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RESEARCH ARTICLE

EFFECTS OF SPROUTING TIME ON PHYSICOCHEMICAL AND BIOCHEMICAL PARAMETERS OF OIL EXTRACTED FROM SESAME (*SESAMUM INDICUM* L.) SEEDS GROWN IN CÔTE D'IVOIRE

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ABSTRACT

Effects of sprouting time (0, 1, 2, 3, 4 days) on the physicochemical and biochemical parameters of sesame seeds oils raw, soaked and sprouted was investigated. Sesame seeds were sprouted in laboratory under room conditions (humidity 85%, temperature 28±3°C) during 4 days. The process significantly decreased the oil content (51.50 to 41.58%) and increased the free fatty acid (FFA) from 0.22% to 9.05%, the iodine value (IV) (from 105.70 to 108.91 mg KOH/g), saponification index (SI) (191.11 to 193.82 mg KOH/g) and the peroxide value is very low (less than 0.1meqO_2/kg. Germination has decreased the viscosity of the germinated seeds oil (from 71.09 to 66.29 mPa.s) and have significantly changed color of the extracted oil from (8.17Y, 2.73R) to (72.90Y, 5.70R). Furthermore it also increased the α-tocopherol (vitamin E) level from 0 to 597.65 µg/g and β-caroten content (provitamin A) from 0.80 to 4.80 µg/g. Oils extracted with present a small percentage of impurity (0.078 to 0.096%). The major unsaturated fatty acids were oleic acid (around 45%) and linoleic acid (around 37%), while the main saturated fatty acid were palmitic acid (around 9%) and stearic acid (around 7%). Sprouting has resulted in a decrease in saturated fatty acids (16.72 to 16.43%) while unsaturated fatty acids have increased slightly (83.28 to 83.57%). So the present study revealed that germination significantly affects the physicochemical and biochemical parameters of sesame seeds oils sprouted.

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INTRODUCTION

The main sources of vegetable oils are plants, including sunflower, soybeans, cotton, peanuts, rapeseed, maize, olive, coconut and palm ... (Ali *et al.,* 2014). African ecosystems abound with many plant species that remain unknown and underutilized. Among these, sesame (*Sesamum indicum* L.), a widespread species in Côte d'Ivoire. Sesame is an annual plant, native to tropical Africa (Bedigian, 2015) and widely cultivated in Asia since ancient times. Belonging to the family Pedaliaceae, it has about 36 species (Saydut *et al.,* 2008). Asian countries are the largest producers in the world (FAOSTAT, 2011). It is an herbaceous plant grown for its edible seeds, oil and flavor (Zebib *et al.,* 2015).

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Oleaginous plant, sesame seeds contain 57-63% oil, 23-25% protein, 13.5% carbohydrates and 5% ash (Elleuch *et al.,* 2007). Sesame is used at 65% for oil extraction and at 35% for food (Okudu *et al.,* 2016). Contain vital minerals, vitamins, phytosterols, polyunsaturated fatty acids, tocopherols and a unique class of lignans such as sesamin and sesamolin (Hahm *et al,* 2009), both of which belong to a group of beneficial fibers specials called lignans Sesame seeds have a special significance for human nutrition because of their high content of sulfur amino acids and phytosterols (Pathak *et al.,* 2014). Germination, used for centuries, can soften grain structure, increase nutrient content and availability; decrease the content of antinutrients and add new flavors (Bau *et al.,* 1997). The germination of seeds is a chain of events that begins when dry, viable seeds are imbibed with water and ends with the lengthening of the embryonic axis. During imbibition, the quiescent seed rapidly resumes its metabolic activity, including respiration, enzyme and organelle activity, and RNA and

protein synthesis. These reactions lead to the structural modification and development of new compound, many of which have high bioactivity and can increase nutritional value and grain stability (Enyinnaya *et al.,* 2015). Germination, an inexpensive and efficient technology, helps to improve the nutritional quality of grains or seeds. Thus, the objective of this study is to characterize the physicochemical and biochemical parameters of sesame seeds oil during germination lasting 4 days.

