Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.65, 2017

Physico-Chemical Composition of the Sesame Variety (Sesamum indicum L.) 32-15 and Characterization of its Derived Products (Seeds, Oil and Oilcake) in Senegal

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Abstract
The variety 32-15 is a variety of sesame (*Sesamum indicum* L.) introduced in Senegal. Its integration into the Senegalese culture system has been accompanied by a process of agro-morphological research. The purpose of this study is to understand the qualities of the sesame variety 32-15 by operating its biochemical characterization for better use. The study of the physico-chemical composition was carried out on the seeds, oil and sesame cakes of the variety 32-15. The results showed that the seed contained 95.15% dry matter, 20.75% crude protein, 5.39% ash, 3.04% crude fiber, 51.92% fat, and 14.05% carbohydrate. Seeds have proven to be good sources of minerals. Calcium showed the highest rate (689.92 ± 15.97 mg/100 g) followed by phosphorus (575.99 ± 16.75 mg/100 g), magnesium (315.84 ± 8.66 mg/100 g), zinc (38.56 ± 1.86 mg/100 g) and iron (122.50 ± 4.21 mg/100 g). The quality factors of oil extracts showed stable oil and liquid state at room temperature. The analysis of the oilcakes showed a protein content ranging from 33.93 ± 0.27 to 39.87 ± 0.95% with a slightly high fat composition revealing the low yields of the used presses.
Keywords: sesame, variety 32-15, derived products, physico-chemical composition, Senegal

1. Introduction

Sesame (*Sesamum indicum* L.) is an important and ancient crop of oilseeds belonging to the Pedaliaceae family **(Bedigian, 2003)**. It is grown in the tropical and temperate areas of the world **(Biabani e t Pakniyat, 2008)**. It has been cultivated for centuries, especially in Asia and Africa, for its high content of edible oil and protein. Almost 70% of the world's production comes from Asia. Africa cultivates 26% of the world's sesame products and Sierra Leone, Sudan, Nigeria, Uganda and Burkina Faso are the main producers. In Senegal, the culture of sesame is relatively old. But she had been abandoned after independence. It was not until 1985 that the sesame was re-introduced into the Senegalese culture system by the African Agricultural and Cultural Youth Association/Committee to fight for the end of Hunger **(Aajac/Colufifa)** on average **Casamance (Kolda region,** (**Department of Sédhiou**) from The Gambia **(CRS, 1999)**. Black and white cultivars are mainly grown in an extensive and informal manner. In recent years, sesame has received considerable attention all over the world. It is taken as an excellent source of high quality oil and protein (**Kahyaglu et Kaya, 2006**). Its oil occupies the second place after olive oil with regard to the nutritional value **(Alpaslan et al., 2001)**. Its seeds are used for oil extraction and food preparations **(Eida et al., 2007).**

Sesame seeds have the highest oil content than rapeseed, groundnut, soybean and other oilseed crops **(Anilakumar, 2010).** Its oil and protein contents are estimated to be (50-60%) and (18-25%) respectively. To this can be added carbohydrates, fibers and ash **(Alpaslan et al., 2001).** This composition is supplemented by methionine (3.2%) which is often the limiting amino acid in legume-based tropical diets; tryptophan and the wide range of minerals such as phosphorus, calcium, iron, magnesium etc. as well as vitamins B1 and Vitamin E **(Ojiako et al., 2010)**. The oil seed is renowned for its stability because it has strongly resisted oxidative rancidity even after long exposure to air **(Global AgriSystems, 2010).** Sesame proteins are found to be useful for human health **(Eida et al., 2011)**. The consumption of whole sesame seeds helps to increase plasma γ-tocopherol and increases the activity of vitamin E, which has a power to prevent cancer and heart disease **(Cooney et al., 2001).** Sesame also has positive effects on sex hormone, antioxidant status and blood lipids in menopausal women **(Wu et al., 2006).**

