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Transformation of the *Typhonodorummadagascariense* Seeds Into Flour, Their Nutritional and Functional Characteristics

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Abstract-The main objective of this study is to develop endemic starchy plants to fight malnutrition in Madagascar. Its specific objective is to transform the seeds of *Typhonodorummadagascariense* into flour and to characterize the flour thus produced.Thus, the physical, physicochemical, nutritional and functional characteristics were determined.The results of the analysis showed that: their pH is 5.83±0.02. The water content is 13.02±0.26%. Their macronutrient (proteins, fat and total carbohydrates) content (in g per 100g of dry mater) are respectively 11.46±0.38; 1.49±0.08 and 71.69±0.01. The starch, reducing sugar, amylose and amylopectine content is respectively 66.90±0.01g per 100g of dry mater; 0.43±0.01%; 9.84±0.23% and 90.16±0.23. The mineral content, calcium, zinc and phosphorus (in mg/100g of dry mater) are respectively 79.14± 0.02; 4.05±0.04 and 218.46±0.09. Their functional properties such as the water and oil retention capacities (in g per 100 g of dry mater) are 235.33±1.07 and 97.35±0.69 respectively; the swelling power is 10.38±0.63g per g of the dry mater and the solubility is 17.01±1.01%. This flour has important functional properties. It can be used as a basic ingredient in pastry and baking.

Keywords- ***endemic, modern food, therapeutic, Madagascar***.

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I. INTRODUCTION

Typhonodorummadagascariense is an herbaceous, macrophyte plant that belongs to the Araceae family, known by the vernacular name "Viha", "Via". It is native to Madagascar and also invaded on the neighboring islands, Comoros, Zanzibar and Mauritius [1]. Currently, on the problem of climate change, this species is included in the list of threatened species in Madagascar [2]. It grows in large numbers and in a grouped fashion at the edge of canals, rivers or lakes and in freshwater marshes. It is still found in the wetland, hydrophilic species and aquatic resources [3]. It is a giant herb; it forms a steep overhung by a tuft of leaf similar to banana tree. That's why it is called aquatic banana for tourists.

In times of scarcity, the fruits are consumed by the population throughout the island of Madagascar. It has now become a raw material widely used the artisans. Apart from its food and artisanal use, the flesh of the tuber is used fresh and grated in application against the bites of poisonous animals [4]. It is also used for other therapeutic purposes: fruit juice is said to be used against asthma. It is used in magical practices. For example, a widow can put apexes over her door to keep the evil spirit from her late husband [5].

Most plants of the Araceae family are characterized by the presence of anti-nutritional factors, such as oxalate and oxalic acid. These substances are responsible for the irritation and the pungent taste felt after consumption of these types of plants [6], [7], [8]. So, consumers are looking for ways to remove these toxic substances before consumption. The main objective of this work is to develop available starchy plants to fight against malnutrition. Its specific objective is to transform the seeds of *Typhonodorummadagascariense* into flour, finally to eliminate toxic substances in the products and to characterize the flour thus produced. The characterization of this flour was made to know the uses in modern food products.

II.MATERIALS ET METHODS

1. Plant material

In this work, *Typhonodorummadagascariense* was used. This plant is endemic to Madagascar. The seeds of the fruits of this plant were used to prepare the flour.

2. Harvest of the fruits

The *Typhonodorummadagascariense* fruits were harvested in February 2019 in the Antalaha District, SAVA-Region, Madagascar. The detachment of the fruits was done using a sharp knife.

3. Transformation of the*Typhonodorummadagascariense* seeds into flour

The transformation of the *Typhonodorummadagascariense* seeds into flour was divided into several stages such as the collect of the seeds, peeling and washing, bleaching or detoxification, drying, grinding, sieving and storage. This method is an artisanal method used by consumers of this plant.

-Collect of the seeds inside of the fruits harvested

Typhonodorummadagascariense is a plant characterized by the high dose of oxalic acid or oxalate. This compound is responsible for the skin irritation and the pungent taste of this plant. Thus, the wearing of protection (gloves, blouse and boot) is mandatory during the harvest and processing this plant. The seeds inside of the fruit pod of the fruits harvested have been removed. Afterwards, seeds covered with a yellow membrane are obtained.

