EFFECT OF CULINARY TREATMENTS ON THE PHYSICOCHEMICAL PROPERTIES OF SESAME OILCAKE FOR USE IN FIGHTING PROTEIN MALNUTRITION

ABSTRACT

To tackle protein malnutrition, the valorization of sesame cake has been initiated. A by-product of sesame oil extraction, it is commonly used as livestock feed. However, it could be used to enrich staple foods and improve their nutritional value, particularly in rural areas where access to quality protein sources is limited. In order to highlight its nutritional richness, certain soaking, roasting and hulling treatments were used to assess their impact on nutritional quality. Then extraction of the oil from the seeds using a mechanical press to obtain sesame cake was proceeded. Standard methods were used for physicochemical characterization of nutritional, mineral and anti-nutritional compounds. The results showed that the sesame oilcake obtained from the various treatments contained significant levels of total protein (26.55- 36.72g/100g DM), residual lipids (24.19- 32.37g/100g DM), carbohydrates (10.86-18.74g/100g DM), ash (4.32 - 6.19 g/100g DM) and fiber (10.71- 20.76 g/100g DM). Similarly, evaluation of the mineral composition of these meal concentrates showed their richness in phosphorus (20.47 - 176.66 mg/100g DM), calcium (15.75 - 467.42 mg/100g DM), magnesium (13.45 - 340.33 mg/100g DM), iron (4.90-14.70 mg/100g DM), and zinc (0.71-4.39 mg/100g DM). However, these sesame cake concentrates also contained anti-nutritional factors such as oxalates (0.48 - 1.04 mg/100g DM), phytates (0.08 - 0.12 mg/100g DM), saponins (0.084 - 1.10 mg/100g DM) and tannins (0.33 - 1.36 mg/100g DM). Fortunately, these were considerably reduced by pretreatment. Indeed, a 40.07, 83.33, 64.64 and 60.95% reduction in tannins, phytates, oxalates and saponins respectively were observed. The considerable reduction in anti-nutrients in the various cakes is an advantage for the digestibility and nutrient availability of this feed. Its high protein and mineral content could therefore be considered for use in protein malnutrition.

Key words: Sesame cake, protein malnutrition, soaking, roasting, shelling.

1. INTRODUCTION

The strong demand for renewable and sustainable protein sources, and the high cost of protein-rich foodstuffs of animal origin (meat, fish, eggs, etc.), are motivating the research for and valorization of alternative nutritious feeds such as plant proteins derived from food by-products [1]. In this context, sesame cake offers interesting potential, since this by-product of sesame oil extraction, commonly used for livestock feed, can be used to enrich staple foods and increase their nutritional value, particularly in rural areas where high-quality protein sources are limited. Lack of access to high-quality protein sources presents a risk of protein malnutrition [2]. Indeed, protein malnutrition is a major public health problem affecting many populations worldwide, particularly in sub-Saharan [3]. It is characterized by a lack of protein and certain minerals required for protein synthesis. It has major consequences on health, particularly in children, whose growth, immune system and cognitive development can be compromised. Protein malnutrition is responsible for 35% of child mortality in sub-Saharan every year [4]. However, although sesame meal is a promising source of protein in the human diet, the presence of certain compounds unfavorable to protein digestibility and the bioavailability of certain minerals, known as anti-nutritional factors, can limit the use of these nutrients. Several studies have shown that sesame seeds in traditional diets undergo treatments that are essential for their consumption. These technological treatments, which include soaking, roasting and hulling, help to reduce these anti-nutritional compounds and improve the nutritional quality of the seeds. These studies show that sesame seeds contain between 15 and 16% of protein, 50 and 60% of fat and 5% of minerals [5]. However, to our knowledge, no study has yet been carried out on the valorization of sesame cake and the impact of culinary technlogical treatments that could have on nutritional quality. Hence the initiation of the present study, which aims to characterize the physico-chemical and nutritional properties of soaked, roasted and shelled sesame cake, with a view to adding value and further enriching certain available foods. Based on the determination of macronutrient (Protein, lipids, total sugars, total fiber, water content) and mineral (Mg, Ca, Fe, Zn, P) contents; and anti-nutrient (Phytates, oxalates, tannins and saponins) contents of sesame cake.

2- MATERIALS AND METHODS

2.1. Sample collection and processing

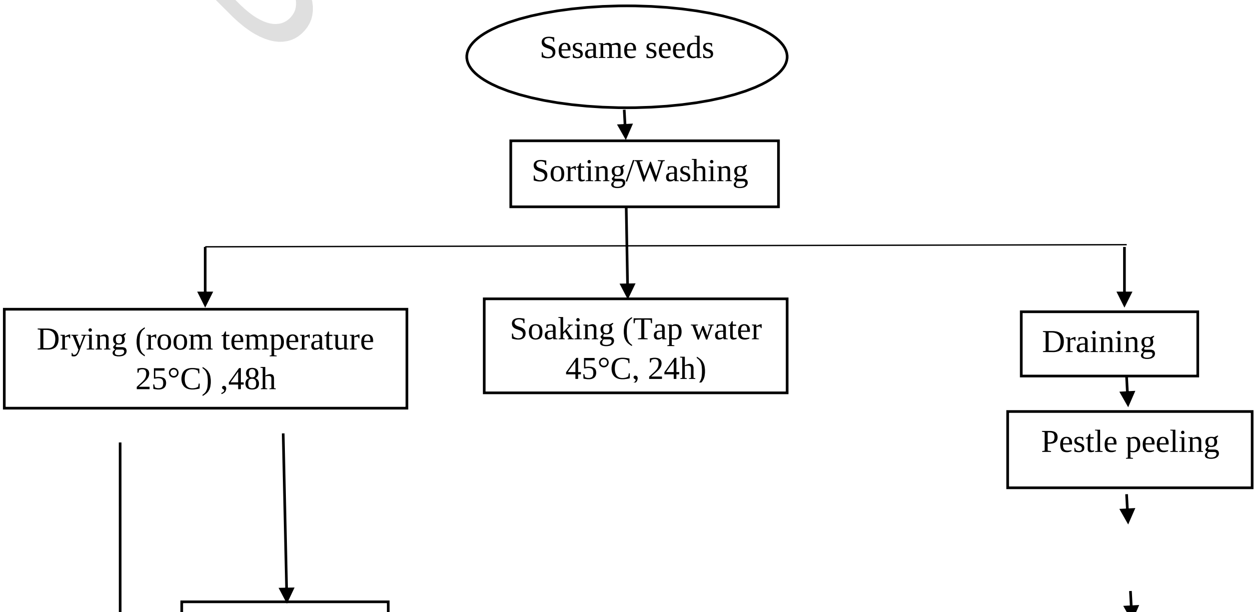
The material used in this work consisted of sesame seeds purchased at the Melen market in Yaoundé-Cameroon. These seeds were transported in a plastic bag to the laboratory, where they were carefully sorted to remove damaged seeds and post-harvest plant debris. The seeds were then washed and dried at room temperature (25°C) for 48 hours.

