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Original Research Article

Evaluation of the Physicochemical Parameters and Nutrient of Milk Powder of Tigernut (*Cyperus esculentus* L.)

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Abstract: The aim of this study was to evaluate the biochemical characteristics of tigernut milk powder and its effects on the growth of pups fed on breast milk. To achieve this objective, the physicochemical parameters, macronutrient content, minerals, antioxidants and anti-nutritional factors of tigernut milk powder were determined. At the end of the experiment, it was found that the milk powder had a pH (5.63 ± 0.01), a titratable acidity content (0.04 ± 0.01%) and a moisture content (4.73 ± 0.29 %) favourable to its preservation. It contains macronutrients such as carbohydrates (59.78 ± 1.34 %), fiber (15.86 ± 0.80 %), total sugars (10.28 ± 0.08%), reducing sugars (4.21 ± 0.66%), protein (3.22 ± 0.04 %), fat (31.50 ± 0.11 %) and an energy value (535.55 ± 1.20 kcal). The milk powder had an ash content of 1.37 ± 0.19%, with high levels of calcium (119.33 ± 1.15 mg/100g), potassium (799.23 ± 1.98 mg/100g), sodium (102.11 ± 1.46 mg/100g), phosphorus (148.06 ± 0.62 mg/100g) and magnesium (94.44 ± 0.83 mg/100g). Certain therapeutic compounds were determined, such as antioxidant factors: polyphenols (3.87 ± 0.08 mg EAG/100g), tannins (0.88 ± 0.1 mg ETA/100g), flavonoids (0.05 ± 0.1 mg EQ/100g) and vitamin C (100 mg/100g) and anti-nutritional factors: oxalates (5.86 ± 1.03 mg) and phytates (34.66 ± 0.18 mg). These results enable us to assess the nutritional quality of milk powder from tigernut.

Keyword: Cyperus esculentus, consumption, milk powder, nutritional value.

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INTRODUCTION

Nutsedge (*Cyperus esculentus* L.) is a plant native to the eastern Mediterranean basin. It is found on every continent except Antarctica, most often in warm regions (Mabberley, 1997). In Africa, the plant was introduced by the Arabs to the Maghreb countries (Pascual *et al*., 2000) and is also cultivated in many West African countries (Ghana, Nigeria, Niger, Burkina Faso, Mali, Côte d'Ivoire) (Defelice, 2002). When ripe, it produces edible tubers.

In Côte d'Ivoire, the tubers are commonly known as sweet peas, «tchongon» or «souchet». The plant is generally grown for its tubers. Its cultivation is thought to help solve a number of economic, nutritional and health problems in developing countries. Yellow nutsedge tubers contain several nutrients, including carbohydrates, fat (Aka *et al*., 2016), minerals and vitamins (Ndiaye *et al*., 2021). However, nutsedge tubers are generally eaten raw as a snack food

The aim of this study was to evaluate the biochemical characteristics of milk powder from tigernut tubers.

MATERIALS AND METHODS

Materials

Tigernut (*Cyperus esculentus*) used are brown in colour. The tubers were purchased with the growers at Dabakala in the Hambol region of northern Côte d'Ivoire. Once harvested, the tubers were cleaned of sand and stones and dried by the growers. The dried tubers were packed in a bag and transported to the laboratory for the various analyses.

Methods

Preparation of freeze dried milk powder from tigernut

The tubers were first sorted in order to eliminate tubers that were damaged or had not reached maturity and foreign bodies (plant debris, stones, etc.). The tubers

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were then washed several times with water and soaked for 72 hours to rehydrate the grains. Once the tubers had been removed from the soaking water, they were washed a second time. The rehydrated tubers were ground using a blender (iLUX).

The grindings obtained were placed in a cloth (poplin) and the milky drink was extracted by pressing. To extract the milky drink, we used 200 ml of water per 100 g of tuber. The extracted milky drink was freeze-dried and milk powder was obtained. The milk powder is quickly stored in special jars to preserve it and prevent it from absorbing moisture from the air. The preparation of milk powder from tigernut follows the unitary stages shown in Figure 1.

