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RESEARCH ARTICLE

EFFECTS OF ROASTING ON THE QUALITY OF SESAME (*SESAMUM RADIATUM* SCHUM AND THONN) SEEDS' OIL

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ABSTRACT

Sesame oil is an edible vegetable oil derived from sesame seeds (*Sesamum radiatum Schum and Thonn*, Pedaliaceae). Sesame oil is composed of fatty acids like linoleic acid, oleic acid palmitic acid, stearic acid and small amounts of other compound. Although other species of sesame have been studied, there has been little study of *S. radiatum* in Togo. The aim of our study is to compare the quality of sesame oil, Roasted sesame seeds (RS) and Unroasted sesame seeds (US) and to optimize the oil extraction yield. Saponification index, Acid index, Acidity and peroxide index were determined using physico-chemical test according to the AFNOR standard. Soxhlet is used for oil extraction. Hexane is used as solvent. We observed that the oil content in relation to weight is the same, while in relation to volume, there is a slight difference which can be explained by the density. The Acid index and the Acidity of the RS oil change significantly after roasting treatment. The color content of sesame oils varied with roasting Roasting seeds treatment change sesame oil quality. The oil of (RS) can be consumed, but that of (US) must be refined. Roasting improves the physicochemical properties and has a positive effect on the nutritional quality of *S. radiatum* oils, the oil is rich in omega-3 and omega-6 fatty acids.

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INTRODUCTION

The plant species Sesamum radiatum (Schum. and Thonn.), is a plant with high nutritional, cosmetic and economic potential (FAO, 1999). The plant grows in tropical and subtropical climates like China, United States, Russia, Australia, South America, Burkina-Faso and Togo (Yahya, 1998). In the world seeds production are 2, 29 million tonnes (FAO, 1999). In America seeds production are 1, 62 million tonnes and are 48.000 tonnes for North, Central and Latin America. In general, sesamum seeds are exported to Japan, Italy and Venezuela, because it plays an important role in food security for these people (IRHO, 1984; Schilling, 1991). Sesame oil has multiple uses in pharmacy, cosmetic and perfumery (Weiss, 2000).

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Sesame culture is little developed in Togo but is localized in the northern region. Togo is the 9th country exporting sesame seed in Africa (ECOWAS, 2011), contributing to 0.3% of the world export (Trade Map, 2011). In Togo, the production of sesame oil has remained artisanal and the plant still not valorized (ECOWAS, 2011). *S. radiatum* is a nutritional and medecinal species, but it has been poorly investigated and is currently classified among the so called neglected and under-utilized plant (Dansi *et al*., 2012). The plant has a very large range of phytotherapeutic applications. The leaves of the plant are used to make soup, relieve pregnant women during childbirth and has significant myorelaxant effect (Konan *et al*., 2008; Konan; Kimiywe *et al*., 2007). The oil helps in the soup preparation and pastries (FAO, 2007). *Sesamum radiatum* oil is rich in monosaturated fatty acids (MUFAs), polysaturated fatty acids (PUFAs), vitamin E and proteins. Sesame oil modulates redox status in hypertensive patients (Mensink, 1989). In vivo many studies revealed that sesame oil composition contains lignans and reduces inflammation and

oxidative stress (Mensink, 1989; Sankar *et al*., 2005; Sankar, 2006). Inflammation plays a major role in Atherosclerosis development. The modified LDL called oxidised LDL (LDL-Ox) is important in atherosclerosis process (Sankar, 2006; Satchithanandam, 1996; Kpokanou, 2015; Ross, 1993; Stemme *et al*., 1995). Sesame oil contains antioxidant prevented as from LDL-OX in atherosclerosis lesions process. Sesaminol one of the antioxidant of sesame oil reduces lypopolysacharide induced oxidative stress and upregulates phosphatidylinositol 3-kinase/Akt/endothelial nitric oxide synthase pathways (Satchithanandam *et al*., 1996; Kpokanou, 2015; Ross, 1993; Stemme, 1995). While other sesame species have already been scientifically studied, work on S. radiatum is at an embryonic stage. This study was aimed to compare the quality of sesame oil, Roasted sesame seeds (RS) and Unroasted sesame seeds (US).

