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# Physico-Chemical and Nutritional Properties of a Food Broth Based on Nere (*Parkia biglobosa*)

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## Abstract

**Purpose:** Diet and eating habits are major risk factors for the health and the development of disease, such as, for example, metabolic disorder leading to cardiovascular pathology and cancer, decreased immunity exposing to infections. This study of the physico-chemical and nutritional properties of a soumara-based food broth was carried out with the aim of promoting the consumption of organic broth made from nere seeds (soumara). That is to alleviate certain metabolic diseases, which is a matter of food safety, and also to limit the risk for the health about the consumption of some cooking stocks on the market. **Methods:** Several natural ingredients such as nere seeds (soumara), ginger, black pepper, parsley and garlic were used to create a nere-based stock. All these ingredients were freeze-dried and the powder obtained was used to make the broth, regarding their physical and chemical properties. **Results:** The broth had a good protein content of 17.41 ± 0.367 g/100g, a lipid content of 16.80 ± 0.08 g/100g and a fiber content of 8.66 ± 0.04 g/100g. In terms of nutritional values, the broth showed good levels of calcium 184.21 ± 0.09 mg/100g, potassium 50.04 ± 1.45 mg/100g and iron and zinc. In terms of antioxidant activity, the broth also showed good antioxidant activity. **Conclusion:** Regarding the properties of our food broth, whose composition is based on natural ingredients, could be recommended for consumption and, its properties, could play an important role in preventing and combating certain metabolic diseases.

## Keywords

Food Broth, Nere, Physico-Chemical Properties, Nutrition, Food Safety

## 1. Introduction

Since the 1960s, particularly in developed countries, eating habits have evolved considerably towards a more diversified diet [1]. Worldwide, consumption of local cereals such as rice, millet and sorghum has declined in favour of wheat and maize, but these cereals still dominate the diet. In 2019, more than 820 million people worldwide were suffering from protein-energy malnutrition [2]. The high cost of animal protein sources such as meat, fish and poultry makes these products inaccessible to people. So, to cover the need, proteins from plant sources are in demand because they are cheaper and more readily available [3]. Furthermore, the nutritional quality of food is not only a public health issue, but is also becoming a strategic issue for the development and innovation of the agri-food industry. Spices are functional foods, *i.e.* foods that can be shown to have a beneficial effect on certain target functions of the body over and above basic nutritional requirements [4]. Spices come in a variety of flavours, colours and aromas, adding a wide range of nutrients to foods [5]. They enhance and complement the flavour of foods without detracting from their organoleptic quality [6]. The same applies to other food additives such as soumara seeds and food legumes that are valued for their nutritional qualities [7]. Soumara is one of the popular food seasonings produced from the alkaline fermentation of African locust bean (*Parkia biglobosa*) seeds in many West African countries [8] [9]. Soumara contained 30% to 47% protein, 20% to 43% fat and 13% to 17% carbohydrates, and was an excellent source of energy (464 to 546 Kcal/100g), and was a rich source of essential amino acids and fats [10]. It is also rich in B vitamins [11]. In addition to its aromatic attributes, soumara is thought to play an important role in maintaining good health [9]. It is said to help regulate blood pressure, combat cardiovascular disease and contain a beneficial bioactive compound [12]. It is also sometimes added as a seasoning in the preparation of various African dishes [13].

This tendency to improve the taste of food using food supplements or adjuvants has led to a profusion of broths flooding the markets, the composition of which is often unknown, and which is unfortunately not without health risks for consumers [14].

Given that broths are widely used in households [15], in the context of food security and with a view to satisfying nutritional needs without risk to consumer health, this study was conducted to develop a natural food broth based on nere (Soumara) using natural ingredients.

## 2. Material and Methods

### 2.1. Biological Material

The biological material consisted of several ingredients: fermented dwarf seeds (*Biglobosa parkia*, Photo 6), garlic cloves (*Allium sativum*, Photo 2), onion bulbs (*Allium cepa*, Photo 3), ginger rhizomes (*Zingiber officinale*, Photo 1), parsley leaves (*Petroselinum crispum*, Photo 4) and black peppercorns (*Piper nigrum*, Photo 5).