MATERIALS AND METHODS

Plant materiel: The biological material used is the sesame seeds (Sesamum indicum), purchased from producers in Soubré(South-West, Côte d'Ivoire). Put in a cooler to preserve its fresh state, they were transported to the Laboratory of Biochemistry and Food Technology of University of Nangui Abrogoua (Abidjan, Côte d'Ivoire) where study was conducted.

Sprouting procedure: A germination experiment was undertaken using two kilogram (2 kg) of sorted sesame seeds was carefully washed with tap water to remove the worn and immature seeds (floating on the surface of the water because their density is low compared to the mature seeds) and soaked during 24 hours in 10 liters of water (ratio 1/5: w / v) contained in a plastic seal of 15 liters. After soaking, the seeds were rinsed and then spread on a 100% cotton fabric, in a room whose humidity and temperature were respectively 85% and 28°C. Each day, the germinating seeds are watered once and samples are taken. The seeds were washed every 24 h with distilled water. Starting from the second day of germination, and every day thereafter, dishes of germinating seeds were removed, oven-dried, weighed and stocked for proximate and chemical analysis. Germination lasted four (4) days.

Oil extraction: The extraction of the oil was carried out using a screw press type Komet Ca59G (IBG Monfort Oekotek, Germany) formed of a perforated cylinder containing a worm which ensures the transport of the material. A pressing head provided with a die of different diameters is fixed on the cylinder. This press has the particularity of ensuring a "cold" extraction of oil from oilseeds and has a flow rate of 5 to 8 kg/h (Savoire, 2008). A mass of 250 g of seeds was introduced through a hopper in the previously heated press. The seeds are transported through a rotational movement of the screw. The compression and the simultaneous entrainment of the seeds causes the extraction of the oil which reflux towards the perforated cylinder (length 9 cm, diameter 3.4 cm, provided with 6 perforations on 20 rows). The oil is collected through the perforations in a 500 ml beaker. As for the cake, it comes out at the end of the axis by a calibrated orifice (6 mm for the study) interchangeable, which acts as a brake on the flow of the cake. The recovered crude oil is freed from suspended particles (press feet) by centrifugation at 4200 rpm for 20 min. It was finally stored in glass bottles with a capacity of 100 ml, previously washed, oven dried and covered with aluminum foil. Oil samples were obtained: ORS (oil extracted from raw sesame seeds), OGS_0 (oil extracted from sesame seeds soaked for 24hrs.) and OGS_1, OGS_2, OGS_3, OGS_4 (respectively oil extracted from sprouted sesame seeds for 1, 2, 3 and 4 days).

Physicochemical parameters: Acid, peroxide, iodine and saponification index were determined by using the (AOAC, 1997) methods. Refractive index at 20°C was carried out following the (IUPAC, 1979) methods by using a refractometer (Mettler Toledo, Japan). Density and viscosity were determined at 20°C by using a viscosimeter apparatus (Anton Paar Gmbh, Austria) equipped with a syringe filled with 1 ml of oilseed. Values were automatically recorded after temperature programming. pH values of oil samples were was determined at 25°C according the (Afane *et al.,* 1997). Color, and cloud point were determined according to the (MPOB, 2005) methods by using a Lovibond colorimeter (Lico, France) and a thermometric system (Mettler Toledo, Japan) respectively.

Biochemical parameters: Moisture and impurities contents were determined according to (MPOB, 2005) test methods. Unsaponifiables matter content of oil samples was determined following the (IUPAC, 1979) method.

