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Comparison of the Chemical Composition of *L. schlechteri* with Other Selected Green Leafy Vegetables

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Abstract: The present study, aimed at analyzing by comparison the nutritional, mineral and fatty acid composition of some available green leafy vegetables, will promote an increased use and consumption of these vegetables for their contribution as a source of nutrients. *L. schlechteri* was used as a reference vegetable to perform this comparison. Recommended AOAC methods were used for the determination of moisture, ash, lipids, carbohydrates, and proteins of *L. schlechteri*, while the gas chromatographic method was used to evaluate the fatty acid profile of the extracted oil. The results showed that the ash of its vegetables ranged from 1.71 to 30.62% (b.h). Moisture was higher in *L. schlechteri* (97.50% b.h) and lower in *C. integrifolia*. (61.22% b.h). Protein and carbohydrate contents varied widely from 3.5 to 30.62 g/100 g, and from 2.30 to 63.22 g/100 g respectively. Lipids were higher in *L. schlechteri* (7.85%) and lower in Hibiscus c. (0.20%), while the calorific value in all leafy vegetables was relatively low. *L. schlechteri* had the highest calcium (1160 mg/100 g) and iron (400 mg/100 g) contents, *M. oleifera* in Mg (1910 mg) and finally *G. africanum* in phosphorus (1340 mg/100 g). It should also be noted that the PMQ oils contain 5 main fatty acids: palmitic, C16:0 (15.7-63%); stearic, C18:0 (1-2.50%); oleic, C18:1 (2-5.1%); linoleic, C18:2 (4-28.68%) and linolenic (9-53%). The values of ω6/ω3 and PUFA/SFA ratios are within the recommended levels for edible oils.

Keywords: Evaluation, Leafy Vegetables, *L. chlechteri*, Mineral Value, Nutritional Value

1. Introduction

Because of their considerable concentrations of vitamins, especially vitamins A, C, and B (such as B6, thiamine (B1), niacin (B3), and riboflavin (B2)); mineral elements, including electrolytes (sodium and potassium); and, more recently, phytochemicals [1, 2] with antioxidant effects, vegetables are widely referred to as "protective foods" in the human diet [3]. They have historically had a place in dietary advice where they are included by most countries as dietary recommendations [2], as they are essential to the metabolic process in the body system [4]. In addition, they provide protein [5] cited by Saha et al, [6], argues that the process of photosynthesis is the only non-depletable source of protein that can provide some essential amino acids, as well as provide sufficient nitrogen in the diet for the synthesis of non-essential amino acids. They also provide lipids, in particular essential fatty acids of the omega 6 (linoleic acid) and omega 3 (alpha-linolenic acid) families. Vegetables are also a source of energy provided by the carbohydrates they contain and include sugars, starches including resistant starch [2], dietary and crude fibers [4] in large quantities. Thus, after noting the inadequate consumption of fruits and vegetables contributed to approximately 14% of deaths from gastrointestinal cancer as reported by the WHO [7, 8], numerous research data support the recommendation of increased consumption of a wide variety of vegetables [9] in addition to fruits, to reduce the risk of developing non-communicable diseases such as cancer, obesity, cardiovascular disease and type 2 diabetes mellitus [10]. Thus, to achieve the Daily Nutrient Intake, the World Health Organization (WHO) recommendation is that at least five 80-gram or 400-gram servings of these foods should be consumed daily [11]. The Dietary Guidelines for Americans [12] recommend five servings of vegetables per day based on an intake of 2000 calories [3]. It is also recommended that one of the five servings of vegetables be green leafy vegetables [3]. Green leafy vegetables (LFVs) have among all vegetables, occupied a unique place [6] organoleptically, for their supreme flavor and aroma, cultured texture, attractive color, and overall appeal to smell, taste, touch, and sight [13]. In Congo, as in most other tropical countries in Africa and in some underdeveloped regions of the world, the daily diet is dominated by starchy staples. Vegetables, which are almost universally available, are the cheapest and most readily available sources of important proteins, vitamins, minerals and essential amino acids [14] that can contribute significantly to household food security [15]. Traditionally, leafy vegetable dishes can be prepared from a single plant species or a combination of different species and are consumed as a side dish or soup with food. Common species consumed among Congolese tribes include *Abelmoschus esculentus* (okra), *Amaranthus spp* (pigweed), Cleome spp. (African cabbage), *Cucurbita spp* (traditional pumpkin), *Moringa spp* (drumstick tree, cabbage-tree), *Ipomea batatas* (sweet potato), Solanum spp (black nightshade, nightshade), *Colocasia esculenta* (leaf) and *Manihot esculenta* (leaf). However, only a very small percentage of edible green leafy vegetables are used for human consumption [6], compared to use for other purposes such as fodder for domestic animals. In addition, some authors [16] have reported a decrease in the frequency of consumption of African leafy vegetables (LFA) over the years, probably because LFA are often considered inferior in terms of taste and nutritional value compared to exotic vegetables such as spinach (*Spinacea oleracea*) and cabbage (*Brassica olearacea*). But these same authors and others [15, 16, 17] have indicated in their work that ALVs contain levels of micronutrients as high as or higher than those found in most exotic LVs. Today, there are still little-known and underutilized wild edible plants, many of which have received renewed attention for their nutritional value; and their use is promoted by health-conscious individuals as part of a healthy lifestyle. *L. schlechteri* is an example. The latter is an aquatic plant that grows spontaneously in rocky areas such as the cataracts of the Djoué River in Congo. This plant is better known by the residents of the Djoué River than the rest of the population, where it is vernacularly called *Michiélé* and is consumed as a vegetable but also as an alicament to remedy stomach aches. Therefore, it could be classified as a leafy vegetable. Due to insufficient scientific knowledge of its nutritional and chemical potential responsible for its underutilization, we were interested in reviewing studies on a few green vegetables (LVs) widely consumed in sub-Saharan Africa; although several works reporting on the evaluation of the composition and functional properties of various types of edible plants used in developing countries abound in the literature, as much remains to be done.