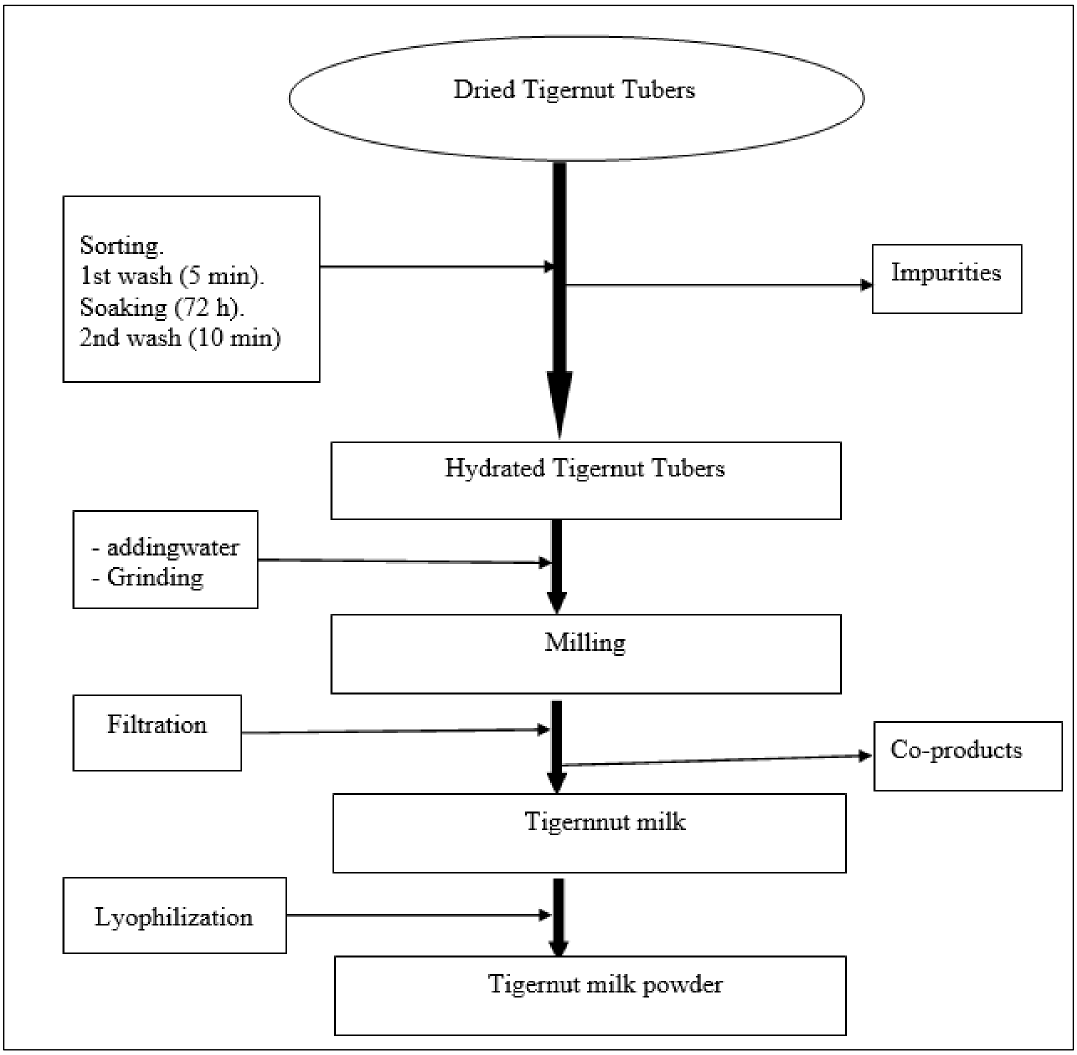

Figure 1: Stages in the production of milk powder from tigernut

Physicochemical analysis of samples of tigernuts milk powder

Determination of physicochemical characteristics (pH, titratable acidity, water content, dry matter)

The pH and titratable acidity were determined according to the AOAC method (1990): 5 g of milk powder was diluted in 50 ml of distilled water and centrifuged at 4200 rpm for 10 min with a centrifuge (Sigma). The pH was read directly from the filtrate after calibration of the pH meter (Tension TM+), and the titratable acidity was measured in 10 ml of the filtrate and titrated with a solution of NaOH (0.1N) until the colour turned persistent pink after adding 2 to 3 drops of phenolphthalein. The water content was determined according to the AOAC method (1990). 5 g of the milk powder was weighed and then dried in an oven (Memmert UN 260) for 24 hours at 105°C. After drying, the sample was cooled in a desiccator for 1 hour, weighed and the moisture content determined. The ash content was determined according to the method of AOAC (1990). 5 g of the milk powder was weighed and then placed in a porcelain crucible. The sample was then placed in an electrically heated oven (Nabertherm Gmbh 20, 28865) for 6 h at 550°C. After heating, the sample was cooled in a desiccator for 2 h and then weighed. The percentage of mineral matter (MM) was determined.

