Original Research Article

Nutritional composition/profile of 'Tchonron' sauce made from *Adenia cissampelïdes* and *Hibiscus asper* leaves cooked with and without potash

ABSTRACT

Leafy vegetables are an essential component of food and health security in many African countries. The Senoufo people of northern Côte d'Ivoire are well known for their high consumption of leafy vegetables, especially in 'tchonron' sauce, a traditional dish prized by the Senoufo for its nutritional and therapeutic value. Unfortunately, it remains little known and little consumed by the Ivorian population. Although databases on the composition of raw foods (leafy vegetables) are available, data on cooked foods in Côte d'Ivoire are still lacking. The aim of this study was to evaluate the biochemical and mineral compounds, fatty acids and to determine the nutritional profile using the SAIN and LIM systems of 'Tchoron' sauces made from *Adenia cissampelïdes* and *Hibiscus asper* leaves. To prepare the 'tchoron' sauces, the leafy vegetables were pre-cooked for 20 minutes with or without potash and then ground. Peanut powder was then added to the crushed leaves and cooked for 10 minutes. The resulting sauces were dried and the powder used for analysis according to standard dietary recommendations. The results showed an increase in ash content from STHA (10.64±1.25%) to STHAP (12.32±1.39%) and STAC (15.70±0.20%) to STACP (16.67±1.02%), in fibre STHA (32.66±1.29%) to STHAP (41.58±1.41%) and STAC (29.85±1.6%) to STACP (38.53±1.62%) and in minerals in sauces prepared with potash. The content of other nutrients decreased, especially vitamin C STHA (33.51 ± 0.8%) to STHAP (17.29 ± 1.08%) and STAC (38.53%) to STACP (29.85%), unsaturated STHA (1047.03 ± 0.65%) and STHAP (898.53 ± 4.5%) and STAC (221.76 ± 4.5) to STACP (168.61 ± 0.7%). In addition, all samples had a SAIN score > 5 and a LIM score < 7.5, which is a recommended profile for health. These results showed that 'Tchonron' sauce is an important source of nutrients. However, cooking 'tchonron' sauce with potassium resulted in more losses than cooking it without potassium. decrease medical as well as financial burden, hence improving the management of cirrhotic patients. These predictors, however, need further work to validate reliability. There was also an increase in the LIM score of sauces cooked with potassium, so potassium-based sauces should be limited. On the other hand, sauces based on *H. asper* showed the best nutritional profiles.

Keywords: Tchonron, senoufo, fatty acids, SAIN and LIM system, Adenia cissampelïdes, Hibiscus asper and potash

1. INTRODUCTION

Undernutrition, obesity and diet-related noncommunicable diseases are the main drivers of malnutrition in Africa. They are caused by poor living conditions, lack of education, precarious livelihoods and lack of access to basic services such as health care and healthy and nutritious food (WHO, 2018; Koné *et al.,* 2023). In 2021, 45 million people and children under the age of five in Africa and globally will suffer from wasting, the deadliest form of child malnutrition (FAO, IFAD, WHO, WFP, UNICEF, (2019); WHO, 2023). As a result, promoting the

consumption of local food resources that are potentially rich in nutrients would benefit everyone, especially the most vulnerable populations (Koné *et al.,* 2016; Oyodeji *et al.,* 2017). Indeed, leafy vegetables are considered to be an important source of health-promoting nutrients. Leafy vegetables are therefore an essential component of food and health security in many African countries (Dappah *et al.,* 2021; Diallo *et al.,* 2023). In Côte d'Ivoire, and particularly in Senoufo country, leafy vegetables are a food of choice. The Senoufo people are known for their high consumption of leafy vegetables (Yao *et al.,* 2015; Diallo *et al.,* 2023). These leaves are usually eaten in sauces, including 'tchonron' sauce, a cultural dish made from leafy vegetables that is highly valued by the population and is part of their cultural identity. However, it is still little known and eaten by the Ivorian population. The leaves of *Hibiscus asper* and *Adenia cissampeloides* are the spontaneous plants most commonly used to prepare 'tchonron' sauce (Diallo et al., 2024). Cooking improves digestibility, but can lead to a deterioration in the nutritional content of these leafy vegetables (Diallo *et al*., 2024). The impact of food processing on the final nutritional quality of foods has only been partially investigated (Ehilé *et al.,* 2019; Dappah *et al.,* 2021; Diallo *et al.,* 2024). Cooking improves digestibility, but can lead to a deterioration in the nutritional content of these leafy vegetables (Diallo *et al.,* 2024). The impact of food processing on the final nutritional quality of the food has only been partially investigated (Ehilé *et al.,* 2019; Dappah *et al.,* 2021; Diallo *et al.,* 2024). Although databases on the composition of these leafy vegetables in relation to raw foods are available, data on cooked foods in Côte d'Ivoire are still lacking. The nutritional profile implies that it is possible to distinguish between foods according to their contribution to a healthy diet and a diet composed of key nutrients (Darmon et al., 2009; Koné *et al.,* 2016; Dappah *et al.,* 2021).

2. MATERIAL AND METHODS

2.1 MATERIAL

The plant material used consisted of 'tchonron' sauce from two (2) spontaneous leafy vegetables, *Hibiscus asper* (HA) and *Adenia cissampeloïdes* (AC), and one (1) oilseed (*Arachis hypogaea*) prepared with and without potash (Figure 1-A and B).

