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Conservation and analysis of the physicochemical parameters of a Congo food plant alicamentary [*Pteridium aquilinum* (L.) Kuhn]

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A B S T R A C T

In order to contribute to the valorization of non-timber products from the Congo, the aim of the study was to contribute to the nutritional value of *P. aquilinum* fern. The harvested fern plants were previously dried by solar drying for up to 4 hours and finally crushed to obtain a powder after sieving. This powder made it possible to study the biochemical and physicochemical characteristics of fronds. The results of the biochemical analysis revealed moisture contents of 13.87 ± 0.17%; the ash content of 9.25 ± 0.49%; lipid content 7.07 ± 0.41%, and that of soluble sugars 0.54 ± 0.021. Meanwhile, the protein and total carbohydrate contents are relatively high, respectively 20.33 ± 0.58% and 49.51 ± 0.2%. The physicochemical analysis, based on the measurement of the chemical indices, showed that only the peroxide index complies with the STAN 210-1999 Codex standards. In addition, the other two indices do not comply with the standards of the CODEX STAN 210-1999 standard, *i.e.*, 256.25 mg of KOH / g of saponification oil, 14.03 ± 1.5% of oleic acid for the acid number and the peroxide value 8.6 ± 1.75 meq O_2/kg of oil.

Introduction

Looking back, we find that man lived in harmony with his environment. He knew how to take advantage of the great wealth of fauna and flora to obtain a balanced diet, with regard to proteins, vitamins and mineral salts (Mbemba and Remacle, 1992).

In developing countries, undernutrition and child malnutrition are major problems often recorded in public health.

In addition, Congo has a significant diversity of food tree species that are sometimes poorly exploited. Many of these species contribute significantly to the equilibrium of rural food rations. Indeed, various edible parts of the plants are used directly or after transformation. These include asparagus, matembele (leaves of *Hypomea batatas*), and ferns. Taking into account the ferns, in the Congo, we have a number that are almost completely edible, including the bracken fern.

In certain localities of the Congo, this bracken fern is called in vernacular language by makoungou or fesi; The bracken fern is known under the scientific name: *P. aquilinum* (L) Kunh is a fern belonging to the family Dennstaedtiaceae. There are two subspecies identified to date, which are *aquilinum* and *caudatum* (Thomson, 2000).

Fern is a crop of young processed fronds that are used as human food in some parts of the world, although there are reports of its toxic effects on livestock (Fenwick GR, 2006, Yamada K, *et al.*, 2007, Madeja, J, *et al.*, 2009).

In traditional medicine, its analgesic, antibacterial and antiparasitic properties have been reported (Hassan SW, *et al.*, 2007, Swain T, 1974). In addition, its decoction is orally taken as a remedy for malarial fever disturbances (Nwiloh Barine Innocent *et al.*, 2014).

The purpose of this study is to value while keeping the bracken fern considered as a vegetable, but unfortunately little known to the Congolese population by making a nutritional contribution.

Materials and Methods

Plant material

The young fronds of the fern were used as vegetable raw material (Figure 1).

Drying equipment

A boat-type solar dryer designed at CRIPT was used to dry the young fronds of *P. aquilinum* with the following characteristics:

6.0 m long, 1.60 m wide and 1.05 m high, with a sheet absorber arranged over a length of 2 m and a width of 1.60 m in the form of a 0.60 m^2 surface partition on the roof of the dryer. It has a wide aeration zone of 0.4 m and at least 1.60 m long located at the end of the surface of the catchment area.

This dryer has a capacity of more than 10 kg of products to dry (Figure 2).

Methods

Collection and identification of plant material

The whole plant of *P. aquilinum* was harvested in the department of Brazzaville precisely in the northern districts of Brazzaville. But only young fresh fronds were used. The harvest took place in August 2017 and this plant was identified at the level of the national herbarium at the Institute of Research in Exact and Natural Science (IRSEN).

Sample preparation and drying kinetics

After separating the young fronds from the rest of the plant (the rhizome), they were washed with tap water to rid them of certain impurities. Once washed, they are drained to remove as much water as possible before being placed in the solar dryer.

The young fronds are arranged in the dryer in order to facilitate the almost total elimination of the water. These fronds were dried for 4 hours following a kinetic while noting the variations of drying temperature and humidity of the air in the dryer.

When the samples are completely dry, they are first milled using an electric grinder (Bruders type Bl-133), and then a fine powder is obtained after sieving.

Drying kinetics

The drying kinetics made it possible to carry out weighing every 30 min, at the same time measurements of the temperature and that of the humidity of the air in the dryer during drying. The brand Thermo-anemometer Lafayette A-M-Flex was used as a device to collect the temperature and humidity of the air in the dryer.