The objective of this paper is to determine if *L. schlechteri* compared with other target African greens, can potentially contribute to the mitigation of protein-energy malnutrition and micronutrient deficiencies. In addition, the role of the mineral and fatty acid quality of this vegetable in disease prevention will be discussed. An additional objective of this review is to make available nutritional information on this vegetable species to the Congolese Ministry of Public Health, which will be useful for public nutrition education and for improving the nutritional status of the population as well as for its marketing.

2. Materials and Methods

2.1. Plant Material

The plant material used for the experimental part of this study consisted solely of the *L. schlechteri* plant from the Djoué River, a river located southwest of Brazzaville, in the Brazzaville department (Figure 1). After collecting and transporting the vegetable samples to the National Institute for Research in Engineering Sciences, Innovation and Technology (INRSIIT) laboratory, the edible parts were separated and washed with running tap water and then with distilled water. A portion of the samples were dried using a hot air oven (VWR brand. S/N: 14-06377) at 35°C for 72 h and ground to a fine powder and then stored in airtight containers for further chemical analysis.

Figure 1. *Michiélé extracted from the river (1a); Michiélé heap from the Djoué (1b).*

2.2. Methods of Analysis

The pre-dried powdered samples were used for different biochemical, chemical and mineral analyses performed in triplicate.

2.2.1. Nutritional Analysis

The methods recommended by the Association of Official Analytical Chemists (AOAC) were used for the determination of moisture, ash, lipids, crude nitrogen and carbohydrates [18-19]. Moisture content was evaluated on 2 g test sample at 105°C for 24 h in a ventilated oven (VWR. S/N: 14-06377) at 70°C for 72 h thereafter. The ash was determined in porcelain crucibles by incineration in a muffle furnace of Nabertherm GmbH, model Bahnhofst 20, 28865 Lilienthal/Bremen, Germany at 550°C for 8 h. Lipids were extracted by the soxhlet method continuously for 6 h with cyclohexane. Nitrogen was estimated by the Kjeldahl method in (Kel plus 20 L Pellican Equipment, model DISTYL EM VA, India) with steam distillation and titrated with N/20 sulfuric acid solution. Crude protein was estimated by multiplying the crude nitrogen content by a factor of 6.25 (% protein = % nitrogen × 6.25). The carbohydrate content of the samples was estimated by the differential calculation method [20].