MATERIALS AND METHODS

Statistical Analysis: Results were expressed as means ± sd. One way analysis of variance was used. Comparison between roasted oil and unroasted oil were performed by analysis of variances (ANOVA).

$p < 0.05$ were consired significant.

Biological Materials: The seed of sesame were harvested in October 2015 in Kara. The species were identified by the herbarium of the University of Lome. The plant were identify by K. Akpagana in the herbarium of Lome University. The species finally identified are *Sesamum radiatum Schum. and Thonn.* The seeds of the plant were dried in our laboratory called "Laboratoire de Chimie Organique et des Substances Naturelles" (Lab COSNat) for three days. One part of the seeds was roasted at 165°C during 25 min using a hotplate and the other part was unroasted. After all the two categories of seeds were reduced in powder using moulinex. The seeds are weighted on an analytical balance type "sartorius", crushed and carefully arranged in cartridges. Soxhlet extractor is used to remove oil in cartridges during three days. We obtained a mixture of oil and hexane. The Rotavapor is used to evaporate a big part of hexane. For the total removal of the hexane anhydrous copper sulphate is chosen. We finally obtained the crude oils and it is stored in a freezer at +4 ° C.

Physicochemical Tests Description: The physicochemical tests concerned the saponification index (Is), the acid number (Ia), the acidity, the water and volatile matter content, the refractive index (nD), the peroxide value, the iodine number (Ii) and the ester number (Ie).

Détermination of Saponification Index (Is): Saponification index is defined as the number of milligrams of potassium hydroxide (KOH) needed to saponify one gramme (1 g) of fat. Saponification index is determined according to the protocol described by standard NF T 60-206 (AFNOR, 1984). Thus, 25 ml of ethanolic solution of 0.5N potassium hydroxide are poured over 2 grammes of oil. The mixture of oil and ethanolic solution is brought to reflux with a slight stirring by hand. The obtained solution is incubates for one hour at a temperature of 107°C. After heating the solution, we stopped the reaction. We finally titrated the solution with 0.5N hydrochloric acid solution in the presence of 5 drops of phenolphthalein. A blank was used in the same conditions.

The following formula was established to calculate the saponification index of the oil.

$Is = ((V_0-V_1) / m * T * 56.1)$

V_0 = volume in ml of 0.5N hydrochloric acid solution used for the blank test;

V_1 = volume in ml of 0.5N hydrochloric acid solution used for the determination;

T = exact title of the hydrochloric acid solution used;

m = mass in grams of the test sample.

Iodine Index Determination: Iodine index was determined using Wijs method. This method has the further advantage of avoiding substitution reactions (18), and provides a means for measuring (determining) the degree of unsaturation of the fat. A mixture consisting of 250 ml of ethanolic solution was added to 2 g of oil and 15 ml of chloroform were prepared. After stirring for 5 minutes, 25 ml of WIJS reagent was added. The obtain solution was incubated at room temperature in the darkness for one hour. After one hour 20 ml of potassium iodide was added. We complete with 150 ml of distilled water. The obtained solution was titrated with an aqueous solution of 0.1N sodium thiosulfate in the presence of starch powders. The control was recorded under the same condition. The iodine index was calculated according to the following formula:

Iodine number $= ((V_0-V_1) * T * 12, 69) / P$ with $P = (m * 2) / 5$

V_0 = volume in ml of 0.1N sodium thiosulfate solution used for the blank;

V_1 = volume of 0.1N sodium thiosulfate solution used for the test;

T = exact title of the sodium thiosulfate solution;

m = mass in grams of the test sample.

Acid Index and Acidity Index: A study was performed to evaluate the acid index and to calculated acidity index. These indices are determined according to the protocol described in standard NFV 03-906 (AFNOR, 1984). The acid index is defined as the number of milligrams of KOH needed to neutralize the free fatty acids contained in 1g of fat. Firstly we prepared ethanol solution which is previously neutralized with potassium hydroxide in the presence of phenolphthalein and we heat the mixture. We weighed 5g of sesame oil and we put it in a conical flask. We add after, 50 ml of ethanol solution to the mixture. This assembly is simultaneously vortexes and titrated with the ethanolic solution. A persistent pink color for more than 30 seconds marks the end of the titration. The acidity index is deduced from the acid index. A blank test was carried out under the same conditions. The following formulas are used to determine the acid number and the acidity of the oil.