**Photo 1** : Ginger roots


**Photo 2** : Clove of garlic


**Photo 3** : Onion bulbs


**Photo 4** : Percil


**Photo 5** : Black peppercorns


**Photo 6** : Fermented Néré seeds

## 2.2. Methods

### 2.2.1. Collection of Samples

A total of 5 kg of each ingredient was purchased in Adjame Gouro in the Autonomous District of Abidjan. The samples were transported to the CeReB laboratory of the Institute Pasteur of Cote d'Ivoire for the various treatments and transformations.

### 2.2.2. Preparation of the Various Ingredients

In the laboratory, all the ingredients were carefully sorted, cleaned, washed and rinsed. Once all the waste had been removed, using a stainless-steel knife, the ginger rhizomes, garlic and onion cloves were cut up and placed in plates, while the other ingredients were placed in separate plates and all subjected to freeze-drying. 72 hours later, all the samples were removed from the freeze-dryer and, using a blender, the various powders were obtained and made ready for the various analyzes.

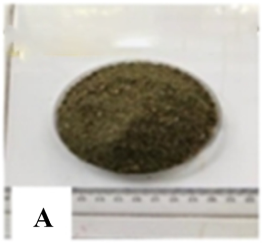


**Photo 7: Parslev powder**

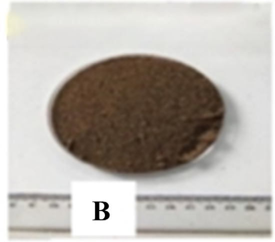


**Photo 8: Pepper powder**

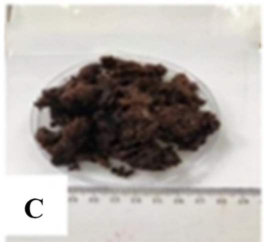


**Photo 9: Garlic powder**

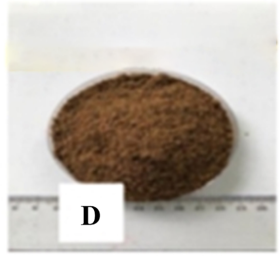


**Photo 10: Soumara powder**

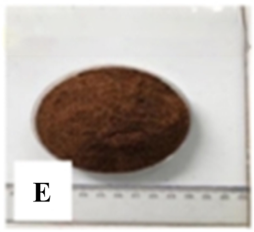


**Photo 11: Onion powder**

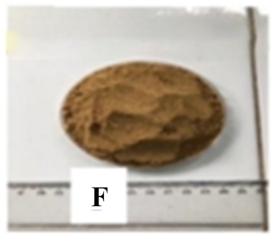


**Photo 12: Ginger powder**

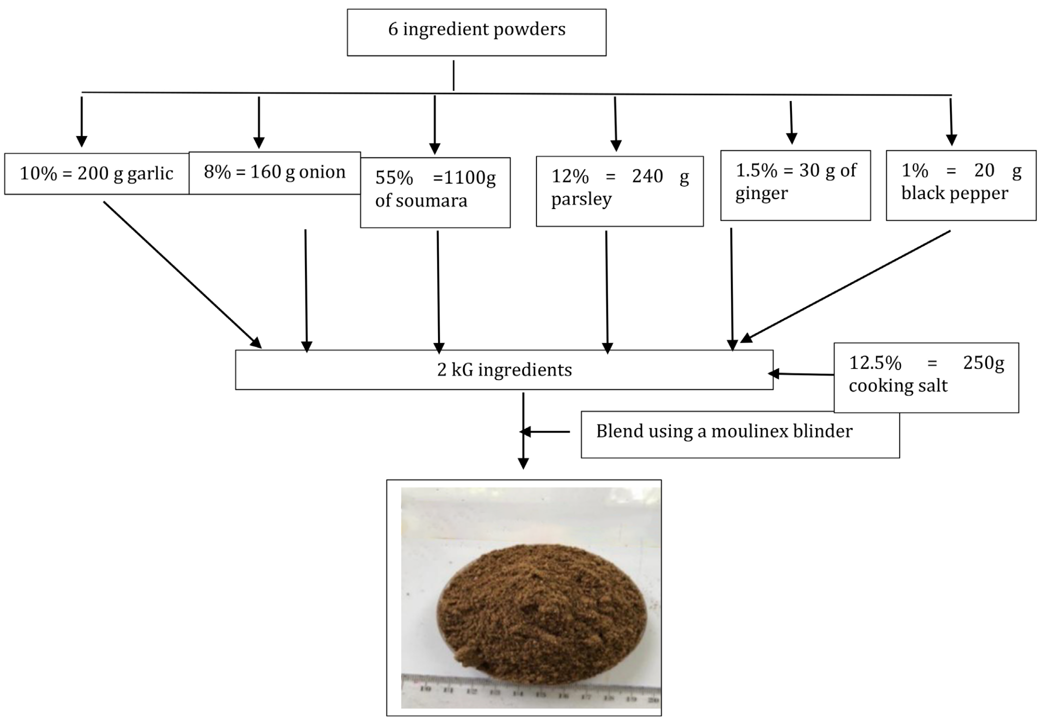


**Figure 1.** Diagram of soumara-based broth formulation.

In the laboratory, using a precision balance of 0.01 g, the ingredients were weighed and gradually placed in a sterilised plate. All the ingredients were then mixed using a moulinex bender. This formulation was carried out under aseptic conditions. This formula was evaluated after a microbiological analysis and a sensory analysis with 100 panalists who participated in the choice of this formulation for the different analyses (**Figure 1**).

## 2.3. Physico-Chemical Analysis

Moisture content was calculated according to the difference in substrate weight before and after oven drying at 105˚C for 24 hours. pH and titratable acidity were determined using the AOAC [16]. The protein and lipid contents of the samples were determined using the AOAC [16]. Protein content was determined by estimating nitrogen content using the Kjedahl method (AOAC method 920.152). This method consists of