Determination of macronutrients

The total carbohydrate content of the milk powder was determined by the difference method according to AOAC (2005). The content of total sugars and reducing sugars were determined by spectrophotometric assay respectively at 492 nm and 546 nm (Dubois *et al.*, 1956; Bernfeld, 1995). Fibres were determined using the method (AOAC, 1990). After the addition of sulphuric acid, followed by sodium hydroxide under boiling conditions, the sample was washed with hot water, filtered, dried in an oven at 105°C for 8 hours and incinerated in an oven at 550°C for 3 hours. Fats Lipids were extracted in hexane using the Soxhlet according to (AOAC, 1995) method. Proteins were determined using the Kjeldahl method (BIPEA, 1976) and the energy value was calculated using the Livesey and Elia method (1995).

Composition of minerals

The mineral content of the milk powder samples was determined using the X-ray fluorescence analytical method. This is a spectrometric method for the quantitative and qualitative analysis of a chemical element in the raw material. The analyses were carried out using the MESA-50 X-ray fluorescence spectrometer. The instrument was set up, calibrated and analysed using HORIBA software.

Determination of antioxidants (vitamin C, polyphenols, flavonoids, tannins)

The method used for the determination of vitamin C was that described by Pelletier (1985). Vitamin C was extracted with 2% (w/v) metaphosphoric acid-acetic acid and titrated with 0.5 g/l 2,6 dichlorophenolindophenol (DCPIP) until a persistent pink colour was obtained for 30 s. Phenolic compounds were extracted with methanol using the method of Singleton *et al*., (1999) and polyphenol content was determined according to the method (Singleton *et al*., 1999) using the Folin-Ciocalteu reagent. Flavonoids were determined using the method described by Meda *et al*., (2005). Tannin content was determined using the method described by Bainbridge *et al*., (1996).

Determination of anti-nutritional factor content

Phytates were quantified using the method of Latta and Eskin (1980) based on the decolourisation of the Wade reagent by phytates. This discolouration is proportional to the quantity of phytates present in the medium. Oxalates were quantified using the method of Day and Underwood (1986). The quantity was determined by titration with a 0.05 M potassium permanganate ($KMnO_4$) solution until the colour changed to a persistent pink.

Statistical analysis

The results of the analysis of the milk powder from the tigernutwere analysed using Excel 2013, which was used to determine the averages and standard deviations of the results obtained.

RESULTS

Biochemical composition of tigernut milk powder

Physicochemical composition of tigernut milk powder

The pH, titratable acidity, ash and moisture content of tigernut milk powder are given in table 1. The results in Table 1 show that freeze-dried tigernut milk powder has a pH (5.63 ± 0.01) of less than 7 and a titratable acidity of 0.04 ± 0.01%. In terms of moisture content, the milk powder obtained had a level (4.73 ± 0.29%) favourable to good nutrient conservation. Table 1 shows a significant ash content (1.37 ± 0.19%) in the milk powder.

Table 1: Physicochemical composition

Paramètre	Tigernut milk powder
pH	5,63 ± 0,01
Titratableacidity (%)	0,04 ± 0,01
Ash (%)	1,37 ± 0,19
Moisture (%)	4,73 ± 0,29

Macronutrient composition of tigernut milk powder

The macronutrient composition of tigernut milk powder is presented in Table 2. The results show high total carbohydrate and fat contents of 59.78 ± 1.34 % and 31.50 ± 0.11 % respectively, and low protein content of 3.22 ± 0.04 %. Table 2 also shows high levels of total sugars (10.28 ± 0.08 %) and reducing sugars (4.21 ± 0.66 %). The fiber content of the milk powder is estimated at 15.86 ± 0.80 %. As for the energy value, milk powder from tigernut has a high value, estimated at 535.55 ± 1.20 kcal.

Table 2: Macronutrient composition of Tigernut milk powder

Parameters	Tigernut milk powder
Total carbohydrates (%)	59,78 ± 1,34
Fiber (%)	15,86 ± 0,80
Total sugars (%)	10,28 ± 0,08
Reducingsugars (%)	4,21 ± 0,66
Protein (%)	3,22 ± 0,04
Fat (%)	31,50 ± 0,11
Energy value (kcal)	535,55 ± 1,20

3.1.3. Micronutrient composition of Tigernut milk powder

3.1.3.1. Mineral composition of tigernut milk powder

The results of the analyses of the mineral composition expressed in (mg/100 g) of tigernut milk powder are given in table 3. These results show the presence of macroelements such as calcium, potassium, phosphorus, magnesium and sodium and also microelements such as iron, zinc, copper and manganese. Tigernut milk powder contains significant amounts of potassium, phosphorus, calcium, sodium and magnesium, with respective values of 799.23 ± 1.98; 148.06 ± 0.62; 119.33 ± 0.42; 102.11 ± 1.47 and 94.44 ± 0.83. In addition, the levels of the mineral microelements present in the milk powder show that manganese, with a level of 53.73 ± 1.35, is higher than the other microelements iron, zinc and copper, with levels of 1.61 ± 1.13, 5.30 ± 0.43 and 1.80 ± 0.08 respectively.