Fatty acid composition: The methyl esters were prepared according to the cold Trans esterification method described by (IUPAC, 1979). The fatty acid composition was determined by conversion of oil to fatty acid methyl esters (FAMEs) prepared by introducing 0.4 g of oil, 5 ml of a methanolic solution of potassium hydroxide (2N), 5 ml of isooctane and 1 g of anhydrous sodium sulphate into a haemolysis tube equipped with a stopper. The mixtures were vortex for 5 min and allowed to settle for 15 min. the top layer containing the fatty acids methyl esters was used for gas chromatography analysis. The top layer (1µl) was injected into a gas chromatograph (CLARUS 580 GC,USA) equipped with a flame-ionization detector and a polar capillary column RT-2560 (RESTEC GC Columns), 0.25 mm internal diameter, 100 m length and 0.2 µm film thickness to obtain individual peaks of fatty acid methyl esters. The separation of the fatty acids is carried out according to a temperature gradient as follows: the initial temperature of the oven (100° C.) is maintained for 4 min, then this is increased from 3°C / min up to 240°C and remains stable for 15 min. Hydrogen is used as a carrier gas at a flow rate of 1.2 ml /min. Volatil fatty acids are detected by flame ionization at 250°C.The fatty acid methyl esters were identified by comparing their retention time with those of the standards. Quantification of the identified fatty acids was performed by reference to established calibration lines for different concentrations of the standards used. The areas obtained was initially corrected by the internal calibration method using erucic acid as internal standard and the yield of each fatty acid was calculated as follow: (area of fatty acid/areas of total fatty acids in the oil sample) x100. The acquired data was processed by Total chrom navigator software (Clarus 580 GC, USA).

Vitamins A and E: Vitamins (A and E) contents were determined according the method (ISO, 2000). The oil sample (1 g) was diluted in 10 ml of hexane. Thereafter, 200 µl of this mixture was transferred into a screw-capped tube where 800 µl of methanol were added. After being votex-mixed and centrifuged (3000 rmp for 5 min), the samples were filtred though a 0.45 µm pore size filter and used for ultra-performance liquid chromatography (UPLC) analysis. Separation by UPLC was carried out using a liquid chromatography system (ACQUITY WATERS, USA) equipped with an optical detector TUV system and a BEH C_{18} column (150x0.25mm i.d., 1.7 µm particle size). The injection volume was 10ul. The mobile phase was methanol-water (98:2, v/v) and the elution was performed at a flow rate of 2 ml/min. the analytical column was kept at 45°C. Vitamin A of oil

sample was detected at 325 nm and identified by comparing its retention time with this of authentic standard. Quantification of vitamin A identified in oil sample was done by using a standard curve (concentration versus peak area) of retinol palmitate. Detection of vitamin E was done at 292 nm using an optical detector TUV system. Vitamin E of oil sample was identified by comparing its retention time with of authentic standard. Quantification of vitamin A identified in oil sample was done by using a standard curve (concentration versus peak area) of α-tocopherol acetate. All the data obtained were stored and processed by Empower software (WATERS, USA).

Phosphorus content: Phosphorus content was determined following the Nephelometric method described by (Sinram, 1996) which measures turbidity in oil acetone mixture due to phospholipids. The turbidity is correlated to the phosphorus level. 1.67±0.01g of oil sample was weighed into a 50 ml volumetric flask, filling with acetone to the 50 ml mark. The flask was stoppered and shaken, and the phosphatide mixture was poured into a sample cell. The sample was capped, thoroughly shaken (by hand for about 10 sec), wiped clean and placed in the turbidimeter with proper consistent alignment. After 5 min, the Nephelometric Turbidity Units (NTU) reading was recorded. The NTU value for the acetone blank was subtracted from the reading. The phosphorus level of oil was calculated using the appropriate equation:

If NTU ≤ 3.55 used P=4.9xNTU+22.59
If 3.55<NTU≤10.4, used P=8,929xNTU+7.14
If NTU>10.4, used P=2.44xNTU+61.17
Where: P= phosphorus (ppm); NTU= turbidity value (Nephelometric Turbidity Units)
Statistical analysis

All analyses were performed in triplicates. Results were expressed by means of ± SD. Statistical significance was established using Analysis of Variance (ANOVA) models to estimate the physicochemical and biochemical properties of germinating and ungerminating sesame oil. Means were separated according to Duncan's multiple range analysis ($p<0.05$), with the help of the software Statistica (StatSoft Inc, Tulsa USA Headquarters).