mineralising organic nitrogen into ammonium by mixing 0.2 g of "soumara" powder with 1 digestion tablet (composed of 3.5 g of potassium sulphate, 4 g of copper sulphate) and 10 mL of sulphuric acid. The total protein content was determined by acidimetry. Ash content was determined by incineration at 525˚C (AOAC method 940.26). In addition, the total lipid content using the Soxhlet as an extractor was determined according to AOAC [17]. Total lipids were determined using the Soxhlet method (AOAC method 963.15). Dietary fibre was determined using AOAC method [18].

Total carbohydrate content and energy value (EV) were determined according to the FAO [19] using the following formulae: Total carbohydrate (%) = 100 − [(% protein) + (% fat) + (% water) + (% ash)] EV (Kcal/100g) = (% protein × 4) + (% fat × 9) + (% carbohydrate × 4). Each test was carried out in triplicate.

Mineral content was determined by ICP-MS (inductively coupled plasma mass spectrometer) as described by [20]. 5 g of the sample was reduced to ash in a muffle furnace (Pyrolabo, France). The ash obtained was dissolved in 10 mL of $HCl/HNO_3$ and transferred to 100 mL flasks and the volume made up with demineralised water. The mineral composition of the sample was determined using an Agilent 7500 c argon plasma mass spectrometer. Calibrations were carried out using external standards prepared from a single 1000 ppm stock solution supplemented with 2% nitric acid.

## 2.4. Total Phenol Content

Total polyphenol content was determined spectrophotometrically using the Folin-Ciocalteu reagent [21]. Results were expressed as mg gallic acid equivalent (GAE)/g sample, averaged over three replicates. Total flavonoid content was determined using the method based on Blasa *et al.* [22], with a few modifications. One millilitre of our sample (10 g/L) was mixed with 0.3 ml $NaNO_2$ (5%) and 0.3 ml $AlCl_3$ (10%) was added after 5 minutes. The samples were vortexed for 2 minutes and after 6 minutes were neutralised with 2 mL NaOH solution (1 M).

Absorbance was read at 510 nm and quantification was performed using a calibration curve. The results were expressed in mg sample gram equivalents averaged over three replicates.

### 2.5. Anti-Nutritional Factors

With regard to anti-nutritional factors, the oxalate content was determined according to the method described [23] using potassium permanganate. Phytate content was determined according to the method described [24].