In recent years there has been a real resurgence of interest by Senegalese farmers in the cultivation of sesame. At the same time, efforts are being made in the direction of Sesame research. Recommended to the rural populations by the Senegalese Institute for Agricultural Research (ISRA), the sesame variety (*Sesamum indicum* L.) 32-15 adapts well to the local conditions of Senegal **(Boureyma, 2010).** It is a widely cultivated variety with yields of 416 kg ha-1 in 2010 **(DAPs, 2011)**. According to **Boureyma** (**2005**), the variety 32-15 offers yields of 686 kg ha-1 in the field and 1590 kg ha-1 at the station with a white color of the seeds. It was chosen because of the clear color of the seed coat (highly appreciated in the international market), the caliber of the seeds and its good adaptability to the Senegal agro-ecological zones. The variety of sesame 32-15 is derived from the crossing of varieties of San Mario and Satara Branco, introduced in Burkina Faso. It is part of the ISRA's enhanced varieties collection. The variety of Sesame 32-15, selected for this study is high yield, early maturing and has drought resistance **(Boureyma, 2005)**. There is little scientific information on the biochemical characterization, the mineral composition of the improved sesame seeds in Senegal.

This knowledge is necessary to enable the breeder to develop improved cultivars by selecting from existing varieties in specific geographic regions **(Adebowale, 2011)**. In addition, in order to provide useful scientific information that will improve the adoption of improved varieties of sesame for various end-use uses, such as nutrition, knowledge of the nutrient and mineral composition of sesame seeds is important. In Senegal, no comprehensive study was reported on the chemical composition of sesame and its derivatives. The objective of this study is to characterize the variety of sesame 32-15 by operating in the analysis of the biochemical and mineral composition of seeds, to the analysis of the chemical properties of its oil and to the study of the performance of artisan presses by the correlative study of the protein and fat contents of its oilcakes.

2. Materials and methods

2.1 Plant material

The plant material consisted of seeds, oil and sesame cake. The sesame Variety studied belongs to the CERAAS (Regional Study Center for the Improvement of Drought Adaptation) collection. This is the variety "32-15" which is derived from a cross of two varieties: San Mario (Argentina) x Sataa Branco (Brazil). The sesame variety 32-15 originates in Burkina Faso, a country in which it was introduced at the same time as the variety 38-1-7. The seeds had been cleaned, sorted and stored at room temperature in the sample storage room. The cakes were finely ground with a hammer crusher before being put in plastic bags and stored in the refrigerator until they were used. As for the oil, it did not undergo another treatment.

2.2 Analytical procedures

The analyses concerned the seeds of the sesame variety 32-15, the oil obtained of Diossong and Sokone and the oilcake obtained after pressure in the processing units of Faoune and Dissong. All the determinations were made in triplicate. The values of the different parameters are expressed on average more or less the standard deviation.

2.3 Methods of physicochemical analysis of seeds of sesame variety 32-15

The water content of the samples has been determined using the standardized method **(AOAC, 2007)**. It consists of drying a sample of seeds at 130-133 ° C in a GENEQ-inc brand incubator for 90 minutes. The ash is assimilated to the residue obtained after incineration at 550 ° C for 5 h in an oven of the Heraeus brand (NF 03-720). The ash rate is expressed as a mass percentage on the dry matter. The protein content of dried seeds was determined by the Kjeldahl method (n x 6.25) **(AOAC, 2007).** The crude Cellulose (fiber) content was determined by the segmental hot digestion of the defatted sample with dilute and alkaline sulfuric acid solutions. The total carbohydrate content was determined by difference by subtracting the sum of the percentage of moisture, protein, ash, cellulose, and lipids, continuing from 100%. The mineral elements (ca, Na, MG, p, and FE) were determined from the ash obtained by the incineration of whole seeds. The residue was dissolved in HCl and the mineral constituents (Ca, Mg, Fe, and Zn) were analyzed separately using an atomic absorption spectrophotometer (**Hitachi Z6100, Tokyo, Japan**). The phosphorus (P) content has been determined by the Phosphomolybdate method (**AOAC, 2007**)