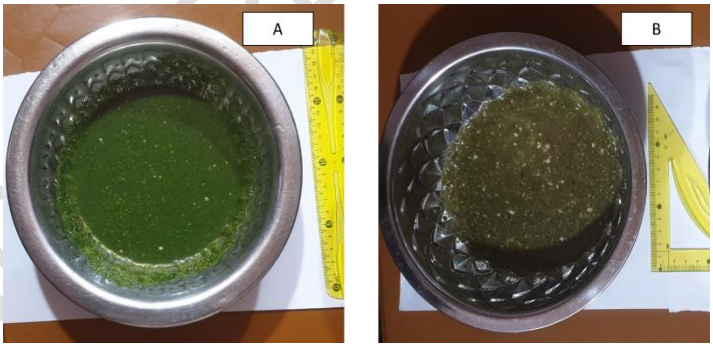

Figure 1 : A: Tchonron sauce with potash; B: Tchonron sauce without potash

2.2 METHODS

2.2.1 Preparation of 'tchonron' sauce

Four types of 'tchonron' sauce were prepared on three occasions. Two sauces were made using *H. asper* (HA) groundnut leaves, one with potash and the other without. Two other sauces were prepared on the same principle using *A. cissampeloïdes* (AC) leaves and peanuts. To prepare the sauce, 300 ml of water was placed in a saucepan with or without 1 g of potash. Then 100 g of fresh AC or HA leaves, previously cleaned of all impurities and washed, were added and precooked for 20 minutes on an electric hotplate (at 100°C). After

precooking, the leaves were removed and crushed with the cooking water, then returned to the pan. The whole mixture was placed on the hot plate, then 200 ml of water and 10 g of crushed peanut powder (A) were added. Everything was brought to the boil for 10 minutes at 100°C to make the sauce. The four sauces thus obtained were allowed to cool at room temperature (20°C) in the laboratory and then oven-dried (BIOBASE; Germany) at 45°C for 72 h. After drying, the sauces were ground using a NASCO type BL1008A-CB blender (China) and stored in Stomacher bags for subsequent analysis. The steps involved in the preparation of 'Tchonron' sauce are summarised in Figure 2.

2.1.2 Biochemical analysis of leaf powders

The analysis of certain biochemical parameters of the samples was carried out in triplicate according to the standard methods of the AOAC (2000). Moisture content was determined by drying the samples in an oven at 105°C to constant weight. Ash content was determined by burning the dried samples in a muffle furnace at 550°C for 4 hours. Crude fibre content was estimated by weighing the insoluble residue. The values obtained were determined using an acid (H_2SO_4, 0.25 M) and a base (NaOH, 0.3 M). Crude protein content was calculated by multiplying the estimated nitrogen content by 6.25 according to the Kjeldahl method. Crude fat was determined by the Soxhlet extraction method. Carbohydrate content was calculated by the difference in weight method. All approximations were expressed as a percentage of dry matter. The energy value of the samples was calculated using the Atwater conversion factor according to the Food and Agriculture Organisation (FAO, 2002).

2.1.3 Fatty acid profile determination

Fatty acids were determined according to AFNOR standard NF ISO 17059 (2005), which requires two preliminary steps: extraction and esterification of fatty acids. The AOAC method (1990) was used for lipid extraction. The lipid extract was subjected to a methanolic and chloridric acid solution to prepare fatty acid methyl esters. One (1) µL of the oil converted to methyl ester was injected into a Shimadzu SPD 14A gas chromatograph (GC) (Japan) to obtain fatty acid methyl ester peaks. The amounts of each fatty acid were calculated from the areas of the internal standards (heptadecanoic acid) (Vidrih et al., 2009). The content of each fatty acid is expressed as a percentage of the sum of all fatty acids analysed.

2.1.4 Vitamin C content

The vitamin C content of the samples was determined by the method described by Pongracz (1971). A 10 g sample was ground in 20 ml of a metaphosphoric acid (3%)/acetic acid (8%) solution. The ground material was centrifuged at 4000 rpm for 20 min. The supernatant was then collected in a graduated flask. The supernatant (1 mL) was titrated with 2,6-dichlorophenolindophenol. The appearance of a persistent champagne pink colour for 15 seconds marked the end of the assay. One (1) mL of a standard solution of pure ascorbic acid (1 mg/mL) was also titrated with 2,6-dichlorophenolindophenol (DCPIP).

