Asian Journal of Biotechnology and Bioresource Technology

Volume 10, Issue 2, Page 60-71, 2024; Article no.AJB2T.116555
ISSN: 2457-0125

Effect of Culinary Treatments on Nutritional and Anti- nutritional Profils of Sesame Oilcake for Use in Fighting Protein Malnutrition

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajb2t/2024/v10i2205

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/116555

Original Research Article

Received: 24/02/2024
Accepted: 28/04/2024
Published: 19/05/2024

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

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Cite as: *Fadimatou, B., Trésor, L., Falang, D. C., & Paul, M. F. (2024). Effect of Culinary Treatments on Nutritional and Anti-nutritional Profils of Sesame Oilcake for Use in Fighting Protein Malnutrition. Asian Journal of Biotechnology and Bioresource Technology, 10(2), 60–71. https://doi.org/10.9734/ajb2t/2024/v10i2205*

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.

Keywords: 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:

2.3 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] method. Ash content was determined by the method of A.O.A.C. [9]. Minerals Ca, P, Mg, Fe, and Zn

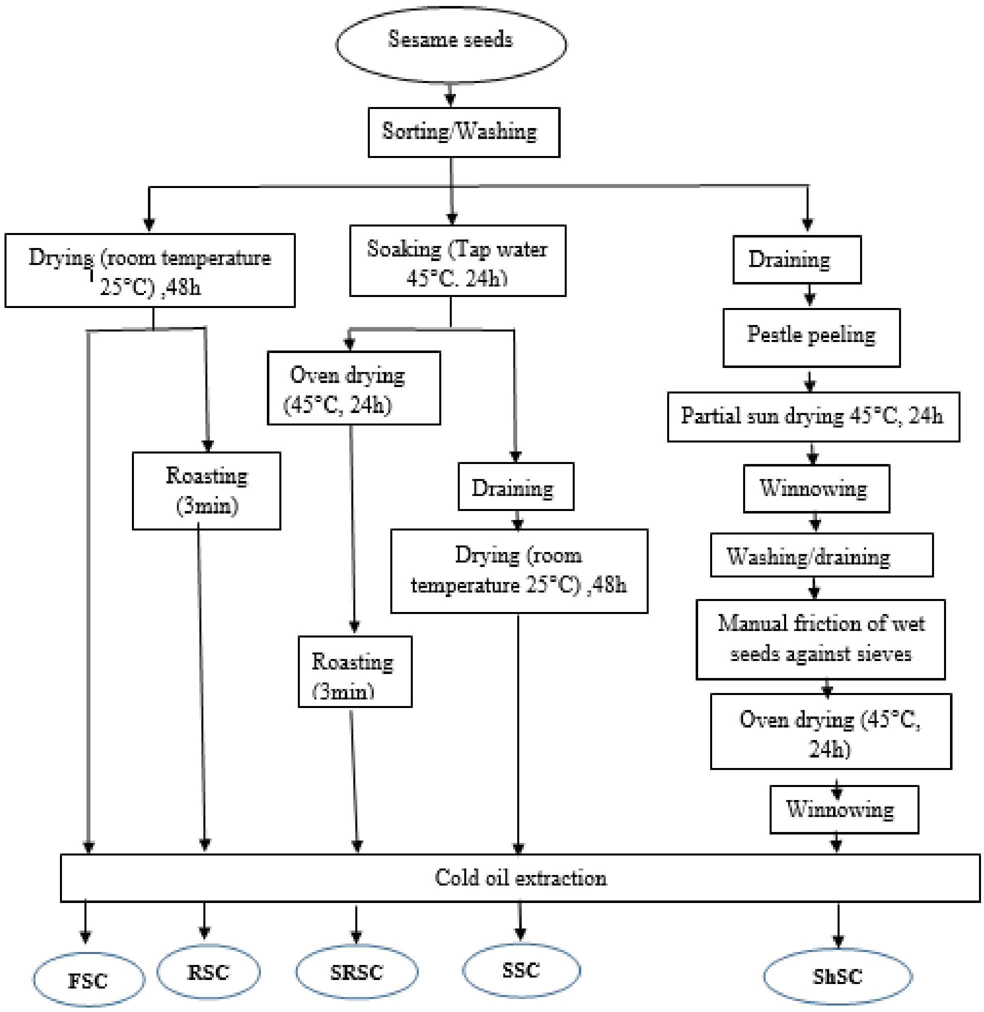

Fig. 1. Sesame cake concentrate production diagram

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

2.4 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].

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

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].

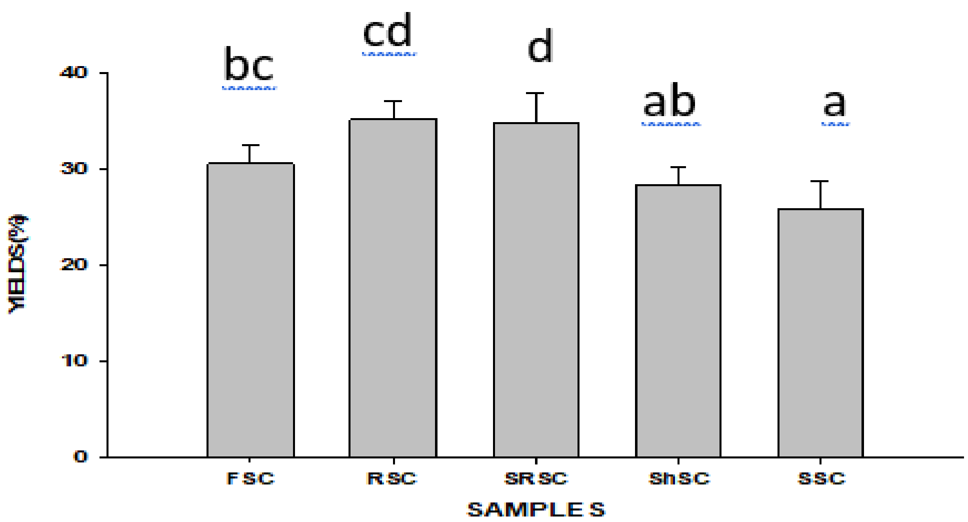

Fig. 2. Extraction yield as a function of treatment applied

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

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 ($P < 0.05$)

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.

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 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.

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 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)*

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

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 560 mg/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].

4. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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