Table 3: Mineral composition of tigernut milk powder

Parameters (mg/100g)	Tigernut milk powder
Calcium	119,33 ± 1,15
Potassium	799,23 ± 1,98
Sodium	102,11 ± 1,46
Phosphorus	148,06 ± 0,62
Iron	1,61 ± 1,13
Zinc	5,30 ± 0,43
Copper	1,80 ± 0,08
Manganese	53,73 ± 1,35
Magnesium	94,44 ± 0,83

Phyto-micronutrient composition of tigernut milk powder

The results of the phyto-nutrient composition of tigernut milk powder are recorded in table 4. Table 4 shows that tigernut milk powder has an estimated vitamin C content of 100 mg and a polyphenol, flavonoid and tannin content with respective values of 3.87 ± 0.08mg EAG/100g ; 0.05± 0.1mg EQ/100g and0.88 ± 0.1 mg EAT/100g.

Table 4: Phyto nutrient composition of tigernut milk powder

Parameters (100g)	Tigernut milk powder
Vitamin C (mg)	100
Polyphenol (mg GAE)	3,87 ± 0,08
Flavonoids (mg QE)	0,05 ± 0,1
Tannins (mg TAE)	0,88 ± 0,1

GAE: gallic acid equivalent; QE: quercetin equivalent; TAE: tannic acid equivalent

Anti-nutritional factors

The composition of anti-nutritional factors in tigernut milk powder, represented by the oxalate and phytate content, is shown in table 5. The results obtained show that the phytate content is higher than the oxalate content, with values of 34.66 ± 0.18 mg/100g and 5.86 ± 1.03 mg/100g respectively.

Table 5: Anti-nutritionalfactors

Parameters (100g)	Tigernut milk powder
Oxalate (mg)	5,86 ± 1,03
Phytates (mg)	34,66 ± 0,18

DISCUSSION

Tigernut milk powder has a pH of less than 7, which shows that tigernut milk powder is slightly acidic (5.63 ± 0.01). The pH is a determining parameter in food preservation. It is one of the main obstacles that microbial flora must overcome in order to proliferate (Sadler and Murphy, 2010). The pH could be compatible with the pH of the digestive tract and avoid possible gastric irritation.

The moisture content was found to be 4.73 ± 0.29 %. This result complies with the Codex Alimentarius standard (2018), which requires a moisture content ≤ 5%. Furthermore, moisture content is a very important parameter for preservation and storage conditions. According to (Iqbal *et al.*, 2012), this low moisture content could limit the development of microorganisms. In fact, water content is an important factor in maintaining food quality, as increasing humidity facilitates the growth of microbes and ultimately destroys the quality of foodstuffs.

The results of the macronutrient composition presented in Table 2 show that Tiger Nuts milk powder is mainly composed of carbohydrate and fat with quantities of 59.78 % and 31.50% respectively. These contents are similar to those found by Djomdi *et al.*, (2020) who showed that Tiger Nuts are composed in large quantities of carbohydrate (49.92 ± 0.12%) and lipid (25.56 ± 0.41%). These differences in values show that environmental factors have an influence on the nutritional composition of tigernuts. In fact, the amount of fat found in this study complies with the Codex Alimentarius standard. According to CodexAlimentarius (2018), the minimum fat content of whole milk powder must be greater than 26% and less than 42%. This determined value remains within the required margin referred to in this standard. Tigernut milk powder could be used as a substitute for artificial cow's milk.

The fiber content of tigernut milk powder (15.86 ± 0.80) is in line with the quantity of fiber (15.56 ± 0.12) found in the work carried out by Djomdi *et al.*, (2020).

From a dietetic point of view, dietary fiber offers a number of health benefits, including an increase in intestinal transit time and frequency of bowel movements (Vries *et al.*, 2015), and a reduction in constipation (Lawton *et al.*, 2013), which could reduce colon disorders.