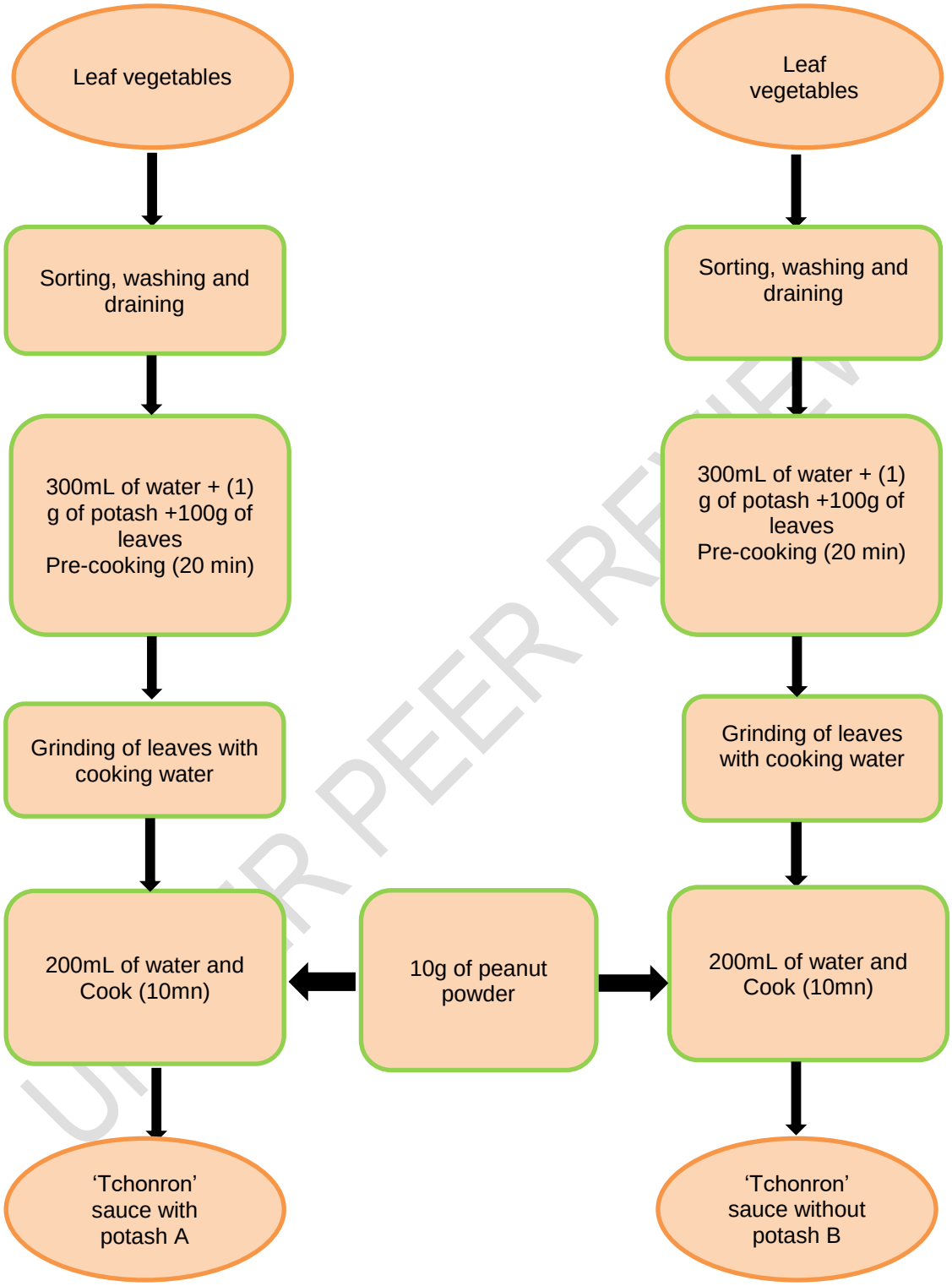

Figure 2: A: Tchonron sauce with potash; B: Tchonron sauce without potash

2.1.5 Mineral analysis

The leaf powders were dry calcined in a muffle furnace and then dissolved in a mixture of HCl/HNO3 before analysis. The mineral content of the samples obtained was determined using a VARIAN flame atomic absorption spectrophotometer, model (AAS; Japan) (AOAC, 1990). The contents were expressed in mg/100 g dry matter (DM).

2.1.6 Determination of the nutritional profile of 'Tchonron' sauces using the SAIN and LIM systems.

The nutrient profile of 'Tchonron' sauce was calculated using the nutrient profiling system proposed by the Agence Française de Sécurité Sanitaire des Aliments (AFSSA), based on two scores, SAIN5 and LIM3 (AFSSA, 2008; Darmon et al., 2009). The SAIN5 score (Score of adequacies to nutritional recommendations) is the average percentage of coverage of recommended nutritional intakes for five (5) essential nutrients (protein, fibre, iron, calcium, vitamin C) in 100 kcal (0.42 MJ) of food, and the LIM3 (score of nutrients to limit) is the average percentage of excess sodium, saturated fatty acids (SFA) and added carbohydrates in 100 g of food. The compositional data were obtained from the physico-chemical analysis of the sauce.

2.1.6 Data analysis

Analyses were performed in triplicate and the data obtained were expressed as arithmetic means with corresponding standard deviations. A one-way analysis of variance (ANOVA) was performed on all the results obtained to determine whether there were statistically significant differences between the values of the calculated means. Statistically significant differences were highlighted by Duncan's test at 95% confidence level and separation of means at P = 0.05 in STATISTICA version 7.1 software.