### 2.6. Antioxidant Properties

The antioxidant activity assay was carried out according to the method described [25] using 1,1-diphenyl-2-pycrilhydrazyl (DPPH). To do this, 1 mL of 0.3 mM DPPH solution prepared in ethanol was added to 2.5 mL of sample solution (1 g of dried sample powder mixed with 10 mL of methanol). This was filtered through Whatman No. 4 paper and left to react for 30 minutes at room temperature. Absorbance values were measured using a spectrophotometer (PG Instruments, UK) set at a wavelength of 517 nm. The mean absorbance values were converted to percentage antioxidant activity using the following formula:

$$(\%)\,\text{Entrapment activity} = \left[\left(A0 - A1\right)/A0\right)] \times (100)$$

The mechanism of this method is based on electron transfer. When the $Fe^{3+}$ ion is reduced in an acid medium (pH = 3.6) to $Fe^{2+}$ in the presence of 2,4,6-tripyridyl-s-triazine (TPTZ), the formation of a $Fe^{2+}$ TPTZ complex (blue colour) occurs, which absorbs in the 593 - 595 nm region. The acid pH prevents the formation of hydroxides and oxides, keeping the iron soluble. It also increases the redox potential, which favours the reaction. The reducing capacity is linked to the degree of hydroxylation and the degree of conjugation of the bonds present in the phenolic compounds in our samples [26]. For analyses with volumes of between 50 and 200 µL, a volume of FRAP reagent of 0.2 to 5.0 mL is generally applied to carry out the antioxidant activity test. Trolox or gallic acid is used in the calibration curve and the blank is standardised with demineralised water [27].

## 3. Statistical Analysis

All these analyses were performed in triplicate. Excel version 2016 was used to process standard deviation and mean.

## 4. Results

### 4.1. Physico-Chemical Characteristics

The results of the physico-chemical composition of the soumara-based formulated broth are given in **Table 1**. The soumara-based broth formula showed a high value of energy, protein, lipid and ash.

**Table 1.** Physico-chemical composition of the formulated broth.

| Parameters in g/100g DM | Concentrations |
|---|---|
| Humidity (%) | **5.85 ± 0.04** |
| pH | 6.6 ± 0.1 |
| Titratable acidity (Meq/100g) | 0.02 ± 0.02 |
| Carbohydrates | 9.99 ± 0.43 |
| Protein | **17.41 ± 0.37** |
| Fat | **16.80 ± 0.08** |
| Fiber | **8.66 ± 0.04** |
| Ash | **11.47 ± 2.62** |
| Energy value (Kcal) | 260.8 ± 10.3 |

### 4.2. Mineral Composition

The mineral composition of the soumara-based powder is shown in Table 2. In terms of macroelements, the results showed a high presence of calcium, followed by potassium and magnesium. Sodium was the only macronutrient in our analysis with the lowest content. Phosphorus had low values with the presence of zinc and iron.

### 4.3. Nutritional and Anti-Nutritional Composition of a Soumara-Based Broth

The results of the nutritional and anti-nutritional composition are given in Table 3, with a high value of Oxalate followed by Phytates and flavonoïds.

**Table 2.** Mineral composition of a soumara-based ingredient formulation.

| Parameters mg/100g | Concentrations |
|---|---|
| Calcium | **184.21 ± 0.09** |
| Sodium | 8.76 ± 0.03 |
| Potassium | **50.04 ± 1.45** |
| Phosphorus | 0.17 ± 0.00 |
| Magnesium | **33.29 ± 6.96** |
| Zinc | 2.44 ± 0.03 |
| Iron | 3.55 ± 0.04 |

**Table 3.** Nutritional and anti-nutritional composition.

| Parameters | Concentrations |
|---|---|
| Polyphénols totaux (mg EAG/g) | 1.37 ± 0.02 |
| Flavonoides (mg EQ/g) | 11.56 ± 0.61 |
| Phytates mg/100g MS | 11.77 ± 0.79 |
| Oxalates EAP/100g MS | **121.05 ± 0.1** |

### 4.4. Antioxidant Activity Composition of Soumbala-Based Broths

The powder of our sample showed a DPPH activity level of 43.62% ± 0.64% and a FRAP activity composition of 23.1 ± 0.03 µg EAA/g.

## 5. Discussion

Numerous epidemiological and clinical studies have shown that regular consumption of soumara-based products is associated with a reduced risk of developing certain metabolic diseases such as cancer and cardiovascular disease. The compounds involved in these effects are found in the protein and lipid fractions, the fiber and above all among the molecules derived from the plant's secondary metabolism, including vitamins, triterpenes and flavonoids, which may act alone or in interaction.