The seeds (1kg) were then soaked for 24 h to reduce the presence of anti-nutrients, then partially dried in an oven at 45°c for 24 h. Roasting was carried out over low heat for 3 minutes to facilitate oil extraction.

The seeds were washed to soften the husks, then quickly drained before being crushed with a pestle and mortar, then exposed to the sun at room temperature for 30 min to achieve partial drying. The still-moist seeds were then rubbed by hand against a sieve to loosen the husks. The seeds were washed a second time to remove the husks, then drained in a basket. Finally, the products obtained were dried at room temperature for 3 h, then winnowed to obtain shelled sesame seeds.

2.2 Extraction

Mechanical extraction is often the preferred method for extracting oils from oilseeds, as this method does not leave any chemical debris in the by-products obtained. In our case, mechanical extraction is carried out using a manual press **(PITEBA press)** , during which the sesame seeds are pressed once without heating, in order to extract the oil they contain and obtain the cake for analysis, according to the following steps:



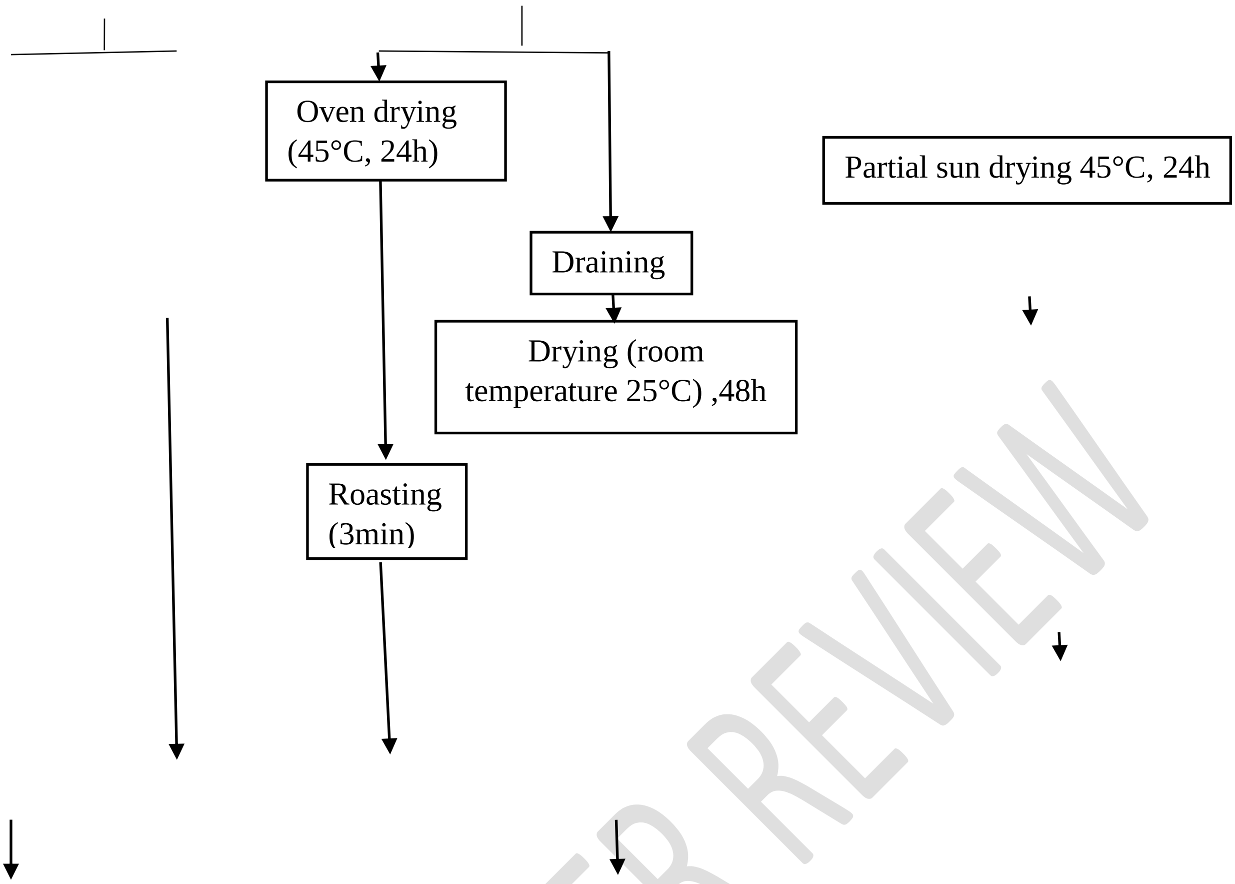


Figure 1: Sesame cake concentrate production diagram.