2.2.2. Mineral Analysis

Samples of the *Michiélé* vegetable were analyzed using an atomic absorption spectrophotometer (model: ANTHELIE LIGHT 5 SECOMAM Distiller BUCHI K 314) for the determination of Ca, Mg, P and Fe. The method used is the one described by R. Nguie et al, [21]. The calculations of minerals were based on the comparison of the absorption of the samples against the known concentration of the standards and the results were converted into mg/100g.

2.2.3. Fatty Acid Profile

The fatty acid contents of the lipids extracted from *Michiélé* were analyzed and determined following the protocol used and described by Belhaj et al, [22]; R. Nguie et al, [21].

3. Results and Discussion

3.1. Nutritional Content

The moisture, lipid, crude protein and carbohydrate contents of some leafy vegetables are shown in the Table 1 [21, 23, 25, 24, 26, 27].

Table 1. *Moisture, macronutrient contents of L. schlechteri and some African leafy vegetable species (values per 100 g edible portion, fresh weight basis).*

Green leafy vegetable	Moisture (%)	Crude protein (%)	Lipid (%)	Carbohydrate (%)	Energy (Kcal)
L. schlechteri[a]	97.50	10.70	7.85	45.45	295.25
Hibiscus c.[f]	84.80	3.5	0.20	10.30	57.00
G. africanum[e]	62.30	4.86	2.45	23.80	136.69
C. integrifolia[e]	61.22	9.56	4.00	25.77	177.36
X. sagittifolium[d]	83.45	3.63	0.55	11.05	63.67
L. siceraria[c]	87.07	24.50	1.93	63.22	368.25
P. dodecandra[b]	81.87	34.56	1.60	2.30	161.84
S. oleracea[b]	91.19	5.20	0.40	3.20	37.20

Source: [21, 23, 25, 24, 26, 27]

3.1.1. Moisture

The moisture content of the vegetables ranged from 61.22 to 97.50% on a wet basis, with the highest being in *L. schlechteri* (97.50 g/100 g), followed by *S. oleracea* (91.19 g/100 g) and the lowest in *Cuervea integrifolia* (61.22 g/100 g). There was no significant difference between *Cuervea integrifolia* (61.22 g/100 g) and *Gnetum africanum* (62.30 g/100 g), as well as between *X. sagittifolium* (83.45 g/100 g) and *Hibiscus c* (84.80 g/100 g). The high moisture content obtained in *L. schlechteri* could be explained by the fact that this vegetable grows in a very humid environment and more exactly in water. This moisture content could allow it to be classified as a leafy vegetable, as indicated by Dorosz Ph. [28] and Depesay L. [29] cited by Itoua Okouango et al, [23] indicate values that vary respectively between 70 to 90%; and 85 to 95% for leafy vegetables. Our results correspond to the range reported by Depesay L. [29]. The high level of moisture in *L. schlechteri* studied suggests that this leafy vegetable could not be preserved for long.

3.1.2. Protein

The analysis of macronutrient results shows that *Phytolacca dodecandra* is richest in protein (34.56%), followed by *L. siceraria* (24.5%) while *X. sagittifolium* (3.63%) and *Hibiscus c* (3.50%) have a lower protein value. *L. schlechteri* (10.75%) and *Cuervea integrifolia* (9.56%) revealed more or less the same protein contents. Referring to the protein content of *L. schlechteri* (10.75%) compared to those of *Hibiscus c* (3.50%) and *Gnetum africanum* (4. 86%), which are two of the most consumed vegetables in Congolese households on a daily basis, it could be estimated that the use of this plant in amino acid supplementation to meet protein and energy needs could be a beneficial factor for both adults and young children, but supplementing the latter with animal protein, cereals and legumes.

3.1.3. Lipid

The lipid content of *L. schlechteri* is 7.85%, which is much higher than that of *Hibiscus sabdariffa* leaves (0.20%) reported by Moussa Ndong et al. [27]; *X. sagittifolium* (0.55%) and *S. oleracea* (0.40%) reported by Kossiwa Wolali et al., [24]; and, Itoua Okouango et al., [23] respectively (see table 1). As for any other food, this proportion in lipids could include a great diversity of essential components (fatty acids) necessary for the good functioning of the organism [30].

