Original Research Article

Biochemical characterization of sesame (*Sesamum indicum* L.) grown in Chad

ABSTRACT

Sesame (*Sesamum indicum* L.) is grown for its seeds, which are used in human food as well as in the pharmaceutical and cosmetic industries. In Chad, sesame is considered a promising sector. It is one of many plant resources that can be exploited for food and economic purposes. The general objective of this study is to evaluate the biochemical quality of sesame. The biochemical characteristics of seeds of local varieties with black seeds and S-42 with white seeds from Kournari (Sahelian zone) and Kélo (in the Sudanian zone) were evaluated from laboratory analyses. The results were analyzed using the Excel spreadsheet XLAT and R software version 4.4.0.The results showed that the seeds of sesame varieties have average protein contents ranging from 22.195 and 26.397%. The lipid contentsobtained varied from 48.679 to 52.769%. The carbohydrate content of sesame seeds varying between from 19.686 to 12.528%. The energy value of sesame varieties is greater than 400 Kcal. It is between 490.981 Kcal/100g (Kélo SN) to 508.126 Kcal/100g (Kélo S 42). This study showed that sesame seeds (local black seed variety and S 42 varieties) produced in Chad are an excellent source of nutrients and highly energetic. Soluble dietary fibers varied between 4.15 ± 0.22 and 3.37 ± 0.22 g/100g. Correlation analysis showed that energy value appears to be moderately influenced by ash (0.651) and crude fiber (0.654) content. Considering their biochemical composition, this oilseed could be exploited in nutrition and food formulation.

Keywords: sesame, local variety, S 42 variety, nutritional quality, food safety, Chad.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is a promising oilseed plant with underutilized potential in industry and food in Africa [1], is positioned as a solution to malnutrition to contribute to food and nutritional security and the fight against poverty in rural populations in sub-Saharan Africa. Its seeds are not only essential for the production of oil and paste, but also in the formulation of foods [2,3]. It is said to be one of the oldest cultivated plants in the world and therefore one of the oldest oilseeds known and used by man [4]. Sesame is sometimes referred to as the “queen of oilseeds” [5,6]. According to Kanu sesame seeds contain many minerals and vitamins [7]. Ground sesame seeds could be used as a dietary supplement against child malnutrition [8].

Currently in Chad, sesame cultivation is in vogue and is one of the priorities of farmers. The sector is considered promising. It is increasingly cultivated, also due to the problems encountered with the main cash crops such as cotton and peanuts. This trend is reinforced by the existence of a lucrative, albeit informal, sector. There are multiple varieties of sesame, of different colors: red, black or white. The yields, the duration of the growing cycle, resistance to insects, fungi, diseases and climatic conditions, etc. are different for each variety [9]. However, its production has remained on a traditional scale due to the lack of suitable technologies, thus degrading its nutrients and exposing it to contamination by pathogenic germs. Research has not yet managed to initiate a real strategy for maximizing the production of this species. Even though sesame seed has nutritional importance in some parts of the world, little scientific information is currently available on its nutritional potential and uses in local foods. Indeed, sesame is produced and consumed by local populations in traditional forms. It is with this in mind that the present study was initiated, in order to determine the biochemical characteristics of the two main sesame varieties grown in Chad: the local variety (mostly used) and the S42 variety (preferred for its high yields, resistance and whiteness).

2. MATERIAL AND METHODS

2.1 Study framework

This is an analytical study that allowed the evaluation of the biochemical parameters of sesame (*Sesamum indicum* L.). The sesame seeds come from the town of Kournari in the Sahelian zone and from the town of Kélo in the Sudanian zone. The physicochemical analyses of the samples were carried out at the Food Sciences and Metabolism laboratory of the Faculty of Sciences of the University of Yaoundé I (Cameroon). They focused on the water, ash, protein, lipid, carbohydrate and fiber content for each of the varieties according to various proposed methods.

2.2Biological material

Biological material used in this study consisted of two (2) varieties of sesame (*Sesamum indicum* L.): the local variety with black seeds from Guéra , a province in central Chad (figure 1 a) and the S42 variety with white seeds (figure 1 b) produced by the Chadian Institute of Agronomic Research for Development (ITRAD). They were selected for their interesting agronomic characteristics (oil content, disease resistance) and their good yields.

a b

Fig. 1.Sesame seeds of local variety (a) and variety S 42 (b)

2.3Sample preparation

The sesame seeds were carefully sorted manually to remove post-harvest plant debris and other foreign bodies, then sorted and stored in bags and finally sent to the Laboratory.