2.3.1 Characterization of products derived from sesame seeds of the variety 32-15

2.3.1.1 Determination of oil quality factors extracted from variety 32-15

The indices of acid, saponification, peroxide and iodine have been defined in accordance with the AFNOR NF ISO 660, NF ISO 3657, NF ISO 3960 and NF ISO 3961, AFNOR, 2007 standards respectively. The color of the extracted oil was determined by the naked eye and compared with the peanut oil. The volatile substances at 105 ° C were determined by the ISO method 662 (2007) and the impurities by the ISO method 663 (2007)

2.3.1.2 Characterization of the variety of oilcakes 32-15

The objective of the characterization of the oilcakes is to evaluate the performance of the artisan presses used in three different places for the transformation of sesame by determining the remaining oil content after pressing but also, to show that sesame oilcake is a protein concentrate that can be valued in the process of manufacturing the products enriched by the determination of the protein content of the extraction residues called oilcake.

2.4 Data analysis

The different determinations were repeated 3 times and the result is expressed as follows: Mean ± SD. They were compared to a few reported values from previous studies.

3. Results and discussion

3.1 Physico-chemical composition of the sesame variety 32-15

Table 1 shows the physico-chemical composition of whole sesame seeds (*Sesamum indicum* L.) of the 32-15 variety. The study shows that the seeds of the 32-15 variety are made up of 20.75% protein, 51.92% fat, 14.05% carbohydrate and 3.04% fiber with an impurities rate of 0.92%. The total ash content (5.39%) shows that they are also rich in minerals.

Table 1: Physico-chemical composition of sesame seeds 32-15

Characteristics	Values obtained a (M ± Standard deviation)	Reported values
Dry matter %	95.15 ± 0.05	94.3 ± 0.24 [b],
Lipids % MS	51.92 ± 2,66	50.88 ± 0.24[e] ; 51.18 ± 0.22b[e]
Proteins % MS	20.75±0.16	20 ± 0.12[b] ; (12.7 to 23.0) [i]
Total carbohydrates[d] % MS	14,05	13.4[b]
Total ashes % MS	5.39±0.22	3.7 ± 0,92[b]
Fiber % MS	3.04± 0.32	3.2 ± 0.22 [b]
Impurities % MS	0.92±0.69	ND[f]

a M ± S.D. Mean ± standard deviation; **b** Nziikou and al. (2009); **c** Crude protein = N (%) × 6.25; **d** Total carbohydrate was estimated by difference in mean values); **e** Zebib and al., (2015); **f** ND Not determined; **i** Adebowale and al., (2011).

Compared to the results of the study by **Bahkali et al., (1998)**, the water content of the 32-15 seeds confirms the range of 3.65-5.60%, found in some countries. Our results on the 32-15 proteins are in compliance with those of **Nziikou et al., (2009)**, namely 20% and those of **Adebowale et al., (2011),** which reported a range of 12 to 23.0%. **Ozkan et al**., (2012) found a range of protein content from 19.81 to 24.45% on Turkish varieties of different locations in Turkey. On the other hand, higher results were found in Sudan by **El Khier et al., (2008).** As for the fat content, it is above the values (45.05 to 50.70%) of **El Khier et al., (2008)** in Sudan and the results (46.09± 0.04) of **Makinde et al., (2013)** in Nigeria as well as those (50%) of **Kanu et al. (2007). Zebib et al.,** (2015) reported similar results (50.88; 52.67; 51.18%) on Egyptian varieties. Compared to the results of **Zebib et al. (2015)**, the carbohydrate content of the 32-15 variety is greater than that found on the ADI, Bawnji and T-85 varieties. Ash and fiber contents are similar to those reported on Niger varieties by **Olagunju et al., (2013).**

3.2. Mineral composition of the sesame variety 32-15

Table 2 shows the mineral composition of the 32-15 seed. These results show a total ash content of the order 5.39% which can be broken down into phosphorus (575.99/100 g); magnesium (315.84 mg/100 g); zinc (38.56 mg/100 g); calcium (689.92mg/100 g) and iron (11.29). Calcium is the most important mineral component.