3.1.4. Carbohydrate

The data in Table 1 show that the carbohydrate content of *L. schlechteri* is 45.45%, which is relatively lower than that of *Lagenaria siceraria* (63.22%), but higher than that of other leafy vegetables (Table 1). However, carbohydrates are the main source of energy in the diet where the Institute of Medicine recommends that 45-65% of total calories come from carbohydrates [31] reported by J. L. Slavin, [2]. In addition, the high carbohydrate content of foods means a high energy content, which facilitates the digestion and assimilation of other foods [6]. This is the case here for *L. schlechteri*, which perfectly fulfills the recommendation and lets us believe in its energy potential.

3.1.5. Energy

The calorific value of target leafy green vegetables listed in Table 1 ranged from 57 Kcal to 177.36 Kcal, with the highest being in *Cuervea integrifolia* and the lowest in *Hibiscus c* these levels are low, probably due to the low crude fat content and relatively high moisture level [4].

3.2. Mineral Composition

Ash content is an index of inorganic minerals in biota [2, 33, 34]. The average ash content of *L. schlechteri* is 13.50%. This content is relatively lower than that obtained for *Spinacia oleracea* (30.62%) and *Phytolacca dodecandra* (20.50%) reported by Itoua Okouango et al, [23]. On the other hand, the ash content of *L. schlechteri* is much higher than that of *Xanthosoma sagittifolium* (1.71%) compared to *Lagenaria siceraria* (10.35%) (Table 2). Referring to the present data, nutritionally, *L. schlechteri* contains a rather large amount of total ash for an aquatic plant compared to another aquatic plant *Neptunia oleracea* (1.03-1.05%) reported by Noorasmah Saupi et al., [34]. The ash available in *L. schlechteri* could contribute to mineral intake through consumption of the plant and this form allows for the consumption of many micronutrients and bioactive compounds that offer their own nutritional benefits as stated by Baudoin WO, Louise Fresco O [35], who argue that attempting to improve protein-energy status without addressing micronutrient deficiencies will not result in optimal growth and function.

Table 2. *Ash contents of L. schlechteri and other leafy vegetables.*

Green leafy vegetable	Ash (%)
L. schlechteri[a]	13.50
X. sagittifolium[d]	1.71
P. dodecandra[c]	20.50
S. oleracea[c]	30.62
L. siceraria[b]	10.35
M. esculenta[e]	6.90

The comparison on the approximate mineral composition of *L. schlechteri* with other leafy vegetables is shown in Table 3. Significant differences in elemental concentration between species were observed for calcium, phosphorus, magnesium and iron (Table 3). Although highly variable, the data on these vegetables show that they are a good source of mineral nutrients.

Table 3. *Mineral elements of L. schlechteri and some leafy vegetables.*

Green leafy vegetable	Ca (mg/100g)	P (mg/100g)	Mg (mg/100g)	Fe (mg/100g)
L. schlechteri[a]	1160	300	360	400
G. africanum[h]	520	1340	160	20.38
M. oleifera[g]	1270	360	1910	381
M. esculenta[f]	210	84	31	1.8
X. sagittifolium[e]	107.09	52.9	19.2	1.19
U. pinnatifida[c]	1042	/	/	7.3
S. oleracea.[b]	110	840	/	83.62
P. dodecandra[b]	40	677	/	39.149
S. platensis[b]	130-1400	670-900	200-400	60-600

3.2.1. Calcium (Ca)

Calcium being the most abundant mineral element in the body, plays many reactions (cellular, enzymatic) such as the strength of bones and teeth [38]. *L. schlechteri* has a predominant calcium content where it is 1160 mg, a value largely superior to those found in *Phytolacca dodecandra* (40 mg), *Spinacia oleracea* (110 mg), *M. esculenta* (210 mg) and *G. africanum* (520 mg). *U. pinnatifida* with 1042 mg [39, 40] and *X. sagittifolium* (107.09 mg) have similar values, which are slightly lower than L. *schlechteri*. But the value of the latter is in the range of the Ca content of *S. platensis*, value between 130 - 1400 mg.

3.2.2. Phosphorus (P)

According to Fleck [32]; Hazra and Som [41], phosphorus generally present with calcium in the body contributes to the supporting structures of the body and whose daily requirement is 1000 mg. It alone is attributed many other physiological functions including skeletal development, mineral metabolism, energy transfer via mitochondrial metabolism, cell membrane phospholipid content and function, cell signaling and even platelet aggregation [42].