200 g of seeds were washed and dried at room temperature (25°C) for 48 h, then ground to obtain fresh sesame flour. This was stored in a hermetically sealed jar for possible analyses. The number of repetitions was 3 for all biochemical parameters studied.

2.4Determination of parameters

The **moisture content** of the samples was determined by differential weighing according to the AOAC method (2007). The method is based on the loss in mass of the samples after drying at 105 ± 2 °C to constant mass following complete removal of free and weakly bound water and volatile matter [10].

Ash content was determined by differential weighing at room temperature of a 5g sample after calcination in a muffle furnace at 550 °C for 8h by gravimetry. The weight of the residue was expressed as ash content.

The crude **protein content** was calculated from the nitrogen contents obtained after mineralization of the samples by the Kjeldahl method. Kjeldahl mineralization consists of destroying all the organic substance contained in the foodstuff by concentrated sulfuric acid in the presence of the mineralization catalyst Dumazert (Merck). The conventional conversion coefficient (6.25) of nitrogen into protein is used to convert nitrogen into protein.

Total lipids are extracted by Soxhlet according to the method described by Bourely[11]. The extraction is based on the differential solubility of lipids in organic solvents such as hexane or petroleum ether. The weight difference allows the lipid content to be assessed.

Carbohydrate content was estimated by the FAO (2002) method. It was calculated by subtracting from 100 the sum of moisture, fat, protein and ash contained in the sample.

$$\%\ \text{Carbohydrates} = 100\% - (\%\ \text{Moisture} + \%\ \text{Protein} + \%\ \text{Fat} + \%\ \text{Ash})$$

The **energy value** per 100 g of the sample was also determined by the FAO method (2002): 1 g of carbohydrate or protein provides 4 kilocalories while 1 gram of lipids provides 9 kilocalories.

$$\text{Energy (Kcal/100g)} = 4^{*}\ \text{Carbohydrates (\%)} + 9^{*}\ \text{Lipids (\%)} + 4^{*}\ \text{Proteins (\%)}$$

The **crude fiber content** was determined according to the Weende method Wolf (1968). For this, 1 g of sesame seed flour is boiled in 50 ml of sulphuric acid (0.25 N) and then in 50 ml of sodium hydroxide (0.31 N) for 30 min. The residue obtained is dried at 105°C for 8 h and then incinerated at 550°C for 3 h.

2.5Statistical analysis of data

The data collected were entered and analyzed using the Excel XLAT spreadsheet. This software made it possible to produce the following descriptive statistics: frequencies, means as well as tables and graphs.
To analyze the effect of sesame variety (local and S 42) and cultivation site (Kélo and Kournari) on the different variables, we used the beta regression model (betareg) and the analyses were carried out using R software version 4.4.0.

3. RESULTS AND DISCUSSION

3.1Biochemical composition of sesame seeds by site and variety

Table 1 gives the average biochemical composition of the varieties of sesame studied by site. Analysis of the results shows that the moisture content of the samples of the different sesame varieties varied from 4.46 to 5.33% of fresh matter. The local variety with black seed (SN) from the Kournari site expressed the highest content (5.33% of fresh matter). The others have approximately the same water content.

Sesame varieties have ash contents between 4.11% (SN from Kournari) and 5.14% (S 42 from Kélo). The S 42 varieties from Kournari and SN from Kélo have almost the same ash content.
Lipid content obtained varied between 48.679 and 52.769 %. The highest value is observed with the S 42 variety of Kournari and the lowest content is also observed in the same site with the local black-seed variety.
The total carbohydrate content of the varieties varied between 12.528 and 19.686 % of M S. The seeds of the sesame varieties studied are, overall, made up of less than 20% carbohydrates.
Sesame seeds have average protein contents ranging from 22.195 to 26.397% (Table 2). The SN variety of Kournari recorded the lowest content (22.195 %), while the SN variety of Kélo expressed the highest value (26.397 %).
The energy value of sesame varieties is greater than 400 Kcal. It is between 490.981 Kcal (SN of Kélo) and 508.126 Kcal (S 42 of Kélo).
The crude fiber content of the seeds ranges from 3.37 ± 0.22 to 4.15 ± 0.22 g/100g of dry matter.