RESULTS AND DISCUSSION

Physicochemical parameters: In this study, from the soaking process (OGS0) to the fourth day of germination (OGS4), the oil content of sesame seeds decreased from 45.85 (OGS_0) to 37.09% (OGS_4). All sesame oil contents (raw, soaked and sprouted) are significantly different ($p<0.05$) (Table 1). This reduction may be due to the fact that biochemical and physiological changes occur during germination. In fact, storage oil breakdown plays an important role in the life cycle of many plants by providing the carbon skeleton that supports growth immediately followed germination. This metabolic process is initiated by lipases which catalyze the hydrolysis of triacylglycerols to release glycerols and free fatty acids (Quettier and Eastmond, 2009; Chinma *et al.,* 2009). Some of which are oxidized into acetyl-CoA then transformed into simple carbohydrates and transferred to the embryo as saccharose (Brou *et al.,* 2010). Therefore fat was used as the major source of carbon for seed growth (Bau *et al.,* 1997; Josh and Varma, 2016). Although sesame seeds are a potential source of oil, it is important to emphasize that the interest of its oils lies in their intrinsic characteristics including the physicochemical, biochemical and nutritive properties that they reveal. The different sesame oils obtained (raw, soaked, sprouted) have viscosity and pH values all significantly different ($p<0.05$). The significant changes in viscosities between the samples could be attributed to the fact that viscosity depends on the fatty acid composition and it decreases with the increase of unsaturation of the fatty acids and increases with increasing saturation (Gunstone, 2004). The highest value of pH was observed on 3rd day of germination (pH 8.11). In contrast, raw sesame oil has the lowest value (pH 5.58). Germination influence significantly pH value. Cloud Point (CP) of the oil indicates the temperature at which a beginning of crystallization appears, resulting in an alteration of the limpidity of the oil (Lambert, 2005). Germination results in a significant decrease in cloud point from -7.57°C (ORS) to -5.48°C (OGS_4) (Table 1). Apart from this oxidation stability, sesame oils also have a low temperature stability compared to their cloud point which is lower than that of palm oil (4 ° C) (Codex Alimentarius, 1993). Oil color is one of the most important quality attributes evaluated by consumers, producers and distributors. The pigments are responsible for the color of the oil, but their concentrations are influenced by a number of factors like geographic origin, degree of ripeness, storage conditions and processing method (Rizki *et al.,* 2016). Those pigments are widely affected by germination process which occur degradation and a change of color. The intensity of the color is higher for the oil from the germinated seeds (72.90y, 5.70r) (Figure 6 & 7). The change in the color of the oil extracted could be due to the increase in the content of chlorophylls and carotenoids which are synthesized during the early stages of germination (Hajer, 2016). Carotenoids, besides their participation in coloring of fruit, vegetables and oils, are bioactive compounds which have provitamin A function and antioxidant activity. Furthermore it has been demonstrated that the chlorophyll compounds, in addition to its function as green coloring, exhibit a series of biological properties such as antioxidant activity (Rizki *et al.,* 2016).