FSC*: Fresh sesame cake;* ***RSC****: Roasted sesame cake;* ***SRSC****: Soaked and roasted sesame cake;* ***ShSC****: Shelled sesame cake;* ***SSC****: Soaked sesame cake.*

2.2. Physicochemical characterization

Dry matter (DM) was determined by using AOAC [6] method ; Crude protein content was assessed by the Kjeldahl method (Devani *et al*., [7]; Total lipid content was determined by the method described by Bourely [8]; Total carbohydrate content was determined by subtracting percentage protein, ash, moisture, crude fiber, along with the fat from 100%. Crude fiber content was determined by the A.O.A.C. [6] (1980) method. Ash content was determined by the method of A.O.A.C. [9]. Minerals Ca, P, Mg, Fe, and Zn were determined according to the method described by Horwitz [10]. Total tannins were assessed by the protocol described by Ndhlala et *al*. [11]; The method of Olayeye et *al*. [12] was used for phytate determination. Oxalate content was determined by the method modified by Aina et *al*. [13]. Saponin content was determined by the method of Obadoni et *al*. [14].

2.3. Statistical analysis

Results were analyzed by IBM/SPSS 20.0 for Windows using the *ANOVA* test followed by a *post-hoc tukey* test to compare means. They were presented as mean ± standard deviation with a significance level of 5%. Microsoft Office Excel 2016 was used for graphical representations.

3. RESULTS AND DISCUSSION

3.1 Extraction yield

Extraction yield is the percentage of oil obtained relative to the weight of seeds used for extraction. Extraction yield is important as a measure of the efficiency of the extraction method used, and to determine the amount of oil that can be obtained from a given quantity of seeds. It is also useful for oil producers and processors to assess the profitability of their operations and adjust their production process accordingly [15].

Figure 2 below shows the oil extraction yield of the different treatments.

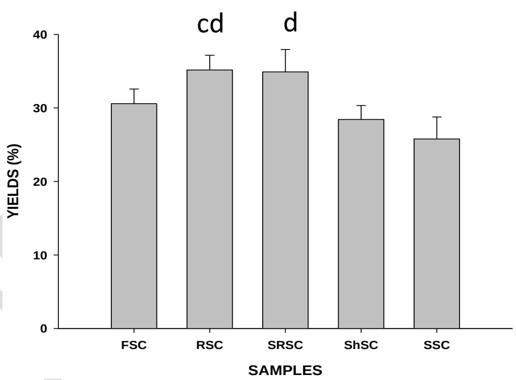


Figure 2: Extraction yield as a function of treatment applied

***FSC**: Fresh sesame cake; **RSC**: Roasted sesame cake; **SRSC**: Soaked and roasted sesame cake; **ShSC**: Shelled sesame cake; **SSC**: Soaked sesame cake.*

The results of the study clearly show that the treatment of sesame seeds prior to oil extraction has a significant impact on yields. Roasted sesame meal gave the best result with a yield of 35.16%, followed by soaked and roasted sesame meal with a yield of 34.90%. This could be due to the roasting treatment applied. Roasting improves oil extraction yields. During torrefaction, heat strongly disrupts cell membranes; dry heat improved seed mass transfer coefficients and facilitated oil release thanks to the increased porosity of the cell wall [16]. It has already been found that roasting sesame seeds under different conditions increased oil yields with increasing temperature and time. These results are consistent with current traditional practices, where seeds are often roasted before oil extraction to improve flavor and oil quality [17].

On the other hand, soaked seeds gave the lowest yields, at just 25.71%. This may be due to the absorption of water by the seeds during soaking, preventing the release of oil during the extraction process. Hulled seeds also gave relatively low yields with only 28.43%. This may be due to the loss of fat during the hulling process [15]. The results obtained in this work are close to those obtained by Claire Clément [18], applying mechanical extraction (37%), but very low compared to the solvent extraction (98%) obtained by Gagnon [15].

Overall, the results of this study show that roasting sesame seeds prior to oil extraction is the most effective way of increasing oil extraction yields. Soaking sesame seeds can also increase yield, but to a lesser extent. Hulling sesame seeds reduces oil extraction yield. Finally, the mechanical extraction method with the Piteba press remains less effective in extracting the full amount of oil.

3.2 Determination of macronutrient content

Table 1 shows the macronutrient content of the sesame oilcake obtained different treatments.

Table 1: Macronutrient content (g/100gMS) of sesame cake obtained.

Parameters	FSC	RSC	SRSC	ShSC	SSC
DM	94.96±0.16^{b}	96.64±1.17^{a}	96.45±0.60^{a}	94.92±3.97^{b}	93.52±3.53^{c}
Lipids	30.35±0.42^{a}	24.19±0.70^{a}	24.60±0.73^{a}	32.10±0.33^{a}	32.37±0.80^{b}
Proteines	36.72±0.47^{a}	28.60±0.01^{c}	28.35±0.76^{c}	26.55±0.26^{d}	33.92±0.07^{ab}
Total sugar	10.86±0.84^{b}	18.74±1.03^{a}	18.23±1.59^{a}	12.94±0.55^{b}	11.54±2.88^{b}
Fibres	10.81±0.04^{b}	20.76±0.04^{a}	19.00±0.08^{a}	18.32±0.07^{b}	10.71±0.27^{b}
Ash	6.19±0.18^{a}	4.32±0.04^{a}	6.24±0.04^{a}	4.96±0.04^{a}	4.95±0.09^{a}

***FSC**: Fresh sesame cake; **RSC**: Roasted sesame cake; **SRSC**: Soaked and roasted sesame cake; **ShSC**: Shelled sesame cake; **SSC**: Soaked sesame cake.* n = 3, mean values are shown, SD was always less than 20%). * Different letters within a line indicate significant differences according to Student's t-test (P < 0.05)

The dry matter (DM) of a sample corresponds to its mass after complete evaporation of free water. The results obtained on samples show that DM increased significantly (P<0.05) from 93.52±3.53 in the soaked sesame cake (SSC) to 96.45±0.60 in the soaked and roasted one

(SRSC). During seed soaking, considerable degradation of constituents, and synthesis of cell wall constituents, structural proteins, vitamins and secondary compounds takes place [5]. Thus, the increase in DM could be explained by high enzymatic activity that will promote the hydrolysis of macromolecules into simple, easily assimilable elements during this soaking process. In addition, roasting eliminates most of the free water contained in the seeds through evaporation. The increase in DM consequently leads to a reduction in the water content of the concentrates. Indeed, for the five (5) samples, the water content varied from 3.36±1.17 in the roasted sesame cake (RSC) to 6.48±3.53 in the soaked sesame cake (SSC). These results show that the concentrates obtained can be stored for a long time. In microbiological terms, these low water contents limit the development of microorganisms, with the exception of molds [19].

