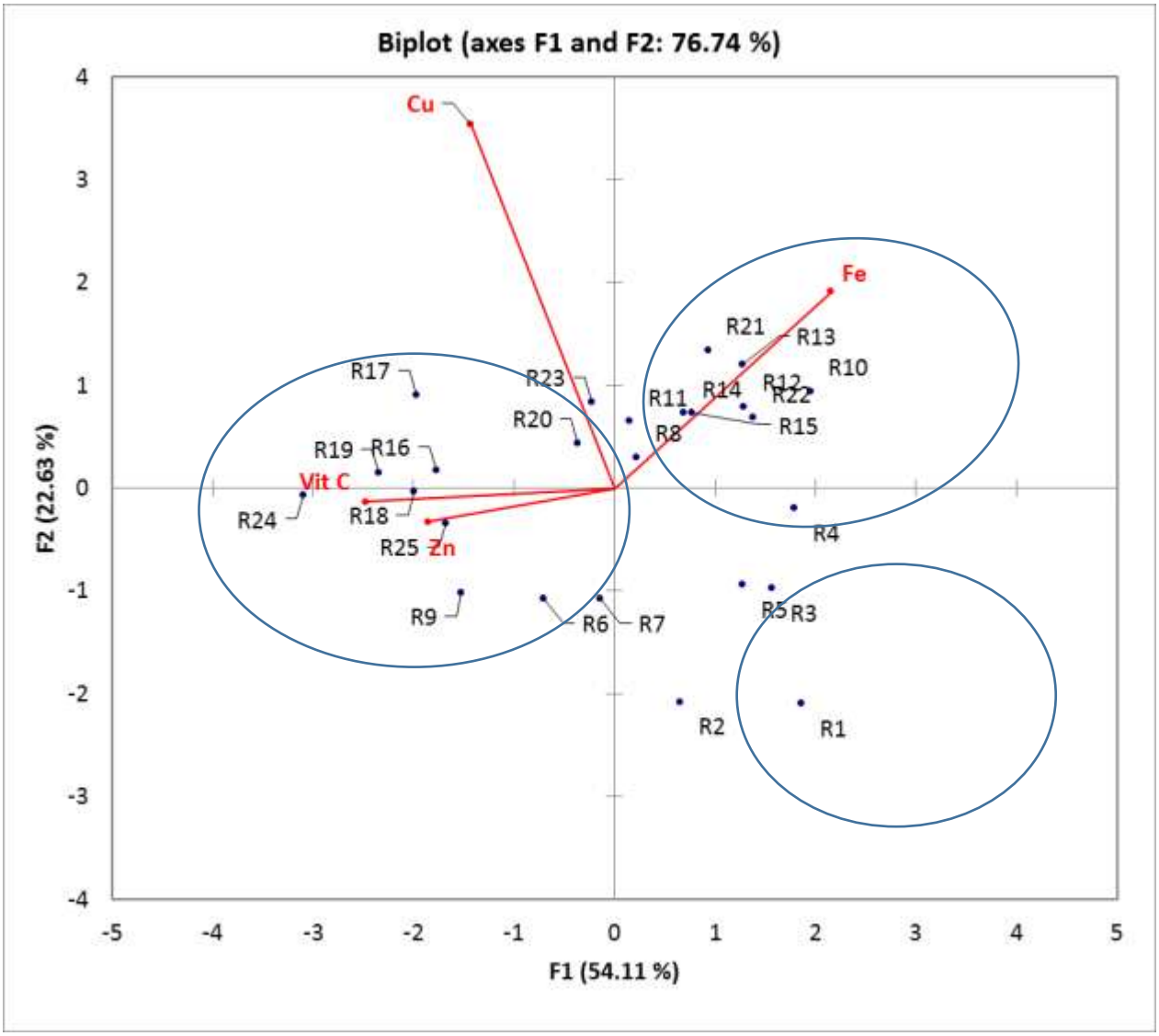

Figure 3: Biplot Representing the Relation Between the Recipes (In Black) and the Micronutrients Content (Red) of the African Nightshade Preparations