The concentration of this element in *L. schlechteri* was 300 mg/100 g much higher than in other studies (such as for *X. Sagittifolium* (52.9 mg) [24] and *M. esculenta* (84 mg) [43].

A balanced proportion of calcium and phosphorus is necessary or even determining in the body for their respective absorption; an excess of one can decrease the absorption of the other [44]. According to Asaolu et al [45], a deficit in the balance of phosphorus and calcium leads to osteoporosis, arthritis, pyorrhea, rickets and dental caries. In addition, some authors [46] have mentioned a Ca/P ratio that plays an important role in the development of the human being for good absorption of the two minerals, but which must be within a low regulatory limit (between 1 and 2). For the Committee of Specialized Experts (CES) in Human Nutrition of the Anses [47], is that exceeding the regulatory limit may seem acceptable for foods recognized as sources of calcium of good quality. This may be the case here for *L. schlechteri*.

3.2.3. Magnesium (Mg)

Although responsible for the formation of chlorophyll or dark green color in vegetables [34], magnesium for humans is an active component of several enzyme systems in which thymine pyrophosphate is a co-factor [48]. Magnesium deficiency can affect a wide variety of medical conditions including hypertension, asthma, angina pectoris, coronary heart disease, cardiac arrhythmias, chronic fatigue syndrome, all types of musculoskeletal disorders, epilepsy, mitral valve prolapse, anxiety, panic disorder and many other medical and psychiatric conditions as reported by Schachter [49] as cited by Sushanta Borah et al, [42].

The magnesium (Mg) determination of *L. schlechteri* revealed an average of 360 mg. This value is much lower compared to that of *M. oleifera* 1910 mg and is in the range of that of *S. platensis* between 200-400 mg. For the other vegetables, the detected magnesium level is relatively very low at 19.2 mg for *X. Sagittifolium* [50], 31 mg for *M. esculenta* [43] and 160 mg for *G. africanum* [24].

3.2.4. Iron (Fe)

Iron plays an essential role in many biological functions Anses, [51] whose deficiency in women and children leads to the development of anemia [52]. In 1998, according to WHO data, iron deficiency anemia was a global nutritional problem affecting nearly 1.78 billion people, 358 million of whom were in the developing world [53, 54].

Green leafy vegetables [53] and some African vegetables are known to be excellent sources of iron [17]. They provide according to Gopalan et al, (1996)[55], about 5 to 10 mg of iron per 100 g on average and where the dietary recommendation for Indians recommends a daily intake of 100 g of green vegetables in an adult diet [56]. But iron levels are influenced by factors mentioned by researchers, such as soil type and pH, water availability to the plant, climatic conditions, plant variety [57], age [13] and fertilizer use [58]. Table 3 indicates that iron in *L. schlechteri* is 400 mg, and is in the range of *S. platensis* between 60-600 mg [39]. While in *X. Sagittifolium* (1.19 mg) and *M. esculenta* (1.8 mg), the iron level is relatively very low. Focusing on the low iron content of *M. esculenta* (1.8 mg) and *G. africanum* (20.38 mg), which are among the most popular vegetables consumed daily in Congo, iron fortification and supplementation, as well as dietary modification/diversification, are the three conventional approaches to improve iron intake and bioavailability, thus requiring the identification of locally available iron-rich foods such as *L. schlechteri*, whose consumption could be improved by recommendations and promotional campaigns.

3.3. Fatty Acid Composition

Table 4 shows the fatty acid composition of oils from some leafy vegetables [21, 35, 26], indicating the presence of five main fatty acids: palmitic, C16:0 (15.7-63%); stearic, C18:0 (1-2.50%); oleic, C18:1 (2-5.1%); linoleic, C18:2 (4-28.68%), and linolenic (9-53%) accounting for about 100% of the total fatty acids.