The residual lipid content of sesame oilcake varied between 24.19 and 32.37g/100gDM according to the different treatments. However, analysis of variance revealed no significant differences (P>0.05). The fat content of the seeds generally reaches 50-60% [20], whereas once subjected to cold-pressed oil extraction, the fat content of the meal decreases by up to 30% on average. This means that pressing systems can increase the nutritional value of the meal obtained, as they still leave a large proportion of oil in the meal. However, the presence of residual lipids in sesame oilcake is an important factor to consider, as it shows that sesame oilcake is an important energy asset in the fight against protein malnutrition. Indeed, lipids are essential macronutrients for the body, providing more energy and having a constitutional and precursor role [21].

Protein content varies from 26.55±0.01 to 36.72±0.47 g/100gDM, with an average value of 30.82g/100g DM. Analysis of variance shows a significant difference (5%) between the different values. Fresh sesame cake (36.72g/100gDM) and soaked sesame cake (33.92g/100gDM) had the highest protein content. Soaked and roasted sesame cake, shelled sesame cake and roasted sesame cake have lower protein contents (28.35 g/100gDM, 26.55 g/100gDM and 28.60 g/100gDM) respectively. The variations in protein content observed in the different treatments may be the result of several factors: firstly, the increase in protein content in soaked sesame cake may be linked to the activation of metabolic enzymes such as proteinases during soaking. Their hydrolytic action leads to the release of certain amino acids and peptides, the synthesis or utilization of these elements would lead to the formation of new proteins [22]. The reduction in protein content in shelled sesame cake shows that shelling could lead to a certain loss of protein, as this process involves the removal of the outer seed coat, which contains part of the protein; finally, the reduction in protein content observed in roasted sesame cake could be due to the denaturation of these proteins or their involvement in other biochemical reactions (Maillard reaction) during the roasting process [23]. Overall, whole sesame seeds contain between 15 and 16g/100g DM of protein [24]**,** while the samples sesame oilcakes studies contain an average of 35g/100gDM. This means that, when the oil is removed, the protein content is concentrated, leading to a higher percentage of protein in the meal**.** Furthermore, the protein content of the studies oilcakes is much higher than the guidelines laid down by the FAO/WHO [25] (11-21g/100g) for the development of complementary food formulas for infants and young children, so these sesame oilcakes can be effective help in combating protein malnutrition.

The total sugar content of our different samples varies from 10.86±0.84 in fresh sesame cake to 18.74±1.03 in roasted sesame cake, with an average of 14.44. The total sugar content of fresh, shelled and soaked sesame cakes showed no significant difference. On the other hand, there was a significant increase in the total sugar content of roasted sesame cake. This is because roasting can release carbohydrates that were previously bound to other sesame seed components. In addition, this roasting treatment can cause caramelization of the sugars present in the meal, which can increase the carbohydrate content [26]. A more recent study by Andrea et *al*, [27] found that roasting sesame seeds would increase carbohydrate content by 2%. The presence of relatively high total sugars in these cakes could be considered an important advantage in the treatment and prevention of protein malnutrition. Indeed, carbohydrates provide energy while sparing protein to avoid muscle loss.

Evaluation of fiber content shows that it varies from 10.71±0.27 in soaked sesame cake to 20.76±0.04 in roasted sesame cake. Analysis of variance reveals a significant difference at the 5% threshold. In general, there is an increase in fiber content in roasted sesame cake. Indeed, cooking causes an increase in fiber content, but this depends to a greater or lesser extent on the raw material involved. Heat treatment can increase the proportion of total fiber by promoting the formation of resistant starch and Maillard reaction products [28]. By essentially degrading pectins, cooking causes partial solubilization. These solubilized compounds may increase the soluble fiber fraction, or no longer be accounted for if their size is very small [29]. Dietary fibers resist digestion and absorption. As fermentable compounds, they are beneficial to health through their effects on the composition and activity of the microbiome. Consumption of dietary fiber confers a whole range of physiological benefits. Introducing various sources of dietary fiber to young children helps crystallize their future food choices and diversify their intestinal microbiota. Low fiber intake is linked to a higher prevalence of constipation and obesity**.**

Total ash represents all the minerals contained in a sample. In the present study, ash content ranged from 4.32±0.04 - 6.24±0.18 with a mean value of 5.33. Analysis of variance showed no significant difference at the 5% significance level. Similar results were reported by Kone et *al*, [5] in sprouted whole sesame seeds in Ivory Coast: 4.75 - 5.25 g/100gDM. However, the range of ash contents in the samples analyzed is wider than that reported by Nzikou [30] in whole sesame seeds in Congo Brazzaville, whose average value is 3.2 g/100gDM. The presence of ash in the various samples analyzed indicates that the samples would be important sources of minerals.

3.3 Assessment of mineral content

Table 2 shows the mineral content of the various samples.