Table 2: Mineral composition of the seeds of the variety 32-15

Mineral elements	Mineral composition in (mg / 100g) (M ± Standard deviation)	Reported values [b]
Phosphorus, P	575.99±16.75	442.94a ±0.58[b] ; 466.03±1.34[c];
Magnesium, Mg	315.84±8.66	399.65a ±1.00[b] ; 412.33±0.58[c];
Zinc, Zn	38.56±1.86	7.97a ±0.13[b] ; 8.78±0.01[c];
Calcium, Ca	689.92±15.97	464.97 ±0.68[b]; 473.59±0.80[c];
Iron, Fe	11.29±0.94	6.42 ±0.02[b] ; 6.21 ±0.01e[c];

a M ± S.D. Mean ± standard deviation; **b** Makinde et al., (2014); **c** Makinde et Akinoso., (2013)

Compared to the studies done by **Makinde et al. (2014) and (2013)**, the 32-15 variety has a phosphorus, zinc, calcium and greater iron composition. This calcium dominance has also been shown. Thus, the variety that is available in rural communities could be used or incorporated in many dishes to diversify and improve the biological availability of certain minerals such as iron. It should also be noted that the protein composition of the seeds of the sesame variety 32-15 is similar to that of other protein-rich food products such as almonds, hazelnut proteins with a content of 20% and 21% respectively **(Blackford et al., 2010)**.

3.3. Oil quality factors of the sesame variety 32-15

Table 3 shows some of the oil quality factors of the 32-15 variety from the localities of Diossong and Sokone in the Fatick region. The oil extracted from the seeds of the variety 32-15 to Diossong has a low index of acidity (this value (1.96 mg KOH/g oil) is less than that of certain usual oils such as soybean (max = 6) and sunflower (max = 4) (FAO, 1981). Compared with the oil extracted at Sokone, the acidity of the oil extracted at Diossong is 5 times lower.

Table 3: Oil quality factors of the variety 32-15

Quality factors	32-15 Provenance: Diossong Average ± SD	32-15 Provenance: Sokone Average ± SD
Acid index (mg KOH/g)	1.96 ± 0. 03	10.73 ± 0.21
Iodine index (g of I_2/100g of oil)	105.75 ± 0.80	105.48 ± 3.45
Saponification index (mg/g)	184.78 ± 1.06	188.43 ± 4.22
Peroxide index (meqH_2O_2/Kg oil)	2.79 ± 0.13	4.49 ± 0.29
Volatile Materials (%)	0.094±0.007	0.134±0.014
Impurities (%)	0.048±0.02	0.063±0.038

The low acid index value characterizes the purity and stability of the oil extracted at Diossong against the value (10.73) found on the oil extracted from Sokone is a proof of a rancidity. The peroxides index of oils extracted from Diossong and Sokone are respectively 2.79 and 4.49 meq H2O2/kg. The peroxide value is lower than that expected of rancid oil, which ranges from 20.00 to 40.00 (Nzioku et al, 2010). This shows that sesame oil is not rancid is considered stable.

A peroxide value of 3.9 was obtained from a Nigerian variety (Goza-25) (**Akinoso et al., 2010)**. These values are significantly different from values obtained from varieties in other locations. These peroxide index values are less than 10 meq H2O2/kg of oil, which characterizes most conventional oils **(FAO 1981)**. In fact, peroxide values below 10 méqO2/kg oil are generally considered to be indicative of an acceptable level of oxidation **(Rossell, 1993).**