The quantity of free-fatty acids (FFAs), usually referred as the acid value, is an important quality factor and has often been used as a criterion for classifying of oils (Gharby *et al*., 2015). FFA determination is important in industrial because FFA can modify the organoleptic or physicochemical properties of oil. The results indicate that germination has increased the acid value and free fatty acids from 0.22 % and 0.32 mg KOH/g (ORS), 9.05 % and 12.83 mg KOH/g (OGS3) (Figures 1 & 2). The values of ORS, OGS_0 and OGS_1 samples low, below the minimum acceptable value of 4.0% for sesame recommended by the Codex Alimentarius Commission for edible oil. The higher percentage of FFA and acid value from germinated sesame seeds oil could be due to the initial hydrolysis (lipolysis) of triacylglycerols by lipases, enzymes that catalyze the three-stage hydrolytic cleavage of the fatty acid ester bonds in triacylglycerols (TAGs), ultimately to yield glycerol and free fatty acids (FFA) (Hajer, 2016). This high value is frequently an indication for a strong enzymatic hydrolysis of sesame seeds during harvesting, handling or oil processing (Mohammed and Hamza, 2008). The iodine value (IV) is a measure of the total number of double bonds present in fats and oils (Gharby *et al.,* 2013). Values of ORS and OGS_0, OGS_1, OGS_2, OGS_3increase slightly but are not significantly different. However, there is a significant difference between the IV of ORS and $OGS_4$with values of 106.26 and 108.91 $mgI_2/100g$ respectively (Figure 3). This increase in IV could be explained by the fact that during germination, there is

Table 1: Physicochemical parameters of sesame seeds oil raw and sprouted

Oil samples	Yield of press (%)	Density at 20°C(g/cm3)	Viscosity at 20°C(mPa,s)	pH (25°C)	Cloud point (°C)	Peroxide index ($meqO_2/kg$)
ORS	45.50 ± 0.10^{d}	0.9190 ± 0.0001^{e}	71.09 ± 0.02^{f}	5.58 ± 0.01^{a}	-7.57 ± 0.06^{a}	< 0.1
OGS_0	45.85 ± 0.15^{f}	0.9192 ± 0.0000^{f}	70.78 ± 0.00^{e}	5.76 ± 0.01^{c}	-7.30 ± 0.10^{b}	< 0.1
OGS_1	45.10 ± 0.13^{e}	0.9173 ± 0.0000^{d}	69.01 ± 0.00^{d}	$6,39\pm0.01^{e}$	-6.23 ± 0.15^{c}	< 0.1
OGS_2	43.82 ± 0.18^{c}	0.9168 ± 0.0000^{c}	68.20 ± 0.00^{c}	5.71 ± 0.01^{b}	-5.83 ± 0.15^{d}	< 0.1
OGS_3	39.70 ± 0.12^{b}	0.9155 ± 0.0000^{a}	66.29 ± 0.00^{a}	8.11 ± 0.02^{f}	-5.57 ± 0.12^{e}	< 0.1
OGS_4	37.09 ± 0.11^{a}	0.9161 ± 0.0000^{b}	67.14 ± 0.01^{b}	6.24 ± 0.01^{d}	-5.48 ± 0.10^{e}	< 0.1

Mean values with different superscripts with in a column are significantly different $p < 0.05$. ORS: Oil extracted from Raw Sesame Seeds;OGS_0: Oil extracted from Sesame Seeds soaked for 24hrs; and OGS_1: Oil extracted from Germinated Sesame Seeds for 1day; OGS_2: Oil extracted from Germinated Sesame Seeds for 2 days; OGS_3: Oil extracted from Germinated Sesame Seeds for 3days; OGS_4: Oil extracted from Germinated Sesame Seeds for 4days.

Table 2:Biochemical parameters of sesame seeds oilraw and sprouted

Oil samples	Humidity (%)	Impurity (%)	Unsaponi-fiables (%)	Vitamin E (µg/g)	Vitamin A (µg/g)	Phosphorus (µg/g)
ORS	0.73 ± 0.06^{b}	0.078 ± 0.001^{a}	1.47 ± 0.01^{c}	0.00 ± 0.00^{a}	0.80 ± 0.10^{a}	93.49 ± 0.02^{d}
OGS_0	0.61 ± 0.02^{a}	0.079 ± 0.001^{a}	$1.45\pm0.01^{b,c}$	28.84 ± 0.29^{b}	0.90 ± 0.10^{a}	91.62 ± 0.14^{c}
OGS_1	0.54 ± 0.05^{a}	0.080 ± 0.001^{a}	$1.40\pm0.03^{a,b}$	89.14 ± 1.35^{c}	1.73 ± 0.12^{c}	86.86 ± 0.04^{b}
OGS_2	0.74 ± 0.06^{b}	0.091 ± 0.001^{b}	1.35 ± 0.01^{a}	433.64 ± 3.99^{d}	2.20 ± 0.10^{d}	106.12 ± 0.17^{e}
OGS_3	0.63 ± 0.06^{a}	0.096 ± 0.001^{c}	1.38 ± 0.03^{a}	552.46 ± 5.72^{e}	4.23 ± 0.21^{e}	86.84 ± 0.24^{b}
OGS_4	0.55 ± 0.05^{a}	0.094 ± 0.001^{c}	1.39 ± 0.03^{a}	597.65 ± 6.24^{f}	4.80 ± 0.35^{f}	85.64 ± 0.04^{a}