Table 2: Mineral content of different samples (mg/100 g DM)

Paramètre	P	Zn	Fe	Ca	Mg
FSC	20.47±0.74^{d}	0.71±0.00^{c}	6.42±0.60^{c}	15.75±0.00^{c}	48.05±0.07^{d}
RSC	90.47±1.02^{b}	3.73±0,28^{a}	14.70±0.16^{a}	645.07±0.55^{b}	340.33±0.66^{a}
SRSC	43.58±0.74^{c}	0.89±0.00^{c}	8.99±0.60^{b}	32.59±0.27^{c}	13.45±0.07^{e}
ShSC	176.66±0.76^{a}	2.40±1.56^{b}	4.90±0.02^{c}	203.75±0.53^{a}	105.99±0.83^{c}
SSC	87.49±0.50^{b}	4.39±0.36^{a}	4.95±0.23^{c}	467.42±0.66^{c}	288.26±0.05^{b}

***FSC**: Fresh sesame cake; **RSC**: Roasted sesame cake; **SRSC**: Soaked and roasted sesame cake; **ShSC**: Shelled sesame cake; **SSC**: Soaked sesame cake.* n = 3, mean values are shown, SD was always less than 20%). * Different letters within a line indicate significant differences according to Student's t-test ($P < 0.05$)

Table 2 above shows the mineral content (Mg, P, Ca, Iron and Zn) of the different sesame seed meals studied. The table shows that the sesame seed cakes studied contain a significant quantity of minerals. The average concentration in mg/100 g dry matter of calcium (639.66) is highest, followed by magnesium (159.21), phosphorus (87.73), iron (7.99) and finally zinc (2.42). The mineral composition (Ca, P, Mg, Iron, Zn) of the various sesame cakes is relatively high, helping to offset the nutritional deficits observed in these various nutrients in children.

Among the macro-minerals analyzed, calcium was predominant, followed by magnesium and then phosphorus. This order of predominance of contents corroborates the studies of Elleuch et *al*. [31] and Sene et *al*. [24] on whole sesame seeds. Of all the cakes studied, RSC has the highest calcium content (645.07±0.55) and the lowest (15.75±0.00) is found on FSC. The calcium contents obtained in this study are lower than those reported by Sher et *al*, [32] and Zebib et *al*, [33] who found, respectively 1450 mg/100 g and 1172.08 mg/100 g in some Indian sesame varieties and Ethiopian cultivars. A lower calcium average (228.3 mg/100 g) was reported by Pellet & Shadarevian, [34] cited by Alyemeni et *al*. [20]. Similarly, Nzikou et *al.* [30] obtained average calcium values (415.38 mg/100 g) lower than those obtained in this study. With regard to magnesium, the values obtained (48.05 to 340.33 mg/100 g) are higher than those reported by Alyemeni et *al*. [20] on sesame seeds and lower than those (579.53 mg/100 g) of Nzikou et *al*. [30]. Finally, compared with the results of Alyemeni et *al*. [20], the levels (540 to 640 mg/100 g) obtained on Saudi Arabian cultivars, the oilcakes studied show a better phosphorus composition and corroborate the levels obtained by Nzikou et *al*. [30] (177.25 mg/100 g).

For the two mineral microelements analyzed, iron gave the highest average value (7.99 mg/100 g) followed by zinc with (2.42 mg/100 g). The iron and zinc levels obtained in this study are in line with the work reported by Deme et *al*, [35]. Similar levels were reported by Sene et *al*. [24] on a sesame variety highly prized in Senegal, with the same pattern of variation in levels, making calcium the dominant mineral element, followed by magnesium and phosphorus. This variability in mineral content could be attributed to the different treatments applied, to environmental factors (soil quality) and genetic factors (seed variety), as well as to the methods used for analysis.

The choice of these parameters is justified by their abundance and/or their essential biological role in the body. In total, mineral elements account for around 4% of body weight, and are involved in a wide range of functions: mineralization, control of water balance, enzymatic and hormonal systems, muscular, nervous and immune systems**.** However, taken individually, the minerals chosen for this study each play a role in the proper functioning of our bodies:

Calcium is involved in building and renewing the skeleton and teeth. It is also involved in protein synthesis. It acts as a cofactor for certain enzymes that catalyze protein synthesis reactions. For example, it is required for the activity of the enzyme RNA polymerase, which is responsible for the transcription of DNA into messenger RNA, the initial step in protein synthesis [36]. Like calcium, magnesium is an essential mineral for enzymatic activity. In fact, it plays a role in regulating carbohydrate and lipid metabolism in muscle, heart and nerve tissue, as well as the body's acid-base balance.

Phosphorus is necessary for bone growth, and is also involved in many biochemical reactions in the form of ATP, a form of energy storage and transport in cells. As for iron and zinc, they are respectively involved in the manufacture and function of hemoglobin; a protein in red blood cells that carries oxygen from the lungs to the cells, and in protection against free radicals and those involved in protein synthesis; hence zinc's important role in cell renewal, wound healing and immunity [36].

3.4 Determining anti-nutrient levels

Table 3 presents anti-nutrient levels of various samples

Table 3: Anti-nutrient content (mg/100gDM) of sesame oilcake

Parameters	FSC	SRSC	RSC	ShSC	SSC
Phytates	0.12 ± 0.01^{a}	0.09 ± 0.00^{b}	0.11 ± 0.07^{b}	0.08 ± 0.01^{b}	0.10 ± 0.01^{b}
Oxalates	1.04 ± 0.12^{a}	0.48 ± 0.01^{b}	0.70 ± 0.00^{b}	0.49 ± 0.01^{b}	0.64 ± 0.01^{b}
Tannins	1.36 ± 0.22^{a}	0.59 ± 0.19^{b}	0.34 ± 0.06^{b}	0.34 ± 0.08^{b}	0.33 ± 0.03^{b}
Saponines	1.10 ± 0.00^{a}	0.50 ± 0.06^{b}	0.58 ± 0.18^{b}	0.08 ± 0.03^{c}	0.33 ± 0.06^{b}

***FSC**: Fresh sesame cake; **RSC**: Roasted sesame cake; **SRSC**: Soaked and roasted sesame cake; **ShSC**: Shelled sesame cake; **SSC**: Soaked sesame cake.* n = 3, mean values are shown, SD was always less than 20%). * Different letters within a line indicate significant differences according to Student's t-test ($P < 0.05$)

Although the samples studied are rich in protein and micronutrients, they also contain anti-nutrients that could interfere with the utilization of certain nutrients [37]. These include phytates, oxalates, tannins and saponins. In effect, these anti-nutrients seem to be linked to the composition in foods, which in turn could be reduced by various processing methods [38]. The differences observed in the values determined in this study could be attributed to the method of analysis and treatments applied.