$Ia = (V * T * 56.1) / m$

$Acidity = (V * T * M) / (10 * m)$

V = volume of ethanolic solution of potassium hydroxide used for the titration;

T = Molar concentration of tritant

m = mass in grams of the test sample;

M = 282 g / mol represents the average molar mass of the fatty acids present.

Refractive Index (n_D): To evaluate the quality of the extracted oil refractive index was applied.

This parameter was determined according to the protocol described by standard NF T 60-212 (AFNOR, 1984). It is defined as a ratio between speeds of light in the vacuum and the sample of oil. The refractive index is determined on the perfectly anhydrous and filtered fatty substance (oil obtained after steaming). We put a drop of sesame oil on a flat section of a glass prism equipped with a thermometer. After we try to find the deviation of the needle indicating the refractive index of the oil. We adjusted the temperature t_1 of the refractometer to maintain it around 3°C. The reference temperature for this oil is t = 20°C. The following formulas were used to calculate the refractive index of the oil.

$nt_D = nt_D + (t_1-t) * F$ if $t_1 > t$ or
$nt_D = nt_D - (t-t1) * F$ if $t > t_1$

t_1 = temperature read;
t = reference temperature;

F = is the correction factor, temperature function which is equal to 0.00035 for oils. The measurement was carried out in accordance with the operating instructions of the apparatus used and the refractive index was read to 0.0002 in absolute value.

Peroxide Index: Peroxide index measures the degree of fat rancidity after exposure to air. The peroxide value of a fatty substance is the number of mill equivalents of active oxygen contained in one kilogram of product. Among oil, the degree of peroxide formation and the time taken for the development of rancidity differ. Peroxide value is a measure of the peroxides contained in the oil. The peroxides present are determined by titration against thiosulphate in the presence of KI. We determined peroxide index using the protocol described by the NFT 60-220 standard (AFNOR, 1984).

A previously 2 g of sesame oil is matched with 10 ml of chloroform. The mixture is immediately closed and shaken. After 15 ml of acetic acid and 1 ml of a saturated KI solution are added. The sample obtained is also closed and shaken for one minute. The mixture were stored in a dark at room temperature for 5 minutes. Then 75 ml of distilled water are added and stirred. Iodine formed is titrated with a solution of sodium thiosulfate using starch as indicator. The control was recorded under the same condition.

The following formula was used to calculate the peroxide value of the oil.

Peroxide value = $((V_0-V_1) * T * 8000) / m$
V_1 = volume of sodium thiosulfate solution used to titrate the test;
V_0 = volume of sodium thiosulfate solution used to titrate white;
T = Normality of thiosulfate solution (0.002N);
m = mass of the test sample in g.
Ester index (Ie)

The ester index of a lipid is the mass of potassium hydroxide KOH, necessary to saponify the esterified fatty acids contained in one gram of fatty substance (AFNOR, 1984). Ester index is not measured, but it is calculated and is expressed in milligrams. And is the conventional expression of the percentage of free fatty acids. To perform physico-chemical tests, after taking an oil sample, the rest is immediately returned to the freezer to prevent it from oxidizing.

RESULTS

Effect of Roasting Sesame Seeds on Weight and Volume of the two Categories of Seeds: In this study we choose to analyse the quality of sesame oil after roasting the seeds. The fat content in US is 40.26% for the weight and is 46.14% for volume. Additionally the value in RS content is 40.11% for the weight and is 41.00% for the volume (Table 1). Comparison of the oil content (weight and volume). RS: Roasted seeds, US: Unroasted seeds

Table 1. Effect of roasting sesame seeds on weight and volume content of the two categories of seeds oil

	RS	US
Yield in weight (%)	40,11	40,26
Volume yield (%)	41	46,14

A

B

C

Figure 1. Organoleptic appearance of sesame oils, Roasted Seeds and Unroasted Seeds. (A) Unroasted seeds (B) Roasted seeds (C) Organoleptic appearance of oils (Roasted seeds oil in the Left and Unroasted seeds oil on the Right)

Effect of Roasting Seeds on Organoleptic Appearance of Sesame Oil: The effect of roasting on the visual color of sesame seeds was also investigated. Generally color development is usually used as a means of measuring the degree of roast. We observed that the visual color of sesame seeds or oils from roasted sesame seeds changed. US oil color is light-yellow and RS oil color is brown (Figure 1).