3. RESULTS

3.1 Physico-chemical characteristics of 'tchonron' sauces prepared from leaves of *H. asper* and *A. cissampeloïdes*

The biochemical characteristics of the different 'tchonron' sauces are presented in Table 1. The analysis shows that the water, lipid and protein contents of the four sauces are statistically identical. However, the content of these compounds decreased in the sauces cooked with potassium, from 16.28±0.43% in STHA to 12.72±1.26% in STHAP, and from 15.97±1.67% in STAC to 12.07±1.50% in STACP for lipids, and the same for proteins. On the other hand, sauces based on *Adenia cissampelïdes* leaves (AC) had a high ash content and a low fibre content compared to those based on *Hibiscus asper* (HA). However, the addition of potash increased the HA content. The fibre content increased from 32.66±1.29 to 41.58±1.41% for sauces based on HA and from 29.85±1.6 to 38.53±1.62% for sauces based on AC. The same is true for the ash content. On the other hand, the addition of potash reduced the carbohydrate content and the energy value of the sauces. The carbohydrate content decreased from 12.01 ± 1.14 to 5.93 ± 2.00 and the energy value from 13.05 ± 1.55 to 7.37 ± 0.63 for HA and AC sauces respectively.

Table 1: Physicochemical composition of 'Tchonron' sauces based on the leaves *H. asper* and *A. cissampeloides*

Paramètres	STHA	STHAP	STAC	STACP
Humidity	87.26 ±0.13[a]	83.15±0.9[a]	85.12±0.21[a]	83.58 ± 0.43[a]
Ashe	10.64±1.25[a]	12.32±1.39[a]	15.70±0.20[b]	16.67±1.02[b]
Fibre	32.66±1.29[a]	41.58 ±1.41[b]	29.85 ±1.6[a]	38.53±1.62[ab]
Lipides	16.28±0.43[a]	12.72±1.26[a]	15.97±1.67[a]	12.07±1.50[a]
Proteins	28.41±1.54[a]	28.24±1.18[a]	25.55 ±1.64[a]	25.36±1.34[a]
Carbihydrates	12.01 ± 1.14[b]	5.93 ± 2.00[a]	13.05±1.55[b]	7.37±0.63[a]
Energy	308.2±5.63[b]	251.16 ±4.98[ab]	298.13 ±6.12[b]	239.55±4.38[a]

STHA : Sauce de 'Tchonron' a basse de *H. asper* sans potasse, ; **STHAP :** Sauce de 'Tchonron' a basse de *H. asper* avec potasse, ; **STAC :** Sauce de 'Tchonron' a basse de *A. cissampeloïdes* sans potasse, **STACP :** Sauce de 'Tchonron' a basse de *A. cissampeloïdes* avec potasse

3.2 Fatty acid content of 'tchonron' sauces

The fatty acid contents of the different 'Tchonron' sauces are shown in Figures 2 and 3. The fatty acid parameters differed significantly ($p < 0.05$) between the 'Tchonron' sauces. STAC (4512.06 ± 0.23%) and STACP (4380.13 ± 0.3%) had high saturated fatty acid content and low polyunsaturated fatty acid content ranging from 221.76 ± 4.5 to 168.61 ± 0.7%, respectively (Figure 3). Whereas STHA (1047.03 ± 0.65%) and STHAP (898.53 ± 4.5%) had a high content of polyunsaturated fatty acids and a low content of saturated fatty acids, STHHA (3400.74 ± 1.15%) and STHAP (3280.53 ± 4.5%). In terms of omega-6 and omega-3 essential fatty acids, the 'Tchonron' sauce made from HA leaves had the highest content (Figure 3). The omega-6 content varied from 544.75 ± 60.39 to 480.53 ± 54.5% and the omega-3 content from 69.07 ± 7.06 to 36.12 ± 4.89% for STHA and STHAP, respectively. On the other hand, the AC-based sauces had the lowest omega-6 content for STAC (270.64 ± 24.12%) and STACP (205.13 ± 21.15) and an indeterminable content. In addition, the addition of potassium resulted in a significant reduction of all the fatty acids.

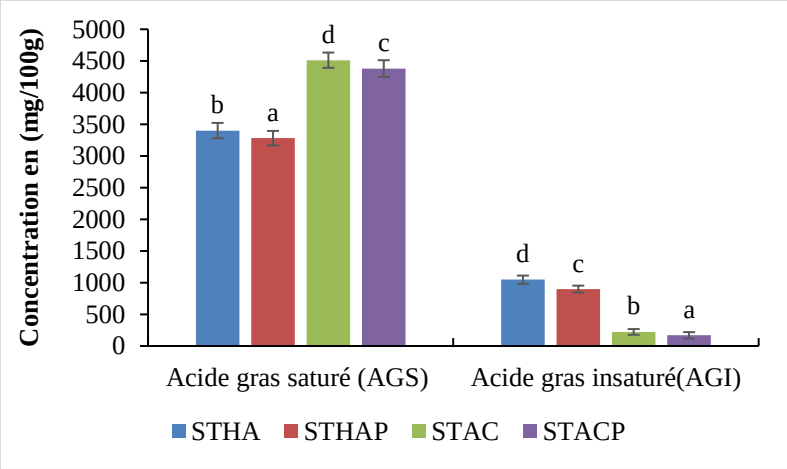

Figure 3: Fatty acids profil in different 'Tchonron' sauce

STHA: sauce from 'tchonron' to low *H. asper* without potash; SHAP: Sauce from 'Tchonron' to low *H. asper* with potash; STAC: Sauce from 'Tchonron' to low *A. cissampeloïdes* without potash; STACP: Sauce from 'Tchonron' to low *A. cissampeloïdes* with potash. On the histograms, the means marked with

different letters are significantly different from each other at the 5% threshold according to the Duncan test.