In terms of energy value, Tiger Nuts milk powder has a high value, estimated at 535.55 ± 1.20 kcal. Compared with the energy value of soya flour (429.60 kcal), it has a high energy content. This high-energy powder could be used as a food supplement for children suffering from energy deficiencies. Tigernut milk powder could play an important role in breastfeeding infants of mothers who have died or who are unable to breastfeed their babies because of its high nutritional value.

With regard to the macroelements studied, the results show that their levels are significant in tigernuts milk powder. The quantities of calcium obtained (119.33 ± 0.42 mg/100g) are practically similar to those of whole UHT cow's milk (120 mg/100g) determined by Galantier and Bernard (2005). These results show that Tiger Nuts milk is a very good source of calcium. Calcium, along with protein and vitamin D, plays a role in bone mineralisation (Galantier and Bernard, 2005). In addition, the quantities of potassium (799.23 ± 1.98 mg/100 g), magnesium (94.44 ± 0.83 mg/100g) and sodium (102.11 ± 1.47 mg/100g) obtained in the milk powder from tigernut are higher than those obtained by Jeant *et al*., (2007) in cow's milk powder, which are for potassium (1212-1681 mg/kg), magnesium (97-146 mg/kg) and sodium (391-644 mg/kg). These results show that the concentration of potassium (799.23 ± 1.98 mg/100 g) is approximately 7 times higher than that of sodium (102.11 ± 1.47 mg/100 g) in Tiger Nuts milk and that Tigernuts milk could be given to pregnant women to stabilise blood pressure. Consumption of potassium reduces sodium consumption (Doorenbos, 2003). Lactation and pregnancy may be responsible for increased magnesium loss, so magnesium intake from the diet should be higher in breastfeeding and pregnant women (Boman *et al*., 2003). As for phosphorus, its concentration (148.06 ± 0.62 mg/100g) in Tiger Nuts milk powder is lower than that of cow's milk powder determined by Jeant *et al*., (2007), which is 1805-2185 mg/kg. According to FAO (2001), phosphorus is involved in the production and use of energy by the body and, along with calcium, in the preservation of bones and teeth.

The results obtained mention the presence of essential trace elements such as iron, zinc, copper and manganese. Their deficiency in the body could lead to serious dysfunctions. Consequently, providing the body with these minerals through the tigernut consumption of foods containing them prevents or cures these disorders (Berthélémy, 2008). The concentration of iron (1.61 ± 1.13 mg/100g) in tigernut milk powder is lower than that obtained in soja flour (Vololonirina et al, 2021), which is 9.93 mg/100g. On the other hand, the values for zinc (5.30 ± 0.43 mg/100g), copper (1.80 ± 0.08mg/100g) and manganese (53.73 ± 1.35 mg/100g) in milk powder from tigernut are higher than the values obtained in soya flour, which are respectively 3.62 mg/100g, 1.19 mg/100g and 2.3 mg/100g (Vololonirina *et al*., 2021). These micronutrient values for Tiger Nuts milk powder compared with the minimum and maximum values of the Codex Alimentarius (2017), which are 10-14 mg/100g for iron, 11-14 mg/100g for zinc and 1.4-1.8 mg/100g for copper respectively, show that Tigernuts milk consumption must be combined with other foods rich in essential micronutrients to meet requirements. The body needs these essential antioxidant trace elements (zinc, copper and manganese) to combat oxidative stress (Favier, 2006).

Vitamin C, polyphenols, flavonoids, tannins, phytates and oxalates were detected in Tiger Nuts milk powder. The vitamin C, polyphenols, flavonoids and tannins found in Tiger Nuts milk powder are antioxidant compounds. Antioxidant compounds act in the body as scavengers of reactive oxygen and nitrogen species (Frei, 2004). The vitamin C content (100 mg/100g) obtained in the milk powder of tigernut is higher than that obtained by Ndiaye *et al*., (2018), which is 12.6 ± 0.12 mg/100g in the flour of tigernut. Our work disagrees with that of Ndiaye *et al*., (2018), who concluded that Tiger Nuts are low in vitamin C. This low value obtained by Ndiaye et al. This low value obtained by Ndiaye *et al*., (2018) would be due to the uncontrolled temperature and sun-drying time of tigernut. In contrast, milk powder from tigernutwas obtained by freeze-drying. This method produces a dehydrated food that retains the quality and quantity of its nutrients. Moreover, vitamin C is a reducing agent involved in antioxidant defences (Frei, 2004). The vitamin C content (100 mg/100g) contained in the milk covers the average nutritional needs of the population (15-100 mg/day) depending on the age of the individual, with the exception of breast-feeding women (Anses, 2021).