Table 1. Average nutritional composition of sesame varieties by site

SITE	**KOURNARI**		**KELO**	
Setting	**SN**	**S 42**	**SN**	**S 42**
Humidity (%)	5.33	4.47	4.46	4.46
Ash (%)	4.11	4,473	4.47	5.14
Lipids (%)	48,679	52,769	50,937	51,478
Protein (%)	22,195	25,503	26,397	22,973
Carbohydrates (%)	19,686	12,528	13,735	15,948
Energy value (Kcal)	498,658	503,529	490,981	508,126
Crude Fiber (g/100g MS)	3.37 ± 0.22	3.64 ± 0.24	3.50 ± 0.02	4.15 ± 0.22

3.2Correlation analysis

The correlation analysis is presented in Table 2. Interpretation of the above correlation table reveals complex relationships between the different nutritional variables. Lipids show a strong negative correlation with moisture (-0.825) and carbohydrates (-0.902), indicating that their content increases when the content of these two components decreases. Proteins show a very strong correlation with water content (0.989), suggesting that they may play a role in water retention. Carbohydrates are strongly positively correlated with moisture (0.862), but negatively correlated with lipids (-0.902) and protein (-0.865). Energy value appears to be moderately influenced by ash (0.651) and crude fiber (0.654) content.

Table 2. Correlation analysis

	Humidity	Ash	Lipids	Proteins	Carbohydrates	Energy value	Raw Fibers	Water Content
Humidity	1	-0.77	-0.82	-0.681	0.862	-0.123	-0.56	-0.713
Ash	-0.772	1	0.70	0.077	-0.478	0.651	0.91	0.128
Lipids	-0.825	0.70	1	0.564	-0.902	0.443	0.44	0.626

Proteins	-0.681	0.07	0.56	1	-0.865	-0.49	-0.18	0.989
Carbohydrates	0.862	-0.47	-0.90	-0.865	1	-0.013	-0.18	-0.896
Energy value	-0.123	0.651	0.443	-0.49	-0.013	1	0.654	-0.41
Raw Fibers	-0.566	0.91	0.44	-0.181	-0.185	0.654	1	-0.148
Water Content	-0.713	0.128	0.626	0.989	-0.896	-0.41	-0.14	1

3.3Analysis of variance

Analysis of p-values for the different models in Table 3 below reveals significant effects of the factors Variety, Site, and their interaction on the biochemical composition of sesame seeds. Moisture, ash, and energy value of seeds are significantly influenced by all the factors studied (p = 2.2e-16), suggesting a strong dependence on both genetic and environmental factors. Lipid content, a major component of sesame, is strongly affected by variety (p = 5.03E-12) and variety:site interaction (p = 1.98E-06), but not by site alone, indicating a predominant genetic control modulated by growing conditions. The protein profile shows a strong dependence on site (p = 1.52E-09) and variety:site interaction (p = 2.2e-16), highlighting the importance of environmental conditions on this nutritional component. Carbohydrates and crude fiber are significantly influenced by all factors, with a particularly marked effect of variety.

Table 3. Analysis of variance of sesame biochemical parameters

Variables	Model	Probability	P-values		
			Variety	**Site**	**Variety: Site**
Humidity			2.2e-16	2.2e-16	2.2e-16
Ash			2e-16	2e-16	0.8035
Lipid			5.03E-12	0.1015	1.98E-06
Proteins	Beta	Pr(>Chisq)	0.6167	1.52E-09	2.2e-16
Carbohydrates			2.67E-12	0.04771	2.2e-16
Raw Fibers			2.2e-16	6.18E-08	0.0004603
Water content			0.001511	2.2e-16	2.2e-16
Energy value	Anova	Pr(>F)	2.2e-16	2.2e-16	2.2e-16

Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Figure 2 presents the analysis of interactions between sesame varieties (White and Black) and growing sites (Kelo and Kournari). For White Sesame (WS), a higher lipid and water content is observed in Kournari than in Kelo, while the protein, carbohydrate and crude fiber content is higher in Kelo. Black Sesame (BS) has a higher moisture and carbohydrate content in Kournari, but higher ash, lipid, protein, crude fiber and water contents in Kelo. The energy value of BS is higher in Kelo, while for SN it is slightly higher in Kournari. These variations highlight the influence of the growing site on the nutritional characteristics of each sesame variety, emphasizing the importance of considering both the variety and the growing location to optimize production according to the desired qualities.