Mean values with different superscripts with in a column are significantly different $p<0.05$. ORS: Oil extracted from Raw Sesame Seeds;OGS_0: Oil extracted from Sesame Seeds soaked for 24hrs; and OGS_1: Oil extracted from Germinated Sesame Seeds for 1day; OGS_2: Oil extracted from Germinated Sesame Seeds for 2 days; OGS_3: Oil extracted from Germinated Sesame Seeds for 3days; OGS_4: Oil extracted from Germinated Sesame Seeds for 4days.

Table 3. Fatty acid composition of sesame seeds oil raw and sprouted

	Oils samples					
Fatty acid (%)	**ORS**	**OGS_0**	**OGS_1**	**OGS_2**	**OGS_3**	**OGS_4**
Myristic acid	$0.07\pm0.01^{b,c}$	$0.07\pm0.01^{a,b}$	$0.07\pm0.01^{a,b}$	0.06 ± 0.01^{a}	$0.09\pm0.01^{c,d}$	0.09 ± 0.00^{d}
Palmitic acid	9.45 ± 0.04^{e}	9.36 ± 0.01^{d}	9.28 ± 0.03^{c}	$9.22\pm0.03^{b,c}$	$9.17\pm0.04^{a,b}$	9.11 ± 0.03^{a}
Stearic acid	$7.15^{a}\pm0.02^{a}$	7.16 ± 0.06^{a}	7.17 ± 0.01^{a}	$7.21^{a}\pm0.07^{a}$	7.18 ± 0.04^{a}	7.16 ± 0.01^{a}
Oleic acid	45.59 ± 0.04^{b}	45.61 ± 0.06^{b}	45.63 ± 0.04^{b}	45.61 ± 0.02^{b}	45.53 ± 0.02^{b}	45.39 ± 0.07^{a}
Linoleic acid	37.57 ± 0.07^{a}	37.59 ± 0.03^{a}	37.60 ± 0.04^{a}	37.60 ± 0.03^{a}	37.65 ± 0.03^{a}	37.59 ± 0.04^{a}
Linolenic acid	0.12 ± 0.02^{a}	0.14 ± 0.03^{a}	0.21 ± 0.03^{b}	0.24 ± 0.04^{b}	0.31 ± 0.02^{c}	0.59 ± 0.02^{d}
Arachidic acid	0.05 ± 0.01^{a}	0.07 ± 0.01^{c}	$0.05\pm0.00^{a,b}$	$0.06\pm0.01^{b,c}$	$0.06\pm0.01^{b,c}$	$0.05\pm0.01^{a,b}$

Mean values with different superscripts with in a column are significantly different $p<0.05$, ORS: Oil extracted from Raw Sesame Seeds;OGS_0: Oil extracted from Sesame Seeds soaked for 24hrs; and OGS_1: Oil extracted from Germinated Sesame Seeds for 1day; OGS_2: Oil extracted from Germinated Sesame Seeds for 2 days; OGS_3: Oil extracted from Germinated Sesame Seeds for 3days; OGS_4: Oil extracted from Germinated Sesame Seeds for 4days.