-Peeling and washing

The outer yellow membranes of the seeds were peeled. The dark green seeds were obtained after cleaning with fresh, clean water.

-Seed whitening or detoxification

Bleaching is a technique used by farmers to remove the toxic compound (oxalate or oxalic acid) in the seeds. The seeds were boiled for a few moments in water until there was the appearance of a gas-cracking crack. The gas released is the decomposition of the oxalate into carbon dioxide under the action of temperature.

-Drying

The detoxified seeds were dried in the sun plain for 4 days.

-Grinding

The well-dried seeds were crushed using a wooden mortar and pestle.

-Sieving

The crushed seeds were sifted manually using a sieve. The sieving produces a very fine flour of uniform size and eliminates large granules.

-Storage

The flour obtained was stored in a tightly closed, opaque box, and then stored at room temperature in a place protected from light.

4. Characterization of the flour produced

Some parameters have been analyzed to characterize the *Typhonodorummadagascariense* seed flour such as: the flour production yield; the density of the flour according to the method described by Okaka*et al*. [9]; the water, fat and crude ash content according to the method described by the Association Official Analytical Chemists (AOAC) in 2005 [10]; protein content according to the Kjeldahal method used by AFNOR [11]; pH according to the method described by Larsonneur [12]; total acidity according to the method of Vascondcelos*et al*. [13] and Oyewole [14]; the total carbohydrate content of the subtraction method described by Bertrand and Thomas [15] and AOAC [10]; the starch level according to the modified Ewers method in 1965 [16] and by BIPEA [17]; the amylose and amylopectin content by the spectrophotometric assay according to the method of Juliano [18], NRI [19] and Williams *et al*. [20]; the reducing sugar content using the Luff-Shoorl reagent; the mineral content using atomic absorption spectrophotometric and UV spectrophotometric; the metabolizable energy using Atwater heat coefficients and calculated by Favier [21] formula. Five important parameters have been determined for functional properties such as: the water and oil retention capacities by the method of Sosulski [22]; the hydrophilic-lipophilic ratio by making the ratio of the water absorption capacity and the oil absorption capacity [23]; the swelling power and the solubility by the method of Leach *et al.* [24].

III. RESULTS

The results of the analysis are presented in the table I below.

Table I: *Typhonodorummadagascariense* seed flour characteristics

Parameters	Values
Yield (%)	30.98
Density (g/cm^3)	0.77±0.05
Water content (%)	13.02±0.26
Dry mater (%)	86.97±0.26
pH	5.83±0.02
Total acidity (g of lactic acid/100 g DM)	0.44±0.05
Protein (g/100g DM)	11.46±0.38
Fat (g/100g DM)	1.49±0.08
Ash (g/100g DM)	2.34±0.38
Total carbohydrates (g/100g DM)	71.69±0.01
Metabolizable energy (kcal/100g)	309.06
Starch (g/100g DM)	66.90±0.01
Reducing sugars (%)	0.43±0.01
Amylose (%)	9.84±0.23
Amylopectin (%)	90.16±0.23
Calcium (mg/100g)	79.14±0.02
Zinc (mg/100g)	4.05±0.04
Phosphorus (mg/100g)	218.46±0.09
Water retention capacity (g of water/100g DM)	235.33±1.07
Oil retention capacity (g of oil/100g DM)	97.35±0.69
Hydrophilic-lipophilic ratio	2.41±0.09
Swelling power (g/g DM)	10.38±0.63
Solubility (%DM)	17.01±1.02

Each result represents the mean ± standard deviation of 3 independent determinations (n = 3); DM: Dry mater.

The results of the analysis show that the *Typhonodorummadagascariense* seed flour is rich in carbohydrates, starch, amylopectin, protein, phosphorus, and calcium, but with a very low acidity, fat and reducing sugars content. This flour has a high-water retention capacity. She has a pH basic. His swelling power and solubility are not negligible. For this flour, the hydrophilic-lipophilic ratio is superior to 1.

IV. DISCUSSION

The water content of the *Typhonodorummadagascariense* seed flour is greater than the flour of Taro (*Colocasia esculenta*) of the lamba variety of value 10.35 ± 0.50 [25]. The variation in the water content of the flours depends on the method of processing, drying and the duration of drying. Taro (*Colocasiaesculenta*) and *Typhonodorummadagascariense* are from the same family (Araceae), but the parts of the plants used are different. This also explains the difference in the water content.