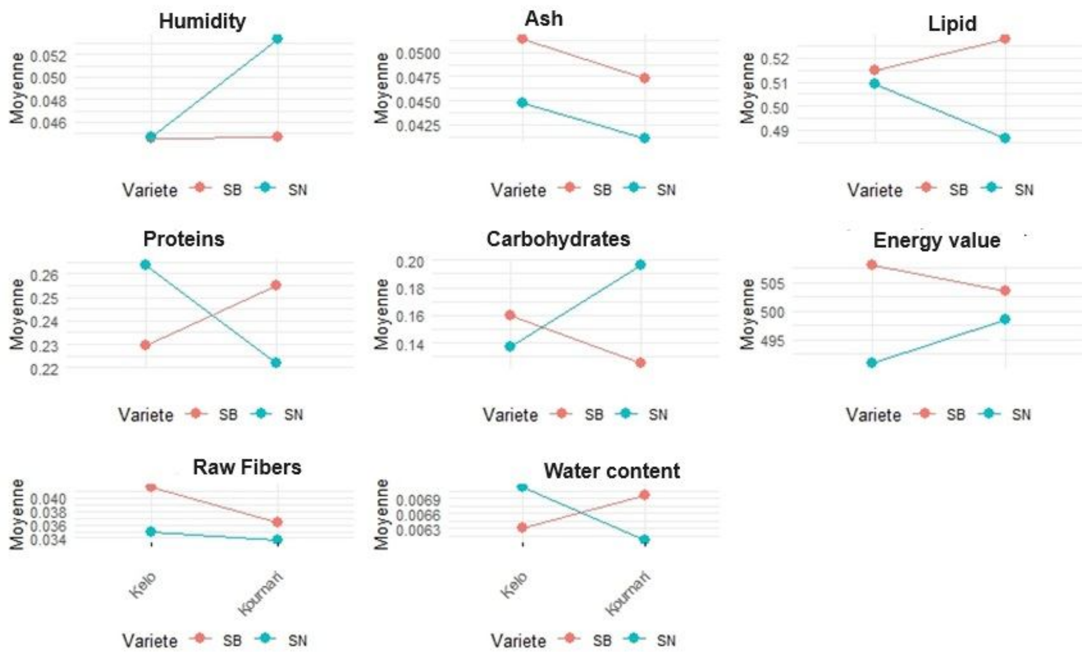

Fig.2.Interaction of variables (variety and site) in relation to sesame biochemical characteristics

3.4Discussion

Sesame seeds have average protein contents ranging from 22.195 to 26.397%. The local variety produced in Kélo has more protein (26.397%) compared to that of Kournari (22.195%) while in the S 42 variety, the opposite is observed. Indeed, the S 42 variety produced in Kournari has a higher protein content (25.503%) compared to that produced in Kélo (22.973%). This variation in protein contents between varieties and within the site is generally attributed to the method of *analysis* or environmental and sometimes genetic factors. However, the range of protein contents in our variety samples is almost similar to that reported by [12-15]whose values are respectively (16.20% to 26.29%), (12% to 23.0%), (19.81% to 24.45%) and (19.81% to 24.45%). [16]found an average value of 24.63% which is within the range of our values. Compared to the range of 32 to 40% contents found by [17], our sesame varieties (local and S 42) have lower protein contents but give higher contents than those measured by[18-20]. The range of protein contents obtained in this study is also higher than the mean values of 21.78% and 20.00% reported respectively by[21-22]. The mean protein values obtained in this study are higher than those of sesame cultivars analyzed in other *countries* such as Morocco 22%, Congo 20%, Nigeria 19%, Turkey 21% and Egypt 18.93% [20].