production of polyunsaturated fatty acids (Okandza *et al.,* 2017). However high iodine-value oil contains a greater number of double bonds than low iodine-value oil and has usually a reduced oxidative stability (Zine *et al.,* 2013), this is why the oxidative stability of the different oil samples has been studied through the determination of the peroxide index. Peroxide index (IP) indicates the presence of primary oxidation products (Gharby *et al*., 2013). It is an index of rancidity, thus the high peroxide value of oil indicates a poor resistance of the oil to peroxidation during storage. Values of peroxide index of sesame seed oil were less than 0.1 $meqO_2/Kg$ (Table 1). These results suggested that sesame seed oil stability to oxidation is relatively good, which is due to the presence of antioxidants (sesamol, sesamolin and sesamin) together with tocopherols (Hahm *et al.,* 2009; Gharby *et al.,* 2015). IP Values of sesame seeds oil are below the maximum value of 10 meq O_2/kg set by the Codex Alimentarius Commission (Codex Alimentarius, 1993). The saponification index is an indicator of the molecular weight of fatty acids and triglycerides as well as the length of carbon chain that contains the oil. It is inversely proportional to the molecular weight of the oil (Benalia, 2016). The values obtained from the saponification index of the oils studied vary from 191.11 to 193.25 mg KOH/g for raw (ORS) and germinated sesame oil (OGS_4) respectively (Figure 4). These values indicate that sesame seed oils contain fatty acids with long carbon chains. The saponification value compares favorably with usual oils such as cotton oil (189-198), soybean oil (189-195), peanut oil (187-196) and corn oil (Codex Alimentarius, 1993). The high saponification value obtained indicates that sesame seeds oil possessesnormal triglycerides and may be useful in the production of liquid soap, shampoos and lather shaving creams (Ugbogu *et al.,* 2013). The refractive index is an indication of oil saturation level. It is not a useful property for specifying oils but it is useful purity criteria that can be used as a quality parameter in preliminary testing of the seed oils. It depends on their molecular weight, fatty acid chain length, degree of unsaturation, and degree of conjugation (Nichols and Sanderson, 2003). The germination decreased refractive index from 1.4724% to 1.4714% for ORS and OGS_4 respectively (Figure 5).

Biochemical parameters: Biochemical parameters of oil extracted from raw and germinated sesame seeds are shown in table 2.The moisture and impurity levels of sesame seed oils are less than 1%. The percentage of impurity of the oils varies from 0.078 (ORS) to 0.096% (OGS_3). The Unsaponifiables matter of fatty substance corresponds to all of its constituents which, after basic hydrolysis (saponification), are very

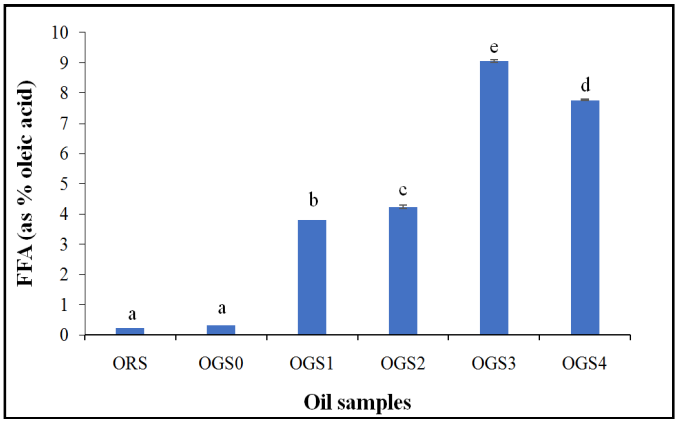

Fig. 1. Changes of free fatty acid (FFA) value of sesame seeds oil raw and sprouted