Phytates are anti-nutrients present in many plant foods, including sesame seeds. Phytate can bind to minerals such as iron, zinc and calcium, making them less bioavailable to the body.

Phytate levels were found to vary by 0.12; 0.09; 0.08; 0.11 and 0.10 respectively in fresh (FSC), soaked and roasted (SRSC), shelled (ShSC), roasted (RSC) and soaked (SSC) sesame cake samples, with an average of 0.10. The reduction in phytates in the soaked and shelled samples can be explained on the one hand by their elimination during soaking by water solubility [38], by the activation of the natural endogenous phytase in oilseeds and legumes which degraded phytates and thus facilitated their diffusion in the soaking water [39], and on the other hand this reduction in the shelled meal may be due to decortication. In fact, phytate is mainly found in the outer layer of the seeds, which is removed during decortication. The values obtained in this study are lower than those reported by Okudu et *al*, [40] on white sesame seeds shelled in Nigeria (0.83-0.85 g/100gDM) and Mahgoub et *al*, [41] (1.4g - 1.8g/100g) who studied the phytate content of different sesame varieties. They also observed that hulling sesame seeds reduced phytate content by around 40%. This is well below the toxicity limit of 2000-2600 mg/day for a vegetarian diet and 150-1400 mg/day for a mixed diet [42].

Oxalates are anti-nutrients that can bind to calcium and proteins, causing problems with the absorption of these compounds [43]. Analysis of table 3 shows that oxalate levels are 1.04, 0.48, 0.49, 0.70 and 0.64 respectively in samples of fresh (FSC), soaked and roasted (SRSC), shelled (ShSC), roasted (RSC) and soaked (SSC) sesame cake, with an average of 0.67. Oxalate content is relatively high in fresh sesame cake. Soaking and hulling significantly ($P<0.05$) reduced oxalate levels. This is in line with studies by Kaur et *al*, [44] whose results showed that hulling and soaking sesame seeds reduced oxalate content by 47.5% to 13.75 mg/100g in soaked seeds and to 7.22 mg/100g in hulled seeds. It's important to note that these results can vary according to many factors, such as the variety of sesame seed and the methods used. However, total oxalate levels in the samples were well below the toxicity limit of 2-5g/day.

Concerning tannin, table 3 results show that tannin concentrations are 1.36, 0.59, 0.34, 0.34 and 0.33 respectively in fresh (FSC), soaked and roasted (SRSC), shelled (ShSC), roasted (RSC) and soaked (SSC) sesame cakes, with an average of 0.59. This decrease in tannin concentration observed in soaked, hulled and roasted sesame cake can be explained by the fact that hulling and soaking removed some of the phenolic components of sesame seeds, including tannins, which are soluble in water and can be extracted during soaking [38]. In addition, roasting can also contribute to the reduction of tannins due to the thermal degradation of these compounds. In general, tannins are anti-nutritional compounds that can bind to proteins and nutrients, reducing their bioavailability and digestibility. Treating sesame seeds can therefore improve their nutritional profile and the quality of foods produced from them. The results obtained are similar to those observed by Adhikari et *al*, [45]. (0.90 g/100g in soaked seeds and 0.19 g/100g in hulled seeds**)**. The tannin values obtained are well below the toxicity limit of 560m/day [46]. Consequently, soaking combined with roasting and hulling could be recommended to reduce the tannin content in the meal concentrate.

According to saponin results, table 3 shows that saponin content are ranged from 0.084±0.03 in shelled sesame cake (ShSC) to 1.10±0.00 in fresh sesame cake (FSC). Statistical analysis of the data shows a significant difference between the different treatments ($P<0.05$). The values are lower than the results (2.45 - 2.49 g/100g) obtained by Jimoh et *al*., [47] on soaked and shelled whole sesame seeds; but corroborate those obtained by Kone et *al*., [5] who observed a significant reduction in sesame sheaths after soaking and germination (1.17% in raw seeds). This reduction in saponin concentration is thought to be due to hydrolysis in the soaking medium. Similarly, the hulling process may remove part of the outer layer of the seeds, which may contain saponins, leading to a reduction in saponin content [43]. Moreover, saponins are thermolabile compounds, therefore they could be destroyed by heat treatments [48]. Variations in saponins in different oilcakes can be attributed to environmental factors, the sesame seed varieties used. However, saponin levels in the samples studied are well below safe values (60-600mg/Day) [49].

CONCLUSION

The aim of the present study was to carry out a nutritional and anti-nutritional characterization of soaked, roasted and shelled sesame cakes: The analyses carried out on these sesame cakes show that, depending on the various technological culinary treatments, sesame cakes are an important source of protein (36.72 g/100gDM), calcium (2037.50mg/100gDM), magnesium (340.33mg/100gDM), iron (14.70 mg/100gDM) and zinc (4.39mg/100gDM), which are beneficial in the fight against protein malnutrition. The various soaking, roasting and hulling treatments significantly reduced the levels of acceptable anti-nutrients (≤1mg/100gDM). Hulling and soaking remain the best treatments for reducing anti-nutrient levels in sesame oilcake. Because of their high nutritional value, sesame oilcakes could be potential sources of essential nutrients. They can also be used as a food supplement or additive in the formulation of complementary diets such as infant flour for malnourished children. However, the protein digestibility and bioavailability of such nutrients as iron and zinc, as well as the various amino acids, need to be studied to establish their suitability or otherwise as food supplements.