Table 4. *Comparison of GA of L. schlechteri with some leafy vegetables and algae.*

Name of the AG	*L. schlechteri*[a] (%)	*A. caudatus*[b] (%)	*R. acetosa*[b] (%)	*S. platensis*[c] (%)	*S. maxima*[c] (%)
C16: 0	43.11	16.1	15.7	25.8	63
C18: 0	2.20	1.6	2.5	1.7	1
C18: 1ω9	2.78	5.1	4.0	3.8	2
C18: 2ω6	28.68	14.3	17.2	16.6	4
C18: 3ω3	23.24	53.0	48.4	12	9
ΣSFA	45.31	17.7	18.2	27.5	64
ΣMUFA	2.78	5.1	4.0	3.8	2
ΣPUFA	51.92	67.3	65.6	28.6	13.0
PUFA/SFA	1.15	3.80	3.60	1.04	0.20
ω6/ω3	1.23	0.27	0.36	1.38	0.44

3.3.1. Palmitic Acid

Palmitic acid (C16:0, PA) is the most common saturated fatty acid in the human body [59, 60] and can be supplied in the diet or synthesized endogenously from other fatty acids, carbohydrates and amino acids [60]. As its name suggests, PA is a major component of palm oil (44% of total fat), but significant amounts of PA can also be found in other foods, such as dietary fats and oils [61]; as is the case here of *L. schlechteri* and *Spirulina maxima* oils [62] with 43.11% and 63% respectively. As for the other oils listed in Table 4, the proportions do not exceed 30%. In addition, PA is present in breast milk [59] with 20% of total fat and which is equivalent to about 10% of energy [63-64]. Palmitic acid is generally thought to account for most of the cholesterol-raising effect of SFA-rich diets [65]. However, it is known not to increase blood cholesterol levels when esterified in the alpha position on triglycerides (as in palm oil) [66]. But when it is esterified in the beta position (as in butter fat) it is more hypercholesterolemic, when it is esterified in the beta position (as in butter fat) according to Ng [67] quoted by E. Fokou et al., [66]. Taking into account the average recommended intake of PA which is about 20 to 30 g/d, i.e. about 8 to 10 in percentage [68], it is suggested that *Michiélé* (*L. schlechteri*) can perfectly fulfill this recommendation with its high C16:0 content and contribute to some benefits.

3.3.2. Stearic Acid

Stearic acid (C18:0, SA) is a long-chain saturated acid, and constitutes 7-10% (or even a quarter) of the total fatty acids in the American diet [69]. Like C16:0, C18:0 is also accused of having effects on serum cholesterol concentrations as an SFA. However, not all SFAs may be equally cholestenolemic as argued by Tholstrup et al, [70]. The latter agree with other authors [65, 71, 72] who state that stearic acid (C18:0), contributes substantially to the intake of SFAs in most industrialized countries, and does not seem to affect total cholesterol. Another possible reason for the lack of LDL (bad) cholesterol lowering is that stearic acid is rapidly converted to oleic acid [69] and over 90% of its normally available proportion in the diet is absorbed [69, 72]. For the latter reason, the presence of C18:0 in vegetables could be an asset. Although very low, the AS proportions of the vegetables presented in Table 4 vary from 1% (*Spirulina maxima*) to 2.5% *Rumex acetosa* (*Sorrel*) where *L. schlechteri* presents 2.20% of the total AG content.

3.3.3. Oleic Acid: Omega 9

Oleic acid [OA, C18:1 (ω-9)] is a MUFA, a non-essential fatty acid that has recently been described as a regulator of immune function and health [73]. It is found in animal and plant products, but more so in olive oil of which it is the main constituent (70-80%) in addition to minor phenolic compounds [74]. It also owes its name to this oil. Oleic acid represents 45% of total fatty acids in most food oils.

The OA content varies from 2% (S. maxima) to 5.1% *Amaranthus caudatus* with a not too significant difference between vegetable oils. The oil of *L. schlechteri* showed a content of only 2.78%. Although very low, we believed that the concentration of C18:1ω9 in *L. schlechteri* oil may play a role in the health of consumers with respect to serum cholesterol, where many researches have shown the most notable effects of the substitution of saturated fats in favor of oleic acid, causing a reduction in the risk of coronary heart disease by 20-40%, mainly via the reduction of LDL cholesterol [75, 76]. However, some authors consider this fatty acid to be a neutral fatty acid, neither increasing nor decreasing cholesterol concentrations in all lipoprotein fractions: VLDL, LDL and HDL [69]. On the other hand, other authors suggest that it seems to be neutral with respect to low density lipoproteins, LDL ("bad" cholesterol), but modestly increases high density lipoproteins, HDL ("good" cholesterol) [77], as reported by E. Fokou et al [66]. Other beneficial effects of AO have been reported in the context of autoimmune diseases, protective effect on breast cancer and improved immune system function [73].