Saponification Index Comparison Between Roasted Seeds and Unroasted Seeds: Our study shows that saponification index is 157.17 ± 0.25 mg of KOH per g of oils for Roasted Seeds (RS) and is 157.99± 1.16 mg of KOH per g of oils for Unroasted Seeds (US) (Fiureg 2).

Effect of Roasting Sesame Seeds on Water and Volatile Matter Content: To determine the effect of roasting sesame seeds on water and volatile matter content, a study was performed. The determined water and volatile matter content (Figure 3) gives us 5.79 ± 0.01 for the RS and 5.05 ± 0.74 for the US.

Effect of Roasting Sesame Seeds on Acid Value: Our studies indicated that the values are 17.08 ± 0.07 mg KOH per g of oil for US and is 3.25 ± 0.08 mg of KOH per g of oil for RS (Figure 4).

Effect of Roasting Sesame seeds on Acidity Index: An investigation was performed to analyze the effect of roasting sesame seeds on acidity index. Our investigation shows that acidity index value is 8.59 ± 0.04 mg KOH / g for US and is 1.63 mg KOH / g for RS. Some data are presented in Figure 5.

Effect of Roasting Sesame Seeds on Refractive Index: We have focused our research by analyzing the effect of roasting sesame seeds on the refractive index. We note that the refractive index is 1.471± 0.0005 for US and 1.475±0.0005 for RS. (Figure 6)

Effect of Roasting Sesame Seeds on Iodine Index, Peroxide Index and Ester Index: On the basis of our previous data we useful examining the effect of roasting sesame seeds on iodine index, peroxide index and ester index of the oil. Our results show that the iodine index value obtained is 102.80 ± 3.45 g of I2 / 100g for the oil of the unroasted seeds (US) against 122.40 ± 9.39 g of I2 / 100g for the oil of the roasted seeds (RS). Peroxide index in milliequivalents of peroxide oxygen per kg of oil obtained (Table 2), are 3.26 ± 0.02 meq O2 / kg for the oil of unroasted seeds (US) and is 3.02 ± 0.18 meq O2 / kg for seed oil roasted (RS). The value of the ester index found (Table 2) is 148 mg KOH / g for US oil and is 144 mg KOH / g for RS oil.

DISCUSSION

The present study was aimed to answers the research question: what is the quality of sesame oil, Roasted sesame seeds (RS) and unroasted sesame seeds (US)?. In the present study, the yield in weight is the same for roasted seeds and unroasted seeds. This result is in agreement with that reported by Junmin *et al*. (2018) which indicated that the yield in weight is the same for the two categories of oil. Additionnally this study shows that the maximum volume yield is slightly higher for RS and lower for US (Table 1).

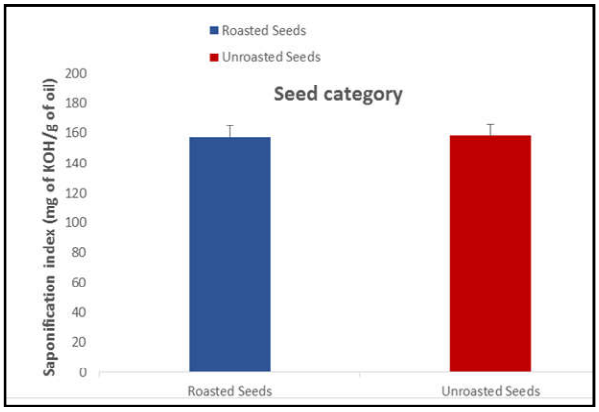

Figure 2. Saponification index comparison between roasted seeds and unroasted seeds. Saponification index is determined using physico-chemical test according to the AFNOR standard as described in the materials and methods. Results are expressed as mean ±sd.