The polyphenol content (3.87 ± 0.08 mg EAG /100g) of Tiger Nuts milk powder is lower than that found in freeze dried cooked soya milk (2.84 mg EAG/g) obtained by Yingying *et al*., (2016). These results show that soya is richer in polyphenols than tigernut. Polyphenols are molecules with anti-atherogenic, anti-inflammatory, anti-thrombotic, anti-carcinogenic and neuroprotective properties (Amiot *et al*., 2009). Soya and tigernutare the most widely used in the production of milk to replace cow's milk, given their nutrient composition.

The flavonoid content (0.05 ± 0.1 mg EQ/100g) obtained in milk from tigernutis lower than that obtained in flour from tigernut (289 ± 1.53 mg EQ/100g) (Lazizi and Ihadaden, 2021). It is true that milk from tigernut is less rich in flavonoids than flour from tigernut. However, the consumption of any food containing them is beneficial for the body. Flavonoids have antibacterial, antitumour, anti-inflammatory, antiviral, antiallergic and antifungal activities (Harbone and Williams, 2000). As for the tannin content (0.88 ± 0.1 mg EAT/100g), it is lower than that found (53 mg/100g EAT) in the work conducted in Nigeria by Ayo *et al*., (2018) in fermented tigernut. These results show that all stages of milk extraction from tigernutreduced the content of tannin compounds naturally present in tigernut. According to Kumari and Jain (2012), the consumption of vegetables that contain high levels of tannins and flavonoids has proven that these phytochemical compounds have numerous curative effects.

With regard to anti-nutritional compounds, the phytate (34.66 ± 0.18 mg/100g) and oxalate (5.86 ± 1.03 mg/100g) content of milk powder from tigernutare respectively lower than the values obtained in cooked beans, which are 341.80 mg/100g and 93.93 mg/100g (Gulukun *et al*., 2020). Unlike cooked beans, the results show that milk powder from tigernut contains fewer anti-nutritional compounds. This could be explained by the different methods used to clean the Tigernuts before producing Tiger Nuts milk. In fact, this low level of these anti-nutritional compounds in Tiger Nuts milk powder is advantageous for the consumer because they are undesirable due to their harmful effects on the human body by chelating essential minerals (Camara and Amaro, 2003). These small quantities can make the minerals bioavailable and assimilable by the body.

CONCLUSION

At the end of our study, we found that milk powder from tigernutis highly energetic, rich in carbohydrates and fat and low in protein, and could be used as a food supplement in the event of energy deficiency. It is an important source of calcium, potassium, sodium, phosphorus and magnesium. It also contains vitamin C, polyphenols, flavonoids and tannins, which are antioxidant compounds that could help combat cardiovascular, neurodegenerative and cancer diseases.