This kinetics made it possible to determine the dry basis water contents and the rate of drying of the sample by the following formulas:

$$X = \frac{m - MS}{MS} \quad (1)$$

$$-\frac{dX}{dt} = \frac{-[X(t + \Delta t) - X(t)]}{\Delta t} \quad (2)$$

Chemical and biochemical analysis

Chemical composition

The chemical composition of the fine powder of *P. aquilinum* was evaluated in terms of protein, water (moisture), ash, soluble carbohydrate, total fat and lipid contents.

Crude protein content

Proteins were determined by the common method of (Glowa, 1974) using micro-Kjeldahl;

Moisture content

The water content was determined according to the (official) AOAC method, 1997 where two (2) grams of powder were placed in the oven at 103 ± 2 ° C for 24 hours. The measurement is stopped until the dry residue is of constant weight;

Ash content

The amount of ash has also been determined by standard methods (Pomeraz and Meloan, 1994). 2 g of the dry matter were weighed into the porcelain crucibles which were placed in the muffle furnace at a temperature of 550 ° C for 8 hours until a white residue of constant weight was obtained;

Soluble carbohydrates

Soluble carbohydrates were determined by the method of (Yemme, 1954).

Total carbohydrates

The total carbohydrates were obtained by simple difference according to the following formula (Manzi *et al.,* 2004):

Carbohydrates= 100 – [lipids + proteins + water + Ash] (3)

Lipid extraction

15 g of *P. aquilinum* was used to extract the oil using 100 ml of n-hexane in a soxhlet extractor (Moulinex SeBPREP'LINE model 850) at 60 ° C for 6 h, as described in the standard method (AOAC, 1997). The solvent was evaporated at 50 ° C under reduced pressure using a rotary evaporator (N-1 model, Eyela, Tokyo Rikakikal Co., Ltd. Japan).

The oil was recovered, placed in a flask and placed under nitrogen until complete removal of the solvent.

Analysis of physicochemical indices

The chemical analysis of the oil was evaluated by measuring the chemical indices. These indices were determined according to known standard methods: The acid number according to standard method 969.1 (AOAC, 2012); the saponification number according to the standard method 965.33 (AOAC, 12) and the peroxide content according to the standard method 920.160 (AOAC, 2012).

Evaluation of the oil indices of *P. aquilinum*

The indices of oils are usually determined according to the standard methods: the acid number [AOAC (12), the standard method 969.1], the iodine content [AOAC (12), standard method 993.20), and the saponification value [AOAC Standard Method 965.33 (12)] and peroxide content [AOAC Standard Method 920.160 (12)].

Statistical analysis of the data

All experiments, measurements and analyses were performed three times, and the results presented are the average values of three replicates. Curves and coefficients of determination (R2) were obtained using the Microsoft Excel 2010 software. Significance was defined at $P < 0.05$.

Results and Discussion

Drying kinetics

The result on the kinetics of drying is shown in Figure 3, which shows the loss of mass, the temperature inside the dryer and that of the relative humidity as a function of time.

Most food products contain high amounts of water, which is partially or completely removed during dehydration. Drying food matrices involves both internal and external processes of heat and mass transfer.

The kinetics of drying achieved, resulted in the plots of the curves appearing on the plot presented above. Figure 3 shows the variation curves of product mass, temperature and air humidity in the dryer as a function of time.

The temperature curve shows an evolution that exponentially increases until reaching its maximum peak at 41.7 ° C after 210 min in the dryer.

As shown in Figure 3, the mass of the sample decreases significantly with increasing drying temperature. The curve of the mass can be described in 3 phases: an initial phase of 0 to 60 min where one observes a sudden and fast fall of mass (28.17 to 23.09 g). This significant loss may be due to the removal of water on the surface of the product. Several researchers have reported similar work in different food matrices (Ridene *et al.,* 2006; Arlabosse, 2008). An intermediate phase between 90 and 270 min where there is a gradual and extensive decrease in mass. A third phase where a very slow and progressive mass loss is observed until stabilization after 360 min.

The curve of the relative humidity as a function of time shows a progressive decreasing pace, until stabilizing from 180 min. This curve is the reverse of the temperature curve (Figure 3a).

Figure 3a shows the dry basis water content or the amount of water evaporated as a function of time. This curve confirms that of mass loss. There was a rapid loss of water during the first 90 minutes. Between 90 and 270 min, there is a slow loss of water that evolves gradually and tends to stabilize just after 270 min.

Subsequently, we evaluated the rate of drying of the product by the formula (2) that we presented previously. This is determined in terms of time.