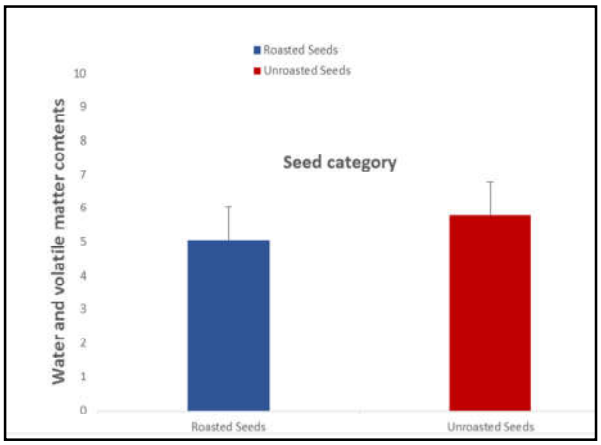

Figure 3. Water and volatile matter contents comparison between Roasted seeds and Unroasted seeds. Water and volatile matter contents were determined using physico-chemical test according to the AFNOR standard as described in the materials and methods. The value is expressed as mean ±sd.

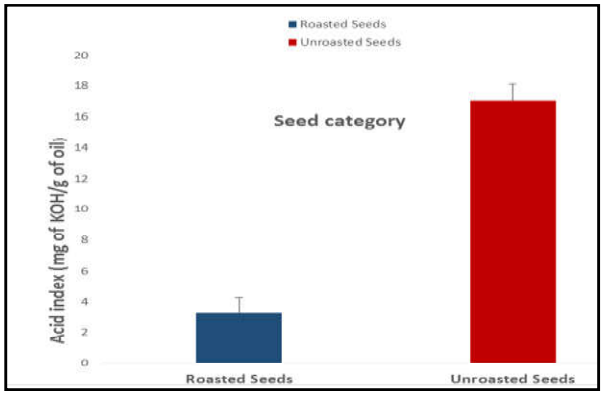

Figure 4. Acid index comparison between Roasted seeds and Unroasted seeds. Acid index is determined using physico-chemical test according to the AFNOR standard. The value is expressed as mean ±sd.

Roasting changes the microstructure, physical state, or chemical composition of oilseeds through temperature. Similar finding were reported in the study conducted by Junmin *et al*. (2018). By the visual observation of sesame oil we note that US oil color is light-yellow and RS oil color is brown. The change of the color is due to Maillard-type non-enzymatic reactions between reducing sugars and free amino acids or amides (Kim *et al*., 2002; Yen, 1990; Yosida, 1994).

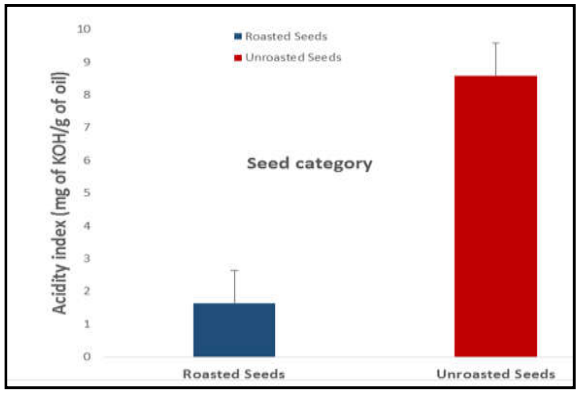

Figure 5. Acidity index comparison between Roasted seeds and Unroasted seeds. Acidity index is determined using physico-chemical test according to the AFNOR standard. The value is expressed as mean ±sd.

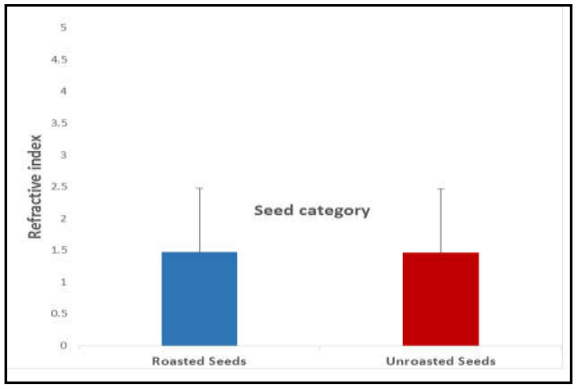

Figure 6. Refractive index value comparison between Roasted seeds and Unroasted seeds. Refractive index is determined using physico-chemical test according to the AFNOR standard. The value is expressed as mean ±sd.