REFERENCES

1.Kumar M., Jayashree P., Sharmila P. Extraction of ultra-low gossypol protein from cottonseed: characterization based on antioxidant activity, structural morphology and functional group analysis. *Elsevier*. 2021;140(11): 178-197

2. Birama S., Fallou S., Diégane D., Mamadou S., Djibrine T., Amadou K., & Marène N.. Synthèse de connaissance et quelques aquis de recherche sur le sésame (*Sesamun Indicum L.*) au Sénégal. *International Journal Biological et Chemical Sciences,* (2018, Juin);*12*(3): 1469-1483. doi:10.4314/ijbes.v12i3.32

3. FAO. Soaring Food Prices: Facts,perspectives, impacts and actions required. Background paper prepared for the Highlevel conference on World Food Security: The Challenges of Climate Change and Bioenergy. Rome. (2020).

4. OMS. Conférence Internationale sur la Nutrition : Les grands enjeux des stratégies nutritionnelles. (2021).

5. Kone F., Kouame I., & Faulet M. Qualité nutritionnelle des graines germées de sésame(*Sesamum indicum L.*) cultivées en Cote D'Ivoire. *Agronomie africaine,* (2021); *33*(2): 203-215

6. A.O.A.C. Official methods analysis of the association of official analytical chemists (éd. 11th). (W. Horwitth, Éd.) Washington D.C. 1980.

7. Devani M., Shisho S. & Suhagia B.. Spectrophotometric method for the micro determination of nitrogen in kjedahl digest. *Journal of the A.O.C.* 1989;(72): 953-956.

8. Bourely J.. Observation sur le dosage de l'huile de cotonnier. *Coton et Fibre Fropical,* 1982; *27*(2): 183-196.

9. A.O.A.C. Oficial Methods of Analysis. Association of Official Analytical Chemist (éd. 16th). Washinton D.C. 1990.

10. Horwitz W. Official method of analysis of AOAC (éd. 17th). Maryland, USA: AOAC. (2000)

11. Ndhlala A., Kasiyamhuru A., Mupure C., Chitindingu K., Benhura M. & Muchuweti M. Phenolic composition of Flacourtia indica, Opuntia megacantha and Sclerocaya birrea. *Foot chemistry,* 2007;*103*(1): 82-87.

12. Olayeye L., Owolabi F., Adesina A. & Isiaka A. Chemical compossition of red and white cocoyam (*Colocasia esculenta*) leaves. *Inernational Journal of Science and research,* 2013; *11*(2):120-122.

13. AinaV. O., Sambo B., Zakari A., Haruna H. M., Umar K. R., Akinboboye & Adama, M. Determination of nutritional and anti-nutrient content of Vitis vinifera (Grapes) grown in Bomo (Area C) Zaria Nigeria. *Advance Journal of Food Science and Technology,* 2012;*4*(6): 445-448.

14. Obadoni B. & Ochuko P.. Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. *Global Journal of Pure and Applied sciences*, 2001;*8*(2):203-208.

15. Gagnon Yancie.. Étude de l’extraction des huiles végétales en milieu aqueux assistée par des tensioactifs. Mémoire de thèse de l'Université Alliance Sorbonne, 2021

16. Yoshida H., Shigezaki J., Takagi S., & Kajimto G. Variations in the composition of various acyl lipids, tocopherols and lignans in sesame seed oils roasted in a microwave oven. *Journal of Sciencces Food and Agriculture,* 1995;.*68*:407–415. doi:10.1002/jsfa.2740680403

17. Lee Y. C., Oh S. W., Chang J. & Kum I. H. Chemical composition and oxidative stability of safflower oil prepared from safflower seed roasted with different temperatures. *Food Chemistry,* 2004; *84(3)*: 1–6. doi:10.1016/S0308-8146(03)00158-4