3.3.4. Essential Fatty Acid: Omega 3 and 6

On the basis of a nutritional classification, fatty acids that are not synthesized by humans and are essential for development and health are called essential. In this context, linoleic [18:2 (n-6), LA] and alpha-linolenic [18:3 (n-3), ALA] acids are polyunsaturated fatty acids (PUFAs) classified as essential, which can only be supplied to the body by the diet. Essential fatty acids are known to help control various chronic diseases [78, 3], and are converted to other long-chain polyunsaturated fatty acids (LCPUFA) such as gamma linolenic acid (18:3n-6); dihomogammalinolenic acid (DGLA) (20: 3n-6); arachidonic acid (AA) (20:4n-6); eicosapentaenoic acid (EPA) (20:5n-3); docosapentaenoic acid (22:5n-3); docosahexaenoic acid (DHA) (22:6n-3)] by desaturase and chain lengthening enzyme systems (Holman, 1998). The n-3 PUFA series is found mainly in fish oils (e.g. cod, salmon, sardine, sole), whereas the n-6 series is more common in vegetable oils (e.g. from grape seeds, corn, sunflower). But it has also been found α-linolenic acid precursor of omega-3, in green leafy vegetables with beneficial effects on health [78, 3] as is the case in our results where the contents vary between 9% (*S. maxima*) and 53% *Amaranthus caudatus* with a significant difference between the vegetable oils. *Rumex acetosa* (*Sorrel*) and *L. schlechteri* oils revealed contents of 48.4% and 23.24% respectively.

C18:2n-6 is largely represented in *L. schlechteri* oil (28.68%), followed by *Rumex acetosa* (*Sorrel*) oil (17.2%), S. platensis oil (16.6%), *Amaranthus caudatus* oil (14.3%) and finally slightly in *S. maxima* oil (4%). Indeed, in most vegetable oils these two fatty acids (linoleic and alpha-linolenic) appear mainly in high concentrations. Their considerable percentages should therefore be taken into account [79, 80, 81].

However, the beneficial effects of the two essential fatty acids on health have been described for some years, and where previous and current work evokes the interest of favouring a diet rich in ω-3 to reduce certain chronic diseases, whereas an increased consumption of ω-6 fatty acids is associated with an increase in chronic diseases [82] on the one hand; lead on the other hand, to an imbalance in the n-6/n-3 fatty acid ratio. An n-6/n-3 ratio of 4 to 10 has been recommended in various countries [83] by the nutritional council, but others prefer a ω-6/ω-3 ratio of less than 4 [84, 85]. Referring to Table 4, the ratio ω6/ω3 of all plant oils is within the indicated limit, and revealed values of 0.27 on *Amaranthus caudatus* oil, 0.36 on *Rumex acetosa* (*Sorrel*) oil, 0.44 on S. maxima oil, 1.23 on *L. schlechteri* oil and 1.38 on *S. platensis* oil.

It is recommended to ensure a balanced intake with a ratio of omega 6 to omega 3 between 1:1 and 4:1, whereas it is often found to be 15-20:1 in the current western diet deficient in ω-3 fatty acids, instead of 1:1 as is the case in wild animals and probably in human beings [86, 85].

3.3.5. All Saturated and Unsaturated Fatty Acid

The classification of fatty acids is based on the hydrocarbon bonds in their structural composition. When a fatty acid has no double bonds in the hydrocarbon chain, it is called saturated fatty acid (SFA) and when it has one or more double bonds it is classified as monounsaturated fatty acid (MUFA) or polyunsaturated fatty acid (PUFA), respectively. Therefore, myristic acid [MA, C14:0] and palmitic acid [PA, C16:0] are examples of SFAs; linoleic acid [LA, C18:2 (ω-

6)] and linolenic acid [LA, C18:3 (ω-3)] are examples of PUFAs while oleic acid [OA, C18:1 (ω -9)] is a MUFA.