Table 2. Effect of roasting sesame seeds on iodine index, peroxide index and ester index

Tests	US	RS	Codex Alimentarius
Iodine index	102,80±3,45	122,40±9,39	104-120
peroxide index (méq/ Kg d'O_2 actif)	3,26±0,02	3,02±0,18	≤5
Ester index	144,73	148,52	-

RS: Roasted seeds US: Unroasted seeds The values are expressed as mean ±sd.

The present study also revealed that the saponification index number is the same for roasted seeds and unroasted seeds (Figure 1). In our knowledge this is the first study reporting the saponification index number for RS and US for the species S. radiatum. It is important to indicate that several articles are talking about the species S. indicum (AFNOR, 1984; Amoukou, 2013; Ashri, 2007). But we focused our study on the species *S. radiatum.* Water and volatile matter content were also investigated. The determined moisture content (Figure 2) is slightly higher for unroasted seeds and lower for the roasted seeds. These results are slightly higher than the Codex Alimentarius standards recommendation for vegetable oils (Codex, 2015). Plausible explanation could be impurities of our oil and probably the presence of water in seeds after drying. The acid number (Ia) and the acidity are important to know the content of free fatty acids. Acidity also provide information on the activity of lipases (oil degradation) and the stability of the oil (29). We note in our study that the acid number and acidity are very higher for unroasted seeds by comparison to Roasted seeds. This increase might be due to the fact that thermal degradation and oxidation of oil produce various volatile compounds such as alkanes, aldehydes, alcohols, esters and carboxylic acids, and some of these volatile compounds would further participate in the Maillard reaction and form complex aroma substances (Kandji, 2001; Junmin *et al*., 2018). The refractive index value is higher for RS and lower for US, confirming that the two categories of oil don't have the same composition (Figure 3). Similar findings were reported in the study conducted by (Wolff, 1968; Yoshida, 1997; Codex, 1999). In order to analyse the quality of sesame oil iodine index and peroxide index were evaluated, and we observed that their values are in agreement with the recommendation of Codex Alimentarius (Labuza, 1992) (Table 2).

Plausible mechanism explaining the high level of iodine index value in RS was justified by the thermal oxidation of unsaturated fatty acids in Roasted sesame oil (Table 2). The same explanation was discused by Kandji *et al*., 2001(Kandji, 2001). We also investigated the acidity of sesame oil by ester index determination. We note that unroasted seed oil has a higher ester number confirming its high acidity. The present study has a limitation as roasting temperature improvement. Do to feasibility contraints sophisticated methods as HPLC and Gas Chromatography instruments could be used to determine the fatty acids compositions, tocols, lignans and vitamins.

Conclusion

In conclusion our study was aimed to compare the quality of sesame oil, Roasted sesame seeds (RS) and unroasted sesame seeds (US). The oil content in relation to weight is the same, while in relation to volume, there is a sligth difference which can be explained by the density. Acid index and the Acidity of the RS oil change significantly after roasting treatment. Roasting changes the acidity and the acid number which improve the quality of the oil. The color content of sesame oils varied with roasting treatment. Further studies are needed to evaluate the chemical composition to determine fatty acids, tocols, lignans and other vitamins in the sesame oil, RS and US.

Conflict of Interest: Authors declare no conflit of interest. We declare that the work described in the manuscript is new and has not published previously. It publication was been approved by all the authors. The work described in the manuscript was supported by the grant from the University of Lome in Togo.

Author Contributions

POTCHO Essowè Badanèzi, BOYODE Pakoupati, SIMALOU Oudjaniyobi and GNEINY Whad Tchani conducted the full work. Kpegba Kafui and GBANDJABA Nagba Yendoubé participated in the writting process. NOVIDJRO K,. Adanlemegbe K., NAMBO P., SALOUFOU I., EVENAMEDE S., gave technical support via the using of apparatus. All authors have approved the submittion of this paper.

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