18. Claire Clement. Sésame : de la graine à l'huile (avec la presse Piteba).Récupéré sur http://1ruche3pintades.over-blog.com/2020/06/sesame-de-la-graine-al-huile-avec-la-presse-piteba.html. 2020.
19 Rizki H., Kzaiber F., Nablousi A., & Hanine H. Chemical composition and morphological markers of 35 cultivars of sesam(*Sesamum indicum L*.) from differnt areas in Morocco. *IJTEER,* 2015;*3*(1):50-55.
20 Aleymeni MN., Basahy AY., & Sher H. Physico-chimical analysis and mieneral composition of some sesame seed (Sesamum indicum L.) grown in the Gizan area of Saudi Arabi. *Journal Med Plants*, 2011;*5*(2): 270-274.
21. Murray R., Granner D., Mayes P. & Rodwell V. *Biochimie de Harper* (éd. 5e). (T. d. Domenjoud, Éd.), 2013.
22. Bau H. M., Villaume J. P., Nicolas & Me-Jean. Effect of germination on chemical composition, biochemical factors of soya bean (Glycine max) seeds. *Journal Science Food Agricuture*, 1997;5(2):1-9.
23. Devi C. B., Kushwaha A., & Kumar A. Sprouting characteristics and associated changes in nutritional composition of cowpea (Vigna unguiculata). *Journal Food Science Technology*, 2015;*52*(10): 6821-6827.
24. Sene B., Sarr F., Diouf D., Kane A. & Traore D. Étude de la composition minérale et des teneurs en protéines et en matières grasses de huit variétés de sésame (*Sesamum indicum L*.) introduites au Sénégal pour un criblage variétal. *EDP Sciences*, 2018;*25*(6):601.
25. FAO & WHO. Protein and amino acid requirements in human nutrition. Report of a Joint WHO/ FAO / UNU Expert. Technical Report Series 935. Cholé – Doc N°111. 2007.
26. Shakerardekani A., Karim R. & Ghazali H. Effet du trempage et de la torréfaction des graines de sésame sur la qualité du tahini (pâte de sésame) et du halva. *Journal of Food Science and Technology,* 2012;*49*(4): 490-496.
27. Andrea Komesu et Luiza Helena da Silva Martins. fruit and vegetable waste valorization in North and Northeast regions of Brazil. *Sciences Directe*, 2023;2(6):45-56
28. Bonnand-Ducasse M., Della Vella G., Lefebvre J., & Saulnier L. Effect of wheat dietary fibres on bread dough development and rheological properties. *Journal of Cereal Science*, 2010;5(2);200-206. doi:https://doi.org/10.1016/j.jcs.2010.05.006
29. Sila DN, Van Buggenhout S, Duvetter T, *et al*. Pectins in processed fruits and vegetables: part II – structure–function relationships. *Compr Rev Food Sci Food Saf*. 2009;8(2):86–104
30. Nzikou . Characterization of seeds and oil of sesame (*Sesamum indicum L.)* and the kinetics of degradation of the oil during heating. *Research Journal of Applied Sciences Engineering and Technology,* 2010;*2(3)*: 227–232.
31. Elleuch M., Besbes S., Roiseux O. & Blecke C. Quality characteristic of sesame seeds and by-products. *Food chemistry*, 2007;*103*:641–650.
32. Sher H., Al-Yemeni M. & Bahkali A. Effect of environmental factors on the yield of selected mushroom species growing in two different agro ecological zones. *Saudia Journal of Biology Sciences*, 2010;*17(3)*: 321–326. doi:10.1016/j.sjbs.2010.06.004
33. Zebib H., Bultosa G., & Abera S. Physico-chemical properties of sesame (Sesamum indicum L.) varieties grown in Northern Area,Ethiopia. *Agriculture Sciences,* 2015;*6(4)*: 238–246. doi:10.4236/as.2015.62024
34. Pellet P., & Shadarevian S.. Food composition, tables for use in composition,*in the Middle East, 2nd ed. Beirut* (éd. 2e). Beirut: American University of Beirut. 1970.
35. Deme T., Haki G., Retta N., Woldegiorgis A. & Geleta, M. Mineral and ant-nutritionnal contents of Niger Seed (*Guizotia abyssinica L.f.*) Cass, Linseed (*Linumusita tissimum L.*) and Sesame (*Sesamum indicum L*.) Varieties grown in Ethiopia. *Foods,* 2017;*6*(27):59-62. doi:10.3390/foods6040027

36. Alan J., Barrett N. D., Rawling J. & Fred W. Proteolytic Enzymes. *Life sciences*, 2012;*79*(20):1921-19228
37. Hassan. Studies on Egyptian sesame seeds (*Sesamum indicum L*.) and its products 1 – physicochemical analysis and phenolicacids of roasted Egyptian sesame seeds (*Sesamum indicum L*.). *World Journal Dairy Food Science*, 2012;*7*(2):195–201.
38. Latika Yadav and Vibha Bhatnagar, Effect of soaking and roasting on nutritional and anti-nutritional components of chickpea (PRATAP-14), *The Bioscan* 2017; 12(2): 771-774,
39. Raj K G, Shivraj S G, Nand K S, Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains, *Journal of Food Science Technology* (February 2015) 52(2):676–684 DOI 10.1007/s13197-013-0978-y
40. Okudu H., Oguizu A. & Nwaokoro C. Nutrients and anti-nutrients contents of white beniseed cultivar (*Sesamum indicum L*.) in Nigeria. *Direct Research Journal of Agriculture and Food Sciences*, 2016;*4*(10): 290-293.
41. Mahgoub S., El Amin H., Salih M. & El Owni O. Chemical composition,Antinutritional Factors and Functional Properties of Sesam(*Semamun indicum L*.) Seed Flour. *Journal od Food Science and Technoloy*, 2014;9(5): 3464-3469.
42. Grases F., March R., Prieto B. & Simonet A. Urinary phytate in calcium oxalate stone formers and healthy people dictary effets on phytate excretion. *Scandinavian Journal of Urology and Nephrology*, 1999; *34*:162-164.
43. Sefa-Dedeh S., Kofi E. & Agyir-Sackey. Chemical composition and the effect of processing on oxalate content of cocoyam Xanthosoma sagittifolium and Colocasia. *Science Direct*, 2004;*85*(4): 479-487. doi:10.16/S0308-8146(02)00244-3
44. Kaur S., Nanda A., Singh B. & Singh N. Effect of dehulling and roasting on oxalatate content of sesame seed. *International Journal of Food Science and Nutrition*, 2017;*2*(6): 65-68.
45. Adhikari S., Basak S., & Bhattacharyya, D. Effect of processing on nutrient, anti-nutrient, and bioactive components of sesame (*Sesamum indicum L*.). Critical Reviews in *Food Science and Nutrition*, 2019;*59*(13):2115-2127.
46. Ikpeme C., Eneji C., & Igile, G. Nutritional and organoleptic properties of wheat (*Triticum aestivum*) and Beniseed (*Sesamum indicum*) composite flour baked foods. 2007.
47. Jimoh W.A., Fagbenro O.A, Adeparusi E.O. Effect of processing on some minerals, anti-nutrients and nutritional composition of sesame (*Sesamum indicum*) seed meals. EJEAFChe, 2011;10(1) :1858-1864.
48. Hamid, NS Thakur and Pradeep Kumar, Anti-nutritional factors, their adverse effects and need for adequate processing to reduce them in food, *agricinternational*, 2017;4(1):56-60. doi: 10.5958/2454-8634.2017.00013.4
49. Shi, Y., Lan, F., Matson, C., Mulligan, P., Whetstine, J.R., Cole, P.A., Casero, R.A., and Shi, Y. Histone demethylation mediated by the nuclear amine oxidase homolog LSD1. *Cell* (2004) ; 119 : 941–953.