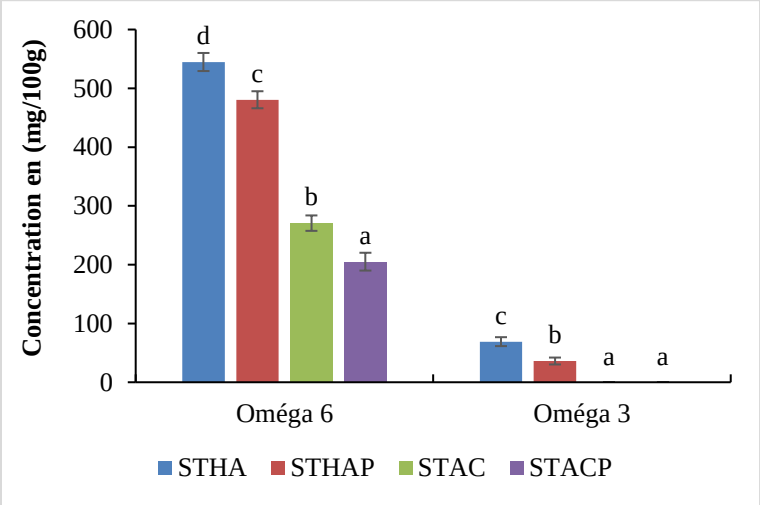

Figure 4 : Fatty acids profil of essential omega 6 et omega 3

STHA: sauce from 'tchonron' to low *H. asper* without potash; SHAP: Sauce from 'Tchonron' to low *H. asper* with potash; STAC: Sauce from 'Tchonron' to low *A. cissampeloïdes* without potash; STACP: Sauce from 'Tchonron' to low *A. cissampeloïdes* with potash. On the histograms, the means marked with different letters are significantly different from each other at the 5% threshold according to the Duncan test.

3.3 Mineral composition

Table 2 shows the mineral content (calcium, phosphorus, potassium, sodium and iron) of 'tchonron' sauces made from *H. asper* and *A. cissampeloïdes* leaves. The study showed that the mineral content of the samples differed significantly at the 5% level. 'Tchonron' sauces made with *H. asper* leaves had the highest calcium (Ca) content, ranging from 409.73 ± 3.12% to 438.23 ± 3.7, and the highest iron (Fe) content, ranging from 48.89 ± 2.24 to 57.39 ± 1.54, for STHA and STHAP sauces respectively. Sauces based on *A. cissampeloïdes* leaves had high phosphorus (P) (65.65 ± 4.81 to 123.71 ± 5.3%), potassium (K) (222.74 ± 3.67 to 318.13 ± 6.44%) and sodium (Na) (274.32 ± 5.62 to 336.68 ± 3.92%) contents. However, an increase in the mineral content of the different 'Tchonron' sauces prepared with potash was observed. As for the Ca/P ratio (2.47±0.81 to 33.47±1.21), the results showed values greater than one (1) in the different samples studied. On the other hand, STHA and STHAP sauces showed the highest ratios of 33.47±1.21 and 5.80±0.12 respectively. With regard to the Na/K ratio, the results showed values lower than one (1). With the exception of the STAC sauce, whose ratio was greater than one (1.01±0.01). In short, sauces cooked with potash had the lowest ratios, whatever the leafy vegetable. 'Tchonron' sauces cooked with potash had the highest mineral content.

Table 2: Mineral composition of “Tchonron” sauces based on the leaves *H. asper* and *A. cissampeloides*

Minerals (mg /100g MS)	STHA	STHAP	STAC	STACP
Ca	409.73± 3.12^{c}	438.23± 3.7^{d}	161.83± 2.02^{a}	189.85±2.43^{b}
P	12.24±1.1 ^{a}	75.55± 2.43 ^{c}	65.65± 4.81 ^{b}	123.71±5.3 ^{d}
K	202.67±7.62 ^{a}	295.59±2.66 ^{c}	222.74±3.67 ^{b}	318.13±6.44 ^{d}
Na	173.45±4.82 ^{a}	235.62±5.1 ^{b}	274.32± 5.62 ^{c}	336.68±3.92 ^{d}
Iron	48.89±2.24^{c}	57.39±1.54 ^{d}	18.87±1.52 ^{a}	26.43±1.37 ^{b}
Ca/P	33.47±1.21 ^{c}	5.80±0.12 ^{b}	2.47±0.81 ^{a}	2.58±0.01 ^{a}
Na/K	0.86±0.05 ^{bc}	0.80±0.09 ^{b}	1.01±0.01 ^{c}	0.4±0.01 ^{a}

STHA: sauce from 'tchonron' to low *H. asper* without potash, SHAP: Sauce from 'Tchonron' to low *H. asper* with potash, STAC: Sauce from 'Tchonron' to low *A. cissampeloïdes* without potash; STACP: Sauce from 'Tchonron' to low *A. cissampeloïdes* with potash. The values in the table are the means of three experiments with standard deviations. Means with different superscript (a-d) on the same row are significantly different at the Duncan's level of 5%.