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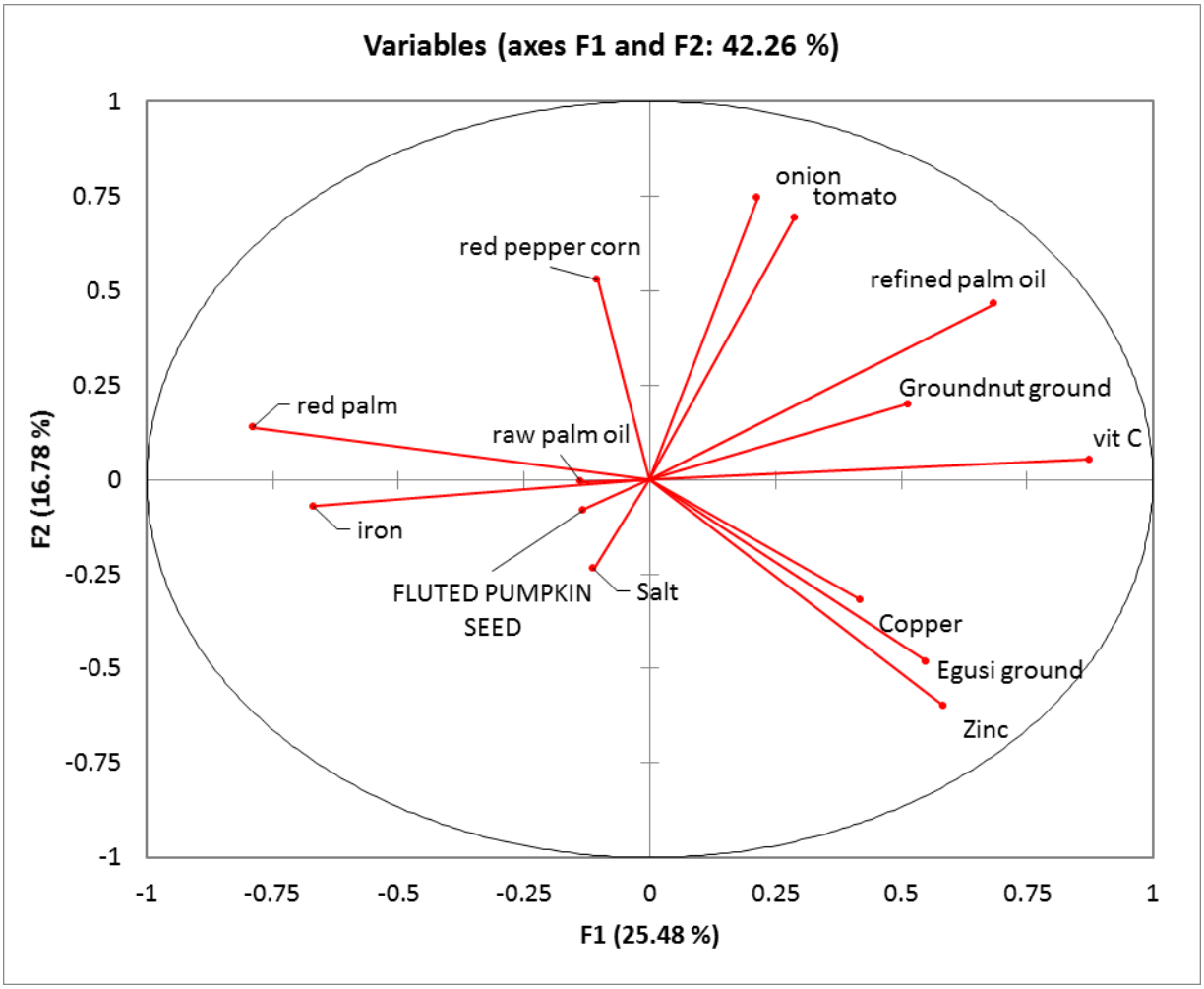

Figure 4: Biplot Representing the Relation Between the Ingredients and the Micronutrients Content Of African Nightshade Preparations

4.0 CONCLUSION

In the Northwest region of Cameroon, African nightshade is the most popular African indigenous vegetable preferably consumed. All the 600 households interviewed consumed African nightshade which is prepared differently. The ethnic preparations of African nightshade commonly consumed in the Northwest region of Cameroon are prepared from seeds of egusi and fluted pumpkins, tomatoes, onions, groundnuts, raw palm oil, red palm oil, and Irish potatoes. In the five ethnic groups vis; Koms, Tikaris, Wum, Widikums, and Moghamos consulted, preparation of this leafy vegetable is different. *Basifhei* is the most consumed African nightshade dish by the Kom people of the Boyo Division; *Mbas a sekoyn* and *Mbas a mtsong mbi* for the Wum people in Menchum Division; *Mbeup Cerie* for the Widikum people of the Momo Division while the Moghamos from Momo Division and the Tikaris from Mezam Division consumed African night prepared in over 15 different ways. Also, the most popular African nightshade recipe in the North West region of Cameroon is recipe 4 which is *all in one pot African nightshade.*

The micronutrient profile established for the 25 African nightshade recipes from the Northwest Region of Cameroon shows that they are rich sources of these micronutrients especially vitamin C, Iron, copper, and Zinc. Recipes 7, 16, 17, 18, 19, 23, 24, and 25 (Nightshade leaves boiled with Irish potatoes, *Mbas a sekoyn* , *Mbas a mtsong mbi* , Seasoned *Mbas a sekoyn*, Seasoned *Mbas a mtsong mbi* , unsqueezed nightshade fried in tomatoes , English style with *egusi and* English style with groundnuts) respectively are superior sources of vitamin C.

Most of the African nightshade recipes (14) are extremely rich in Iron as they all recorded values higher than 12mg/100g DW. These recipes: 16 *(Mbas a sekoyn)*, 15*(Basifhei)*, 5 *(mbep woyih)*, 11 **(**Nightshade leaves in ground fluted pumpkin seeds**),** 22 *(Mbep Tarti ga mowot whow)*, 23 (unsqueezed nightshade fried in tomatoes), 12 *(Mbep Tarti Gu Nang)*, 8 (Raw sliced nightshade leaves cooked in fried onions and ground groundnuts), 3 *(Sautee* Nightshade Leaves), 13(*Mbeup Cerie)*, 21 *(Mborueh)*, 14 ***(****Mpoub****)***, 4 (All in one pot nightshade) and 10 **(** Raw sliced nightshade leaves fried in tomatoes).

Finally, the data generated from this study provides an important insight into the value of the African nightshade recipes from the North West Region of Cameroon. It is therefore clear that these African nightshade recipes contain different nutritional qualities especially vitamin C, Iron, and Zinc which when combined with starchy staples could be of tremendous benefit to the body.

5. RECOMMENDATIONS

1) The leafy vegetable of African nightshade should be integrated in the Cameroon food systems to alleviate micronutrient deficiencies since they contain high levels of vitamins and minerals. However, the quantities of palm oil should be used in moderation.
2) African night shade should be cooked by boiling, addition of tomatoes, onions, *egusi* and frying are good sources of vitamins and minerals and should be adopted in households to alleviate micronutrient deficiencies and to improve on nutrient availability.
3) The government of Cameroon, NGOs and common initiative groups should have joint efforts in promoting the cultivation and consumption of African night shade for health and income generation. This vegetable is cheap to grow and can survive in harsh environmental conditions.

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