The indices of saponification obtained during these analyses are 184.78 for the oil extracted from Diossong and 188.43 for that obtained at Sokone. These values are comparable to the saponification index of usual oils **(FAO, 1981)** such as soybean (189-195), Groundnut (187-196) and Cotton (189-198). The iodine index is in the order of 105.75 for oil extracted from Diossong and 105.48 for oil extracted from Sokone. The iodine value of some local Sudanese and imported sesame seed cultivars varied from 101.52 to 114.85 for the local cultivars and 97.70 to 111.30 g/100g for the introduced cultivars **(El Kheir et al., 2008)**. Compared with other usual oils, the iodine index of sesame seed oil 32-15 is lower than that of soybean oil (120-143), but is stronger than that of peanut oil (85-90). **Karleskind, (1992)** reported a sesame oil iodine index range of 118-120 above our values. The oil content and the iodine index of the oil from the 32-15 seeds attest to the food potential of this food fat. In all the analysis of the oils, it is the iodine index that represents the most useful constant. It is on its value that the important division of vegetable oils is based on drying, mi-drying and non-drying oils. The main ones of these oils are sesame, cotton and rapeseed. Oils with an index of less than 95 are said to be non-drying. However, further studies will assess its oxidative stability and its level of anti-nutrients but also the profile of fatty acids.

The volatile substances at 105° C dosed are in the order of 0.094% for oil extracted from Diossong and 0.134 for that obtained at Sokone, what is in accordance with the Codex standards for oils to be less than 0.2% m/m **(FAO, 1981).**

3.4. Characterization of the oilcakes of the sesame variety 32-15

Table 4 presents two important elements for the characterization of oil seed oilcake, namely protein and fat content. Indeed, the oilcake that is the extraction residue is a source of protein for human and animal food. It appears from the characterization that the oilcakes of the variety 32-15 are high in protein with values of 35.05, 33.93 and 39.87% obtained respectively, after extraction with the local presses of Diossong, Sokone and Faoune in the region of Fatick in Senegal.

Table 4: Characterization of the meal of the variety 32-15

Protein and fat composition of sesame oilcake: variety 32-15	oilcake 32-15 Diossong Mean ± SD	Oilcake32-15: Sokone Mean ± SD	oilcake 32-15 Faoune Mean ± SD
Proteins %	35.04 ± 0.43	33.93 ± 0.27	39.87 ± 0.95
Fat %	16.53 ± 63	20.79 ± 61.86	11.47 ± 64.82

Mean ± Standard Deviation

Compared to the values found by **Westphal et Felizt,** (**1985**) in Sesame oilakes, those of the sesame variety 32-15 are a source of protein. The authors reported that the sesame meal contains 5-14% fat and 25% protein content. This composition has been one of the most popular livestock feed by ranchers in local markets in the region. Sesame oilcakes are thus an interesting solution zoo technically and economically. Correlatively, the analysis of the fat content of the sesame variety 32-15 gave 16.53% for the oilcake at Diossong, 20.79% for that obtained at Sokone and 11.47% for the oilcake at Faoune. This difference in fat rates would be related to the performance of the presses used. The information we can learn from our study is that the more the press is used, the less fat is left in the oilcake, and the more protein composition increases. The study also showed that the Faoune press is more efficient followed by that of Diossong then comes that of Sokone. It would therefore be interesting to improve the latter to increase the oil extraction efficiency.

4. Conclusion

This study revealed that the seeds of the sesame variety 32-15 are doubly interesting in nutritional terms. On the one hand its physico-chemical composition shows that it is a seed rich in protein, fat in carbohydrates and minerals. This nutritional richness can allow its incorporation into cereal flour prepared for children during weaning. On the other hand the analysis of the oil extracted from the seeds of the sesame variety 32-15, both at Diossong and at Sokone shows very stable oil. In addition, the chemical indices of this oil show the food potential of sesame oil in the 32-15 variety. As for the analysis of the cake, the amount of residual fat found reveals that the presses used in Diossong, Faoune and Sokone are to be improved to increase their extraction efficiency and thus decrease the residual oil remaining in the cakes. Our study also helped to confirm the protein richness of the cakes. The latter, obtained from good sesame seeds and by a process that respects the food standards are usable in the enrichment of the feeding of children of weaning age or in human food in a way. We'd rather talk about defatted sesame flour than sesame cakes. However, further research is needed, in this sense, to develop food formulations with this defatted sesame flour.

Competing interests: We the authors declare that there is no conflict of interest regarding publication of this paper whatsoever.

Acknowledgments: This work was carried out under the funding of WAAPP2. The authors are grateful for the promotion of research and support in various initiatives for the development and promotion of agriculture

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