3.4 Determination of vitamin C content and nutritional profile

The vitamin C content is shown in Figure 5. The vitamin content of the different sauces differed significantly ($p < 0.05$). The vitamin C content of the HA-based 'Tchonron' sauce ranged from (17.29 ± 1.08 to 33.51 ± 0.8%) and was higher than that of the AC-based sauces (12.13 ± 0.63 to 26.26 ± 0.47%). However, the addition of potassium significantly reduced the vitamin C content. All samples had LIM values below 7.5 and SAIN values above 5, with the HA-based sauces showing the best values (Figure 6). However, the addition of potash resulted in an increase in the LIM score for all sauces.

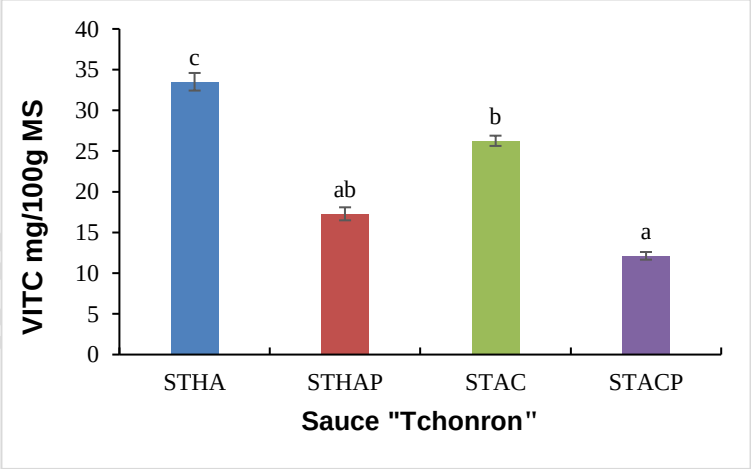

Figure 5 : Vitamin C content Tchonron sauce

STHA: sauce from 'tchonron' to low *H. asper* without potash; SHAP: Sauce from 'Tchonron' to low *H. asper* with potash; STAC: Sauce from 'Tchonron' to low *A. cissampeloïdes* without potash; STACP: Sauce from 'Tchonron' to low *A. cissampeloïdes* with potash. On the histograms, the means marked with different letters are significantly different from each other at the 5% threshold according to the Duncan test.

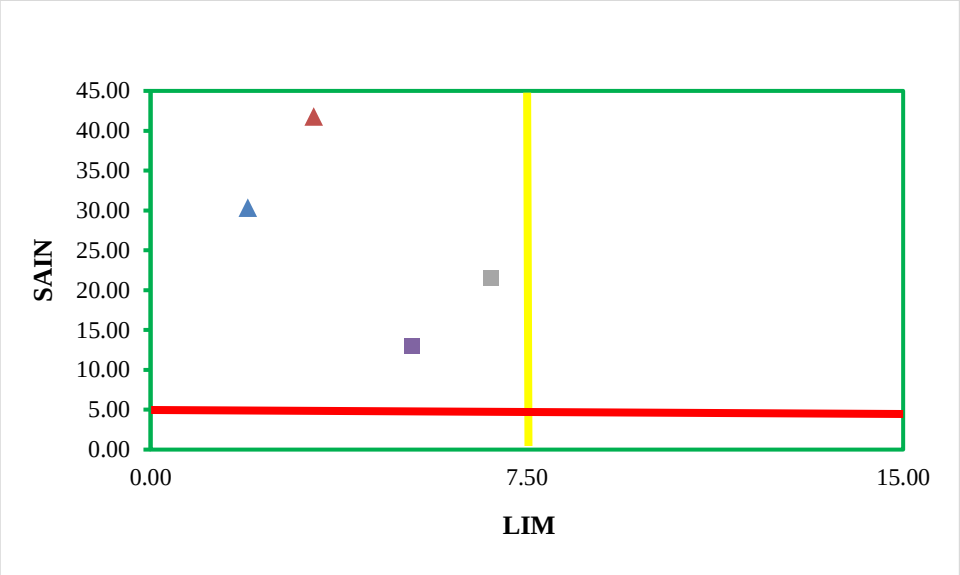

Figure 6: LIM and HEALTHY Scores of “Tchonron” sauce cooked with and without potash