The drying speed is given in Figure 3b below.

The drying rate of *P. aquilinum* powder samples were evaluated by calculation according to formula 2. This speed is determined in terms of time.

Figure 4 shows the curve of variation of the drying speed. The latter is the speed of the air inside the dryer which depends on the speed of the ambient air outside the dryer. The speed curve shown in Figure 4, corresponds to the speed of water loss of the product inside the dryer. It can be seen that the initial value of the speed is very low, especially since there is no renewed air circulation. This low speed justifies the way of circulation or convection of air which is done naturally. The rate of water loss gradually decreases to around 210-240 min.

Chemical composition

The chemical composition of *P. aquilinum* powder is summarized in Table 1. This shows that the powder contains approximately 7.07 ± 0.41% oil content, 9.25 ± 0.49% ash content and 13.87 ± 0.17% ash content. water content. It is also noted that the total protein and carbohydrate levels of the slings are relatively high (20.33 ± 0.58% and 58.89 ± 0.2% respectively).

Soluble carbohydrates determined gave 0.54 ± 0.021%. This low soluble sugar content reveals that the fern fronds contain very little reducing sugars and that the other sugars are involved in the saccharide bonds.

We were led to verify all the sugars in this plant by performing a calculation formula 3.

Awe, S and Amobi, O., (2015) also studied the chemical composition of *P. aquilinum* fronds. Their work reports a slightly high protein content (21.90%), while the ash, water and lipid contents are relatively lower than those obtained in our work. This can be explained by the source of *P. aquilinum* fronds where geographical factors may have an influence.

Table.1 Biochemical composition of fronds of *P. aquilinum*

Composition	Young fronds of *P. aquilinum* (%)
Moisture	13.87±0.17
Ash	9.25±0.49
Lipid	7.07±0.41
Proteins (N_tx6.25)	20.33±0.58
Carbohydrates	58.89±0.2
Carbohydrates Soluble	0.54 ± 0.021

Table.2 Oil index of different seeds

Indices	Young fronds of *P. aquilinum* (%)
Peroxide Values (Pv)	8.6±0.75
Acidity (Oleic)	14.03±1.5
Saponification Values (Sv)	256.25±6.2