On the other hand, the protein content of sesame is above that of cereals consumed in Chad, which gave in the Sahelian zone a range of 8.96 to 9.75% for millet, 11.67% for sorghum and 8 to 8.6% for corn, and in the Sudanian zone a range of 8.2 to 11.9% for millet, 11.67% for sorghum and 7.96% for corn [23]. The relatively high protein content compared to cereals gives sesame a nutritional advantage and makes it an important source of protein that can be used to enrich other foods. According to [24], sesame seeds contain more protein (17 to 40%) than meat (18 to 25%) and cereals (7 to 13%). This particularity leads us to recommend it in the protein enrichment program *in* infant flours. It is obvious that protein

is one *of the nutrients that are often low in plant products. The high protein quantity helps to solve* protein -energy malnutrition.
Sesame seed is rich in oil with a content ranging from 37 to 63% [25-29]. Except for the local variety from Kournari, all our studied varieties and in the different sites have fat contents higher than 50%. In addition, there is a significant difference between the varieties regarding the fat content: they vary from 48.69% to 52.769%. The best content is observed with the S 42 variety in both sites (52.769% and 51.478%) while the local variety displayed the lowest fat content in both sites (50.937 and 48.679%). This variability in lipid content can only be attributed *to* agro-climatic, environmental and/or varietal factors, the date of seed harvest or also the laboratory analysis method. *Sesame* oil content and composition vary genetically and depending on environmental factors [27,30].

The results of the present study are consistent with the results of[31-34]. Similar results have been reported by several other authors.

Similar results (49.7%) were reported by extraction from sesame seeds by [35]and [6]reported a rate of 49.7%, [36,37]reported a respective composition of 43.2% to 54.0% and 47.8 to 52.2% *oil* in Turkish varieties. Our results are also on average in agreement with the mean contents (50%) found by [3] but also corroborate the findings of the oil content (51%) conclusions *of* sesame varieties studied by [38]. Other *studies* conducted on Egyptian varieties by [39] gave similar results: 50.88%; 52.67%; 51.18% for fat.

However, the results of this study differ from those of [40-41] on Nigerian varieties which gave an average of 46.09 ± 0.04% fat content.

Gopalan 's results *et al* . (2011) and Bukya and Vijayakumar (2013) [42,43]who found 43.30% and 44.53% fat contents in Indian sesame varieties, respectively, and the results of [40-41] who found an average of 46.09 ± 0.04% fat contents in Nigerian varieties, our varieties all yield contents beyond their results. However, [19, 44]reported significantly higher oil content averages of 56% in Egyptian cultivars and 63.25% in Turkish cultivars, respectively.

Since temperature influences oil content [34, 45]reported that *early* water stress leads to a reduction in oil content and when it *is* late, it induces an increase in oil content. However, according to [46, 47], moderate postflow stress always resulted in an increase in oil content. Furthermore, compared with the oil contents *of* peanut *from* the 48.36% and 46.72% zone [48], the S 42 variety of Kournari which is the richest in fat (52.769) of all the sesame varieties studied, gives a higher fat content. Therefore, it can be recommended in a program for oil production *by* processing its seeds. Its valorization and popularization could directly impact the level of income of the populations who are in the sesame sector.

Sesame seeds contain a carbohydrate content varying between 19.686 and 12.528%. The local variety produced in Kournari in the Sahelian zone had a high carbohydrate content (19.686%) compared to the same variety produced in Kélo in the Sudanian zone (13.735%). This content, conversely, is high in the S 42 variety from Kélo (15.948%) compared to that of Kournari (12.528%). Moreover, the S 42 variety from Kournari had the lowest content. For [49], the carbohydrate content is strongly affected by the color of the seeds in sesame. Whole and hulled white seeds contain 17.70 and 12.90% carbohydrates, respectively, while whole and hulled black seeds contain 10.80 and 7.90% carbohydrates, respectively [49].

Soluble dietary fibers ranged from 4.15 ± 0.22 to 3.37 ± 0.22 g/100g DM. Variety S 42 had the highest content at both sites. The contents from this study are lower than those from

[50]who found soluble dietary fiber contents varying between 5.5 and 8.6% of dry matter of the tegument.

4. CONCLUSION

This study showed that sesame seeds (local variety with black seeds and S 42 varieties) produced in Chad are an excellent source of nutrients. In view of their biochemical compositions, these oilseeds could be used in nutrition and for food formulation. These foods could contribute to reducing the case of protein -energy malnutrition. The results from this study constitute a scientific and technical database that can be used in the context of the valorization of these foodstuffs and the improvement of food and nutritional security. In addition, these results can be used to establish a food composition table in Chad.

From a research perspective, it would be interesting in the continuation of the research to study the characteristics of other varieties cultivated in Chad in order to identify those which would best respond to the different bioclimatic zones of Chad.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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