4. DISCUSSION

Food quality often depends solely on primary production and food preparation as the last stage in the chain. It also has a major influence on the parameters that determine food quality (Dappah *et al.,* 2021). The different sauces had a high water content. According to Sobowalé *et al.,* (2011), this could be explained by the preparation method, the texture of the sauce and its raw material composition. These results are higher than those for *Solanum nigrum* and *Talinum triangulare* sauce, which were around 75% water (Dappah *et al.,* 2021). The high water content of the leafy vegetables and 'tchonron' sauce studied indicates that they cannot be preserved for long periods without a suitable preservation method. The fibre content varied from 29.85 ±1.6 to 41.58 ±1.41 %. These results are better than those obtained by (Diallo *et al.,* 2024), who found an increase in fibre content of between 16 and 22% in pre-cooked *Ficus exasperata* leaves at different times. However, the fibre content of sauces prepared with potash showed the highest values compared to sauces cooked without potash. According to Yao *et al.,* (2021), adding potash to flour increases the hydrophilic groups of soluble dietary fibre and its content. However, the high fibre content of 'tchonron' sauces is a nutritional advantage because fibre is important for the body. In fact, fibre intake has many health benefits, including maintaining good laxation and reducing the risk of cardiovascular disease and obesity (Mohamed *et al.,* 201; Diallo *et al.,* 2024). As a result, sufficient consumption of 'tchonron' sauce made from the leaves of *H. asper* and *A. cissampeloïdes* could meet the daily fibre requirement of between 25 and 30 g (Depezay, 2006), thereby protecting people against these diseases. The protein content varied from 25.36±1.34 to 28.41±1.54 % in the 'tchonron' sauces. This high content could be explained by the addition of peanuts during cooking. These results are in line with those of Tarnagda *et al.,* (2019), who reported that the addition of legumes during the cooking of 'Babenda' significantly increased the protein content of this dish. However, the addition or non-addition of potash had no effect on the protein content. What's more, the protein levels obtained in these studies are higher than 12 %, the minimum recommended value for foods considered rich in protein (Ali, 2009). 'Tchonron' sauces could be recommended to vulnerable groups, especially malnourished people, children and pregnant women. The fat content of 'tchonron' sauces ranged from 15.97±1.67 to 16.28±0.43% for sauces cooked without potash, which had the highest fat content. The sauces cooked with potassium had a lower content (12.07±1.50 to 12.72±1.26%). However, the lipid

content was higher than that of *Solanum nigrum* leaves (3.22±0.06 to 6.36±0.06) and *Ficus exasperata* leaves (4.92±0.01 %) reported by (Dappah *et al.,* 2019; Diallo *et al.,* 2024). This high lipid content observed in the sauces could be due to the addition of groundnuts during the preparation of 'Tchonron' sauce (Tarnagda *et al.,* 2019). These vegetable fats are mostly unsaturated and have nutritional and functional properties (Hammouda *et al.,* 2017). Consumption of 'tchonron' sauce could therefore be recommended for vulnerable individuals such as children and dieters. Carbohydrates are generally macromolecules that are primarily biosynthesised by plant cells and used by the human body for energy production. In the present study, the total carbohydrate content varied from 5.93 ± 2.00 to 13.05 ± 1.55% in 'Tchonron' sauces. This decrease could be related to the Maïllard reaction, as carbohydrates (reducing sugars) are also substrates for the non-enzymatic reaction (Gouekou *et al.,* 2021). However, sauces prepared with potash have a lower carbohydrate content than those cooked without potash. This decrease is likely due to the action of potash on enzyme activity and acceleration of the Maillard reaction. These results corroborate those of Ehilé *et al.,* (2017) report that leafy vegetables contribute little to the carbohydrate content of a food. However, the energy values, the contents of which were from 298.13 to 308.2 kcal/100 g respectively for STAC and STHA sauces (sauces without potash), and from 239.55 to 251.16% for STACP and STHAP sauces (sauces with potash). Fatty acids are the constituents of fatty substances or lipids, they play very important roles in the human body, especially in the nervous system. They help produce energy that is essential for many of the body's biological tissues to function properly. However, the unsaturated fatty acid concentrations in the 'tchonron'sauces (168.61 ± 0.7 to 1047.03 ± 0.65%) were lower than the saturated fatty acid contents (3280.53 ± 4.5 to 4512.06 ± 0.23%). As well as the omega-6 contents (205.13 ± 21.15 to 544.75 ± 60.39%) compared with omega-3 (0 to 69.07 ± 7.06). Furthermore, the addition of potash results in a significant decrease in essential fatty acids in these sauces. This is because during cooking at a temperature above their melting point, fatty acid triesters decompose into glycerol and constituent fatty acids, losing the flavor and nutritional value of essential oil (Ehilé *et al.,* 2019; Dappah *et al.,* 2021). Also, according to (Poh *et al.,* 2018) the omega-3 and omega-6 contents decrease during cooking. Similarly, the addition of potash during the preparation of Chonron sauces results in lipid peroxidation by-products such as carbonyls and cyclic fatty acids that are toxic to the human body (Saramma *et al.,* 2015). However, this decrease was more pronounced in sauces prepared with potash. This is because during cooking at a temperature above their melting point, fatty acid triesters decompose into glycerol and constituent fatty acids, losing the flavor and nutritional value of essential oil (Ehilé *et al.,* 2019; Dappah *et al.,* 2021). Also, omega-3 and omega-6 contents decrease during cooking (Poh *et al.,* 2018). Similarly, the addition of potash during the preparation of 'tchonron' sauces results in lipid peroxidation by-products such as carbonyls and cyclic fatty acids that are toxic to the human body (Saramma *et al.,* 2015). Ash content is an indicator of the mineral content of a food (Sika *et al.,* 2019). The ash contents obtained for the sauces based on *H. asper* varied from 10.64±1.25 to 12.32±1.39 % and are lower than those based on *A. cissampeloides* (15.70±0.20 to 16.67±1.02%). However, the center content of sauces cooked with potash was higher than those cooked without potash. These higher rates are thought to be due to the use of leaf cooking water and the addition of potash, which increases the ash content of the sauces. These results are in agreement with those of Agbo *et al.,* (2019) that recommend the use of cooking water to reduce nutrient losses and conserve minerals. Given the high ash content of 'Tchonron' sauces, they could be considered as good sources of minerals. Minerals play an important role in the human body. In fact, sodium and potassium are involved in membrane and cell exchanges, thus contributing to the regulation of plasma volume, of base acidity, of balance and of muscle contraction (Ehilé *et al.,* 2017; Yao *et al.,* 2020). Also, calcium plays a major role in ossification and dentition and has a preventive effect on high blood pressure in the elderly. In addition, iron plays an important role in preventing anemia (Agbo *et al.,* 2019; Gouekou *et al.,* 2021). The 'tchonron' sauces based on *A. cissampeloids* have a high content of P, K and Na, while the 'tchonron' sauces based on *H. asper* have an