REFERENCES

- Aka, B. A. A., Konan N. Y., Coulibaly, A., Chatigre, K. O., & Biego, G. H. (2016). Physico-chemical and Nutritive Properties of Seeds and Oil deriving from the Sweet Pea (*Cyperus esculentus* L.) Marketed in Côte d'Ivoire. *International Journal of Biochemistry Research*, *13*(2), 1-9 p.
- Amiot, M. J., Riollet, C., & Landrier, J. F. (2009). Polyphenols et syndrome metabolique. *Médecine des maladies Métaboliques, 3*(5), 476-482.
- Anses (Agence nationale de sécurité sanitaire) 2021. Rapport de l'Anses relatif à l'actualisation des références nutritionnelles françaises en vitamines et minéraux. 278 p.
- AOAC. (1990). (Association of Official Analyticalchemists). Official Methods of Analysis 15th edition. AOAC, Ar- lington, VA, sec, 935-939 p.
- AOAC. (1995). Official Methods of Analysis.Washington D.C. 15th edition: 375-379.
- AOAC. (2005). Official method of analysis of the Association of official AnalyticalChemist,
- 5th ad. AOAC Press, Arlington Virginia, USA.
- Ayo, J. A., Adedeji, O. E., & Ishaya, G. (2018). Phytochemical composition and functional supported by properties of flour produced from two varieties of tigernut (*cyperus esculentus*). *FUW Trends in Science & Technology Journal*, *1*(1), 261-266.
- Bainbridge, Z., Tomlins, K., Wellings, K., & Westby, A. (1996). Methods for assessingqualitycharacteristics of non-grains starchstaples (Part 3. Laboratorymethods). *Chatham, UK: Natural Resources Institute*. 83, 185-193.
- Bernfeld, P. (1955). Amylase α and β. Methods in enzymologyColwich and N.O Kaplan, 9thedition, AcademicPress, Inc., New York: 154p.
- Berthélémy, S. (2008). Les oligoéléments, généralités et macroéléments. *Actualités Pharmaceutiques, 47*(472), 24-29.
- BIPEA. (1976). Bureau Inter Professionnel d'Etude Analytique. Recueil des Méthodes d'Analyse des communautés européennes, 1-110.
- Boman, X., Guillaume, T., & Krzesinski, J. M. (2003). Comment j'explore un trouble de la magnésémie. *Revue Médicale de Liège,* 58(2), 104-108.
- Camara, F., & Amaro, M. A. (2003). Nutrional aspect of zinc availability. *International Journal of Food Sciences and Nutrition*, 54, 143-151.
- Codex Alimentaruis. (2017). Programme mixte FAO/OMS sur les normes alimentaires comité du codex sur la nutrition et les aliments diététiques ou de régime. Avant-projet de lignes directrices pour les aliments thérapeutiques prêts à l'emploi (RUTF), Berlin, Allemagne, 60 p.
- Codex Alimentarius Commission, (2018). Standard for milkpowders and creampowder. CXS 207-1999. 1-6.
- Day, R., & Underwood, A. (1986). Quantitative analysis 5th edition. Prentice. *Hall publication*, 701p.
- Defelice, M. S. (2002). Yellow nutsedge*Cyperus esculentus* L. Snack food of the gods. *Weed Technology*, *16*(4), 901-907.
- Djomdi, Hamadou, B., Gibert, O., Tran, T., Delattre, C, Pierre, G, Michaud, P., Ejoh, R., & Ndjouenkeu R., (2020). Innovation in tigernut (*Cyperus esculentus* L.) milk production: in situ hydrolysis of starch. *Polymers*, 1-13.
- Doorenbos, C. J., & Vermeij, C. G. (2003). Danger of salt substitutes that contain potassium in patient with renal failure. *British Medical Journal*, 326, 35-36.
- Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A., & Smith, F. (1956). Colorimetricmethod for determination of sugars and related substances. *AnalyticalChemistry*, 28, 350-356.
- FAO. (2001). Improving nutrition through home gardening. A training package for preparing fieldworkers in Africa. Rome.
- Favier, A. (2006). Stress oxydant and pathologies humaines. *Annales Pharmceutique Française*, *64*(6), 390-396.
- Frei, B. (2004). Efficacy of Dietary Antioxidants to Prevent Oxidative Damage and Inhibit Chronic Disease. *Journal of Nutrition*, 134, 3196-3198.
- Galantier, M., & Bernard, B. (2005): En pratique: connaissance et place du lait et des produits laitiers dans une alimentation équilibrée. *Cahiers de Nutrition et de Diététique*, *40*(1), 57-63.
- Gulukun, E. Z., Ari, M. M., & Alu, S. E. (2020). Proximate composition and antinutritional factors of differently processed kidney bean (Phase olusvulgaris) seeds. *Nigerian Journal of Animal Production*, *47*(5), 169-175.
- Ihenetu, S. C., Ibe, F. C., & Inyamah, P. C. (2021). Comparative study of the properties of yellow and brown *Cyperus esculentus* L., *International Scientific Journal*, 35, 25-37.
- Iqbal, S., Younas, U., Chan, K. W., Zia-Ul-Haq, M., & Ismail, M. (2012). Chemical Composition of *Artemisiaannua* L. Leaves and Antioxidant Potential of Extracts as a Function of Extraction Solvents. *Molecules*, *17*(5), 6020-6032.