Figure.1

Figure.2

Figure.3

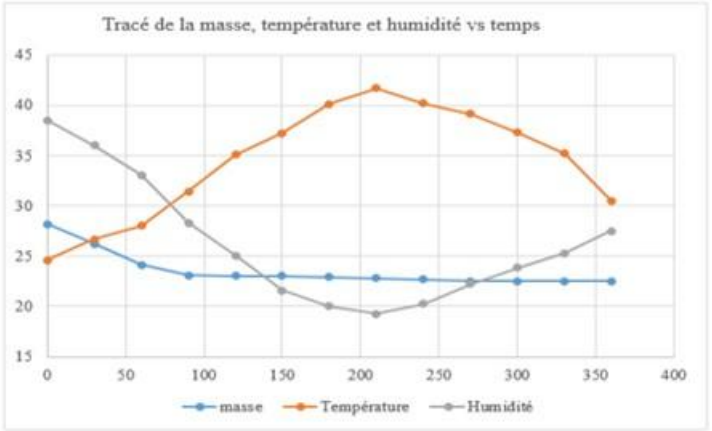


Figure.3a

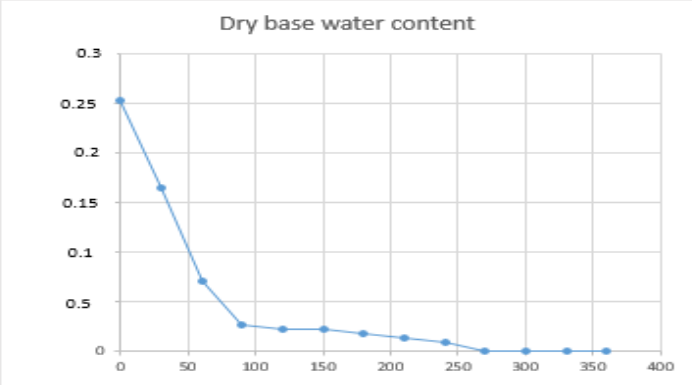


Figure.3b

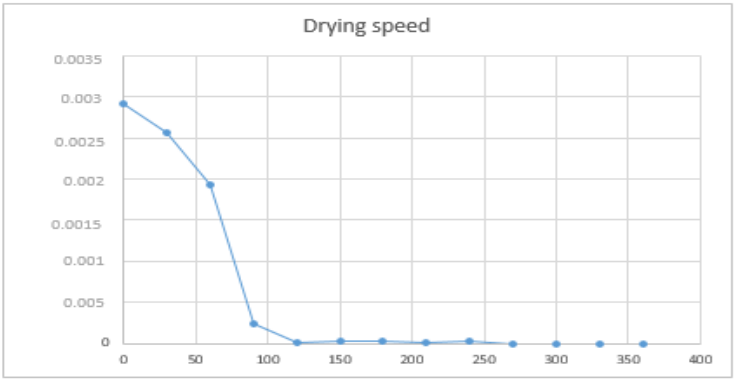
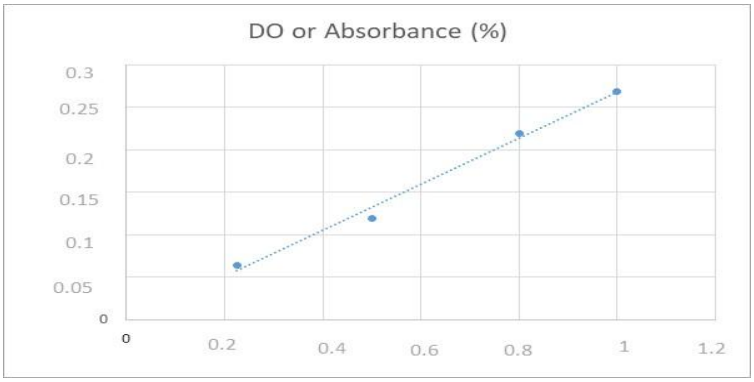


Figure.4



Physico-chemical indices

The acid number (Ia), the peroxide content (Ip) and the value of the saponification number (Is) are shown in Table 2.

In agreement with the literature, the acid number can be considered as an indicator of hydrolytic deterioration (Yaghmur *et al.*, 2001) of fat caused by a combination of

enzymes and moisture (Gan *et al.,* 2005) but it can also be related to their quality.

When the acid value content of the oil exceeds the objectionable quantity, it must be discarded (AB Bhattacharya *et al.,* 2008) because a high acidity is not acceptable in any consumable and commercial product due to the bad taste caused by the degradation products (volatile and non-volatile compounds) of free fatty acids (Yaghmur *et al.,* 2001) during a treatment. The standards of CODEX STAN 210-1999, stipulate for unconventional oils, values of acid number is 4.0 mg KOH / g of oil. In this study, the acid value of *P. aquilinum* (Ia) oil obtained is 14.03 ± 1.5. This value reveals a high acidity of the oil studied, which excludes it for a human diet.

According to Bensmira *et al.,* 2007, peroxide formation is an important concern from the point of view of rancidity and toxicology, and are also considered to be good guides to oil quality (H.L. Gan *et al.,* 2005). For this reason, some authors report that the extent of oil oxidation is frequently assessed by measuring peroxide levels (Melton *et al.,* 1994, Yaghmur *et al.,* 2001). The results obtained from the peroxide index (Ip) give the average value of 8.6 ± 1.75 meq O_2 / kg of oil. In fact, the value obtained is higher than the limit value recommended for a food oil by CODEX STAN 210-1999 which is 15 meq O_2 / kg of oil. The value of this index indicates that the oil of *P. aquilinum* fronds studied does not oxidize easily, as it must probably be rich in saturated fatty acids. At room temperature, this oil is solid.

As regards the saponification number, the value of 256.25 mg KOH / g of oil does not comply with CODEX STAN 210-1999 standards, the standard of which is between 189.7 and 195.2 mg KOH / 100g d 'oil. This oil can be used in cosmetics or soap.

Regarding soluble sugars, the respective concentrations found in solutions S1, S2, S3 are: 0.56 mg / ml, 0.52 mg / ml, 0.54 mg / ml. Taking into account the dilution factor and the concentrations obtained was possible to calculate the carbohydrate masses. These masses were used to determine the percentages of soluble carbohydrates, which gave an average value of 0.54% ± 0.021 (Table 1).

In conclusion, the fronds of *P. aquilinum* have a good nutritional value according to the chemical composition determined. The protein content (20.33 ± 0.58%) is very important that this vegetable deserves to be consumed and valorized in terms of the toxicity that can be eliminated by cooking. The ash content (9.25 ± 0.49%) reveals that the fronds of the fern contain a certain amount of minerals. The oil of *P. aquilinum* is solid at room temperature. It is dark green in color.

The fronds of *P. aquilinum* contain a low content of soluble sugars (0.54 ± 0.02%). The total carbohydrates (49.48 ± 0.2%) contained in *P. aquilinum* fronds make this vegetable a good source of protein and energy.

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