appreciable content of Ca (409.73±3.12 to 438.23±3.7) and Fe (48.89±2.24 to 57.39±1.54). However, adding potash increases the mineral content of sauces. This could be because potash is a condensate of minerals. Minerals are essential to the proper functioning of the body. According to FAO (2004), the recommended dietary allowance (RDA) for calcium, phosphorus, and iron requirements are 1000, 800, and 8 mg/day, respectively. Based on the results of this study, the consumption of 'tchonron' sauce could be a cheap source of nutrients and minerals and contribute substantially to the improvement of human nutrition. These benefits will be necessary for proper immune and bodily functioning, as a lack of one of these basic nutrients could lead to a number of health problems. The appreciable amount of iron in the *H. Asper* 'tchonron' sauce suggests that they are ideal for preventing and combating iron deficiency anemia. The sodium-potassium (Na/K) ratio is of great interest in the prevention of hypertension. It is recommended that it be less than 1. In our study, the sauces analyzed had a sodium/potassium ratio of less than 1, with the exception of the STAC sauce. In view of this, the consumption of the 'tchonron' sauce based on the leaves of *H. asper* could help to prevent high blood pressure and should be recommended to hypertensive individuals. Unlike the leaf-based drug of *A. cissampeloides*, which should be avoided in people with hypertension and restricted in healthy people. Turan *et al.,* (2003), a diet could be considered beneficial when the Ca/P ratio is greater than 1 and poor when it is less than 0.5. In the case of this study, the Ca/P ratio is greater than 1 for all 'tchonron' sauces. However, cooked 'tchonron' sauce with or without potash is a satisfying diet. Vitamin C plays a fundamental role in the body. However, cooking affects its content in the leaves. Vitamin C content of 'tchonron' sauces based on H. asper leaves was higher than that based on *A. cissampeloides*. However, sauces cooked with potash were inferior to those cooked without potash. These observations in sauces cooked with potash are thought to be related to the increase in hydrophobic groups of vitamin C under the action of potash, thus inducing its solubilization in cooking water and its pronounced degradation under the effect of heat, unlike sauces prepared without potash (Oboh, 2005; Yao *et al.,* 2021). In metabolic processes, several vitamins are involved in the processes of normal metabolism and cell regulation, and they are necessary for growth and development; therefore, they are chemicals that we all need to stay healthy (Zhang *et al.,* 2018). All samples had a high HEALTHY (HEALTHY> 5) and a low LIM (LIM < 7.5). However, the sauces prepared with potash had a LIM sore that increased. Therefore, it would be advisable to limit the consumption of sauces with added potash. In addition, foods with a high HEALTHY and a low MIL have a good profile and are recommended for disease prevention (Koné *et al.,* 2016, Dapppah *et al.,* 2021). Base of the results of the SAIN and LIM system, the 'tchonron' sauce has a better nutritional profile and would help reduce malnutrition.

5. CONCLUSION

The objective was to evaluate the nutritional profile of the 'tchonron' sauce based on the leaves *H. asper* and *A. cissampeloides* in order to promote it as a human diet and to integrate it into the dietary habits of the Ivorian population. This study revealed that 'tchonron' sauce has valuable nutritional compounds. However, sauces based on *H. asper* leaves are an important source of protein, fiber, vitamin C, and iron and calcium. Whereas those based on *A. cissampeloides* are rich in macroelements and ash. This study also shows that the addition of potash during cooking of the various 'tchonron' sauces based on *H. Asper* and *A. cissampeloides* influences the biochemical parameters of the latter. In fact, nutrient losses were observed in the *"Tchonron"* sauces, but they were more pronounced in the sauces cooked with potash. Thus, potash induces changes in the nutritional value of 'tchonron' sauce by increasing the fiber, ash and mineral contents. Potash, on the other hand, reduces the levels of other nutrients such as fat, carbohydrate and vitamin C. The 'tchonron' sauces exhibited values of SAIN>5 and LIM<7.5. These values are characteristic of the foods recommended for health, with the exception of sauces cooked with potash, which may be less recommended. On the other hand, consumption of 'Tchonron' sauce cooked without potash

would be safe for the body. As such, it could be recommended as a hygienic-dietetic food in the prevention of certain nutritional deficiencies. These sauces prepared without potash and particularly those based on 'tchonron' leaves have excellent nutritional qualities. With all these advantages, the sauce 'tchonron' could be used in the diet to improve the notional state of the population and could help to fight against anemia.

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1.

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