The SFA content varied from 17.7% *Amaranthus caudatus* to 64% (*S. maxima*), with a significant difference between the vegetable oils. The oils of *L. schlechteri* (45.31%) and that of *S. maxima* (64%) are the highest in SFA because of the C16:0 content of 43.11% and 63% respectively. SFAs have generally been long labeled as the cause of cancer and coronary heart disease. To decrease the risk of coronary heart disease (CHD), many official dietary recommendations therefore include reducing SFA intake. However, there is some controversy about the relative effects of these SFAs on serum cholesterol. An example of this disagreement is provided by two different findings by Hegsted et al, [71] cited by Tholstrup et al, [70]. Thus, it is possible that the general recommendation to reduce saturated fatty acid intakes needs to be reconsidered. This encourages us to recommend the consumption of *L. schlechteri* oil on this specific case.

MUFAs contribute to dietary fat consumption in many parts of the world. There are two types of monounsaturated fatty acids in the diet with the predominant form being 9-cis 1 8: 1 (oleic acid). Since saturated fat intakes in many developing countries such as Congo are higher than recommended levels, an increase in the intake of MUFAs, in this case oleic acid, may be beneficial, particularly for human health. The MUFA content of all vegetable oils is the same as listed for OA. Polyunsaturated fatty acids (PUFAs) are of two different groups: the "omega-3 fatty acids" and the "omega-6 fatty acids". The main ω6 fatty acid and precursor of this group is linoleic acid (C18:2ω6), while the main ω3 fatty acid and precursor of this group is alpha linolenic acid (C18:3ω3). They are both considered essential fatty acids because they cannot be synthesized by humans so can only be obtained from diet or dietary supplementation.

Omega-3s in particular are essential nutrients for health and development, two of the most beneficial of which are EPA eicosapentaenoic acid, (20:5ω3) and DHA docosahexaenoic acid, (22:6ω3) having several beneficial impacts on human health such as reducing the risk of myocardial infarction [87]. For several years, the general public has been made aware of the health benefits of consuming less saturated and more polyunsaturated fats and, to a lesser extent, of the need to adjust the fatty acid balance of the diet so that the ratio of linoleic acid (LA, 18:2n-6) to alpha linolenic acid (ALA, 18:3n-3) is between 4:1 and 10:1.

Overall, the highest proportions of PUFA are found in Amaranth oil (67.3%), *Rumex acetosa* (*Sorrel*) oil (65.6%) and *L. schlechteri* oil (51.92%). The oils of *S. platensis* (28.6%) and *S. maxima* (13%) have lower proportions. Just as there is a ω-6/ω-3 ratio, there is also a PUFA/AGS ratio of nutritional interest to the consumer. The UK Department of Health recommends that this ratio should be greater than 0.45, and WHO/FAO experts have published guidelines for a "balanced diet" in which the suggested PUFA/AGS ratio is greater than 0.4 [80, 85]. As a result, all oils listed in Table 4 had a favorable PUFA/SFA ratio of 1.04 (*S. platensis*) to 3.80 *Amaranthus caudatus* with the exception of *S. maxima* (0.20).

4. Conclusion

From a nutritional point of view, vegetables, particularly green leafy and/or African ones, are an excellent source of phytoconstituents (such as vitamins, minerals, carbohydrates, proteins...) that can be used to reduce the burden of NCDs in Africa. Those in our study, whose referent is *L. schlechteri* which was used as a comparative study with other target green leafy vegetables, appear to be a good source of protein, carbohydrates, calcium and iron to ensure proper body function. Although the oil content in vegetables is rather low and 10%, it still represents an important nutritional factor, particularly important in vegetarian populations. It was detected quite important proportions of SFA, particularly in C16:0, of PUFA represented by the two essential fatty acids, with also appropriate ω6/ω3 and PUFA/SFA ratios. In sum, the objective of this study was achieved because *L. schlechteri* demonstrated that its contribution to the dietary intake of macro- and micro-nutrients would be comparable to, or even greater than, that of the vegetable and/or wild crop species usually consumed in the diet.

We can therefore say that green leafy vegetables, seaweeds and many others of the same category, which are mostly neglected, have good potential in terms of food value and can serve as easily accessible food resources.

Conflicts of Interest

The authors declare that they have no competing interests.

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