The pH of the *Typhonodorummadagascariense* seed flour is lower than that of the flour of the six varieties of taro cultivated in Cameroon and Chad, values varied from 6.20 to 7.10 [26]. The difference can perhaps be explained by the difference in the part of the plants studied, the method of transformation into flour, the genera of the plants.

The value of the fat content in our work is close to the result of the work of Aboubakar*et al.* [27] of the Taro (*Colocasia esculenta*) flour of the Ibo coconut variety worth 1.17±0.32g per 100g of dry mater. The two plants are from the same family, but different genera and the parts of the studied plants are also different (Tuber and seed).

The protein content is similar to the results of the work of PanyooAkdowa [25] in the Taro (*Colocasia esculenta*) flour of lamba variety with value 11.69±0.58g per 100g of dry mater.

The total carbohydrates, starch and reducing sugars contents in our study are lower than the results of the work of Aboubakar [28] on the Taro variety WCN (White Country Coco Ngoundéré) flour with value respectively 91.00±0.09g per 100g dry mater; 79.85±0.20g per 100g of dry mater and 26.70±0.10g per 100g of dry mater. The two plants are from the same families, but different genera, the parts of the studied plants are different (One tuber and the other seed) and the methods of transformation into flour are also different. These explain the differences in values.

The crude ash rate and the mineral contents (Calcium and zinc) of our study are higher than that of the Taro of WCN variety (White Country Coco Ngoundéré) flour which is respectively 3.80±0.90g per 100g from dry mater; 30.70mg per 100g; 1.00ppm (0.10mg per 100g) [28]. The ash and mineral rates depend on the genera or families of the plants studied, the parts of the studied plants, the harvest season and the agronomic conditions of the harvest locations. Those who explain the differences in values.

The amylose content of our flour is lower than that of amylose content of the Taro flours analyzed by Njintang [29] varies between 17 and 31%. The variation in the amylose content can be explained by the method of determination, the genus of the studied plants, the ecology and the part studied.

The metabolizable energy of the flour produced is lower than that of the flours from six varieties of taro (BR, Boloso I Raw; AR, Acc. 236000 Raw; BB, Boloso Boiled; AB, Acc. 236000 Boiled; BF, Boloso I Fermented; AF, Acc. 236000 Fermented) (in kcal per 100g of dry mater) analyzed by AdaneTilahum [30] with values, respectively 372.55±0.41; 375.11±0.30; 373.68±0.62; 372.00±2.51; 370.46±0.49; 374.32±1.94. The variations in metabolizable energy depend on the macronutrient content (Proteins, fats and total carbohydrates).

The water retention capacity in our study is higher than that of flour of Taro cultivated in Hawaii reported by Tagodoe and Nip [31], varying from 150 to 180g per 100g of flour. This variation may be due to the method of analysis, plants of different genera and the amylopectin content in the samples.

The solubility of flour produced during this study is lower than that of the Taro flour of the Sosso variety (maturity ages 6months and 10months) obtained by Himeda [32] in the ranges of the values, respectively 17.46% at 20°C and 20, 82% at 100°C; 22.30% at 20°C and 23.47% at 100°C. The variation can be justified as the increase in solubility is linked to the high amylose rate. In our study, the rate of amylose is 9.84±0.23%; it is lower than that obtained by Himeda [32] from 35.90g per 100g of the age of maturity 6 months to 27.65g per 100g of maturity 10 months.

The swelling power of the *Typhonodorummadagascariense* flour in our study has been just lower than that of the flour analyzed by Jrarat*et al.* [33]; they indicated that the swelling power of flour is in the range of 10.99 to 16.02g per g of flour. *Typhonodorummadagascariense* and *Colocasiaesculenta* are from the same family, but of the different genus. The variation can be explained as the swelling power depends on the content of amylopectin, fat and protein in the flour.

V. CONCLUSIONS

The method of transforming seeds of *Typhonodorummadagascariense* into flour eliminates the harsh taste of this plant. The flour produced is a source of carbohydrates, essentially starch. Thus, this species is a starchy plant. This flour also is a source of protein, phosphorus and calcium. It has important functional properties. Therefore, this flour can be used to prepare modern food in the food industry.

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