The spice powder obtained from 60% soumara and certain ingredients had a low moisture content of 5.85 ± 0.04. These results are similar to those of Kabré *et al.* [28], which were 3.09% ± 1.95% and 6.72% ± 0.17%, and higher than those reported by Camara *et al.* [29], which ranged from 15.35% ± 3.28% to 27.53% ± 2.33%. This difference could be linked to the drying techniques used. Moisture levels below 10% are very important for shelf life. The results gave a pH value of 6.6 ± 0.1. They are similar to those of Camara *et al.* [29], who found pH values in soumbala powder between 6.60 ± 0.13 and 7.45 ± 0.18 respectively in their studies. With regard to protein content, our spices showed an excellent value of 17.41% but lower than that of Camara *et al.* [29] in fermented seeds of *Parkia biglobosa* from Cote d'Ivoire with a value of between 28.47% and 28.84%. The difference in content would be due to the addition of other ingredients (onions, garlic, parsley, ginger, black pepper), which would have a low protein content. This protein content in our spice could help prevent protein-energy malnutrition in children [30] [31]. The crude fibre content of our spice is 8.66% ± 0.04%. This content is lower than that found by [32] 10.49% and higher than that of Ndamitso *et al.* [33] who obtained crude fibre contents of fermented *Parkia biglobosa* seeds of around 1.71%. This difference could be due to climatic and environmental factors and the processing technology used [34], as well as the low fibre content of certain ingredients used in the formulation of soumara-based spices [35]. Fiber promotes intestinal transit (good digestion) [36]. This content in crude fiber would give the food a low glycaemic index, which could make this powder an asset as part of an anti-diabetic diet [37]. The energy value of our soumara-based formulation with different ingredients is 260.8 ± 10.3 g/100 dry matter. Part of this energy comes from the protein and fat content. This energy value is lower than that reported by Ndamitso *et al.* [33], who reported an energy value of 471.75 kcal/100g dry matter. This difference is due to the low protein and fat content of the other ingredients used to make up our broth. The very high ash content (11.62 ± 2.62) resulting from the incineration of the spice with the various soumara-based ingredients enabled us to quantify a number of mineral substances (calcium, phosphorus, sodium, potassium, iron and zinc) essential to the body. The presence of macroelements and trace elements confirms that our spice formulation provides sufficient quantities of mineral salts to the populations that consume it. In addition, the very high calcium content of our spice comes from the seeds of soumara (*Parkia biglobosa*) and ginger (*Zingiber officinale*), an herbaceous perennial plant native to tropical regions of Asia [38]. In addition, it can benefit consumers by promoting bone growth, skeletal strength and tooth hardness in children and adolescents. Calcium also helps to maintain bone structure and prevent osteoporosis in adults. It also helps reduce the risk of colon cancer [39]. In addition, adequate calcium intake based on the recommended dietary allowance of 500 to 1200 mg/day may have a protective effect on arterial hypertension [40]. The presence of zinc and iron in our spice production (soumara-based broth) is important for the health of the population. In fact, these two important trace elements are undeniable micronutrients for health and nutrition and are increasingly appreciated, as their deficiencies can play an important role in the onset of certain diseases. In the case of zinc, this level in the diet of the population would reduce certain risk factors for immune deficiency and susceptibility to infections in the elderly [41]. The significant presence of iron in the spice is thought to come from ginger (*Zingiber officinale*). However, regular consumption of this spice in the diet of the population (children and adults) would reduce the risk of martial deficiency and associated anaemia, which can contribute to reduced energy efficiency, lower aerobic capacity, reduced endurance and the appearance of muscular and general fatigue. The potassium present in our spice powders could help regulate blood pressure and support the proper functioning of the nervous system and muscles [42] [43]. Magnesium is considered a natural anti-stress agent and is found in foods [44]. It is involved in neuromuscular transmission of impulses and regulation of heart rate [45]. Recent studies have shown the effects of benefits of an adequate magnesium intake (6 mg/kg·bw) in the prevention of cardiovascular disease [46]. In addition, such a broth would be recommended as a regular seasoning in people's meals. Several epidemiological studies have shown that a diet rich in bioactive molecules provides long-term protection against the development of cancer, cardiovascular disease, diabetes and osteoporosis [47]. The inclusion of phenolic compounds in our spice formulations would be beneficial for consumers because of their protective effects. Such food in the population dish would prevent the body from the harmful effects of free radicals that can accelerate cellular aging [48]. In addition, the presence of flavonoids in this powder would strengthen the body against the effects of antioxidant stress, which are powerful antioxidants [49] [50].

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## Conflicts of Interest

The authors declare no competing interests.

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