- Harborne, J. B., & Williams, C. A. (2000). Advances in avonoid research since 1992. *Phytochemistry*, 55, 481-504.
- Kumari, M., & Jain, S. (2012). Annins: An antinutrient with positive effect to Manage diabetes. *Research Journal of Recent Sciences*, *1*(12), 70-73.
- Latta, M., & Eskin, M. (1980). A simple method for phytate determination. *Journal of Agricultural and Food Chemistry, 28*(6), 1313-1315.
- Lawton, C. L., Walton, J., Hoyland, A., Howarth, E., Allan, P., Chesters, D., & Dye, L. (2013). Short Term (14 Days) Consumption of Insoluble Wheat Bran fiber-Containing Breakfast Cereals Improves Subjective Digestive Feelings, General Wellbeing and Bowel Function in a Dose Dependent Manner. *Nutrients, 5*(4), 1436-1455.
- Lazizi, S., & Ihadaden, S. (2021). Effets biologiques de *Cyperus esculentus* L. Master en Sciences Alimentaires, Université Abdelhamid Ibn Badis-Mostaganem. 69 p.
- Livesey, G., & Elia, M. (1995). Short chainfattyacids as an energy source in the colon: metabolism and clinical implications. Physiological and clinical aspects of short chainfattyacids, (Cummings, J. H., Rombeau, J. L., Sakata, T. eds.) Cambridge UniversityPress, Cambridge: 472-482.
- Mabberley, D. J. (1997). The Plant-Book: a portable dictionary of the vascular plants. 2nd edition. Cambridge, U.K.: Cambridge UniversityPress, 857p.
- Mada, S. B., Garba, A., Mohammed, A., Muhammad, A., Olagunju, A., & Mohammed, H. A. (2012). Effects of boiling and roasting on antinutrients and proximate composition of local and some elected improved varieties of *Arachis hypogaea* L (Groundnut). *International Journal of Food Nutrition and Safety*, *1*(1), 45-53.
- Meda, A., Lamien, C. E., Romito, M., Millogo, J., & Nacoulma, O. G. (2005). Determination of the total phenolic, flavonoid and proline contents in Burkina Fasanhoney, as well as their radical scavengingactivity. *Food Chemistry*, 91, 571-577.
- Ndiaye, B., Ayessou, N. C., Cisse, O. I. K., Balde, S., Cisse, M., Diop, C. M., & Sakho, M. (2018). Potentialités technologiques par l'évaluation biochimique de la farine des tubercules du souchet (*Cyperus esculentus* L.). *Afrique*, *14*(2), 209-214.
- Ndiaye, B. (2021). Contribution à la valorisation des tubercules de souchet (*Cyperus esculentus*): apport nutritionnel, itinéraires technologiques et propriétés galactogènes. Thèse de Doctorat Université Cheikh Anta Diop de Dakar, Sénégal, 183p.
- Ojokoh, A. O. (2011). Physiochemical proprerties and antinutrient content of fermented popcorn and groundnut composite flours using pure strains. *Nigerian Journal of Biotechnology*, *23*(2011), 35-39.
- Pascual, B., Maroto, J. V., Lopez-Galarza, S., Sanbautista, A., & Alagarda, J. (2000). Chufa (*Cyperus esculentus* L. var. sativus Boeck): An unconventional crop studies related to applications and cultivation. *Economic Botany, 54*(4), 439-448.
- Pelletier, O. (1985). Vitamin c (L-ascorbic and dehydro-L-ascorbicacid), in methods of vitamin Assay, 4th edition, 334-336.
- Sadler, G. D., & Murphy, P. A. (2010). pH and Titrable Acidity. In: Nielsen, *Food Analysi*, 219-238.
- Salve, A. R., LeBlanc, J. G., & Arya, S. S. (2020). Effect of processing on polyphenol profile, aflatoxin concentration and allergenicity of peanuts. *Journal Food Scientists and Technologist*, 58, 2713-2724.
- Singleton, V. L., Orthofer, R., & Lamuela-araventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Cioalteaureagent. *Methodsin Enzymology*, 299, 152-178.
- Solenne, M., & Solène, L. (2017). Le lait, controverse en santé. Thèse de Doctorat, UFR de pharmacie, Université Grenoble Alpes, France, 152p.
- Tanni, S. P. (2013). La culture du souchet : une source de revenus pour les femmes de la commune de Banfora. Mémoire de maitrise option géographie rurale, à l'université de Ouagadougou, Burkina Faso. 104p.
- Vololonirina, R. F., Razafimahefa., & Rakotomalala, R. S. (2021). Fabrication de la farine infantile à base des farines de soja, de patate douce à chair jaune et de poudre des feuilles de *Moringaoleifera*. Biodiversité des plantes et développement durable, 3 au 5 février 2021, Madagasca, 1p.
- Vries, de J., Miller, P. E., & Verbeke, K. (2015). Effects of cereal fiber on bowel function: A systematic review of intervention trials. *World Journal Gastroenterol*, *21*(29), 8952-8963.
- Yingying, T., Sam, K. C. C., & Yan, Z. (2016). Innovative Soaking and Grinding Methods and Cooking Affect the Retention of Isoflavones, Antioxidant and Antiproliferative Properties in Soy milk Preparedfrom Black Soybean. *Journal of Food Science*, *81*(4), 1-8.

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