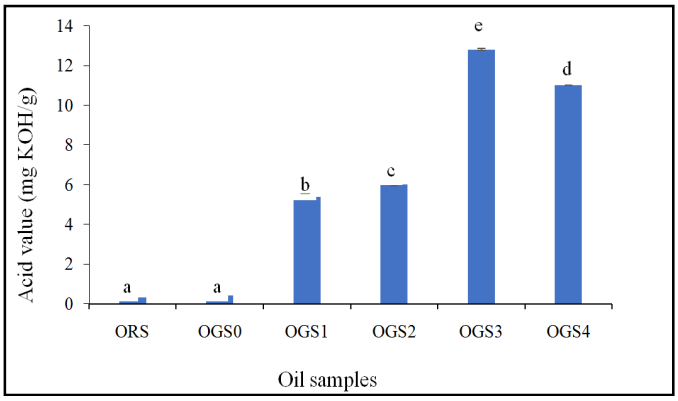

Fig. 2. Changes of acid value from sesame seeds oil raw and sprouted

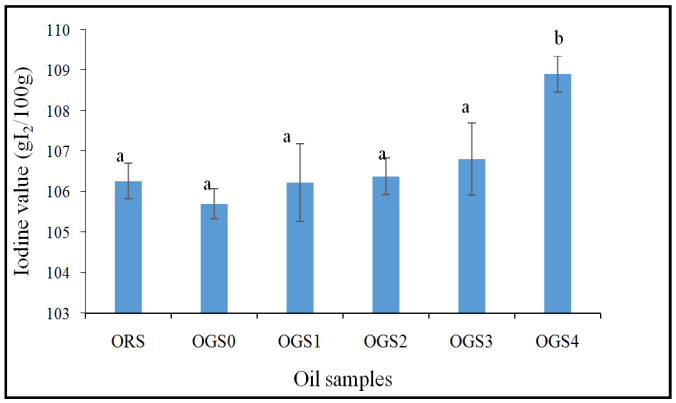

Fig. 3. Changes of iodine value from sesame seeds oil raw and sprouted

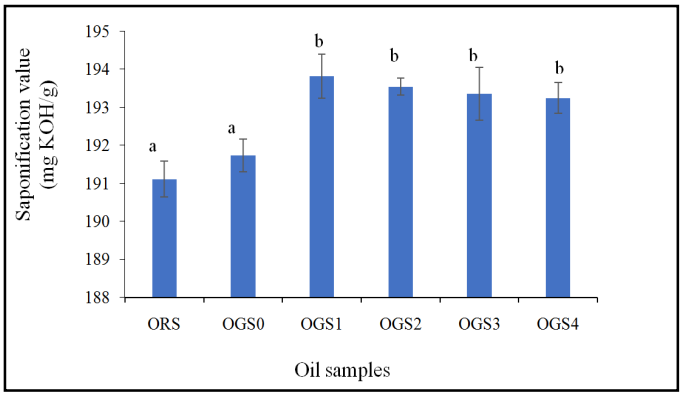

Fig. 4. Changes of saponification values from sesame seeds oil raw and sprouted

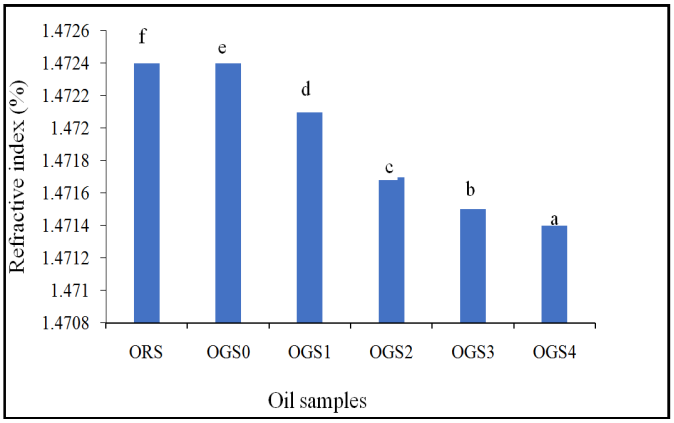

Fig. 5. Changes of refractive index from sesame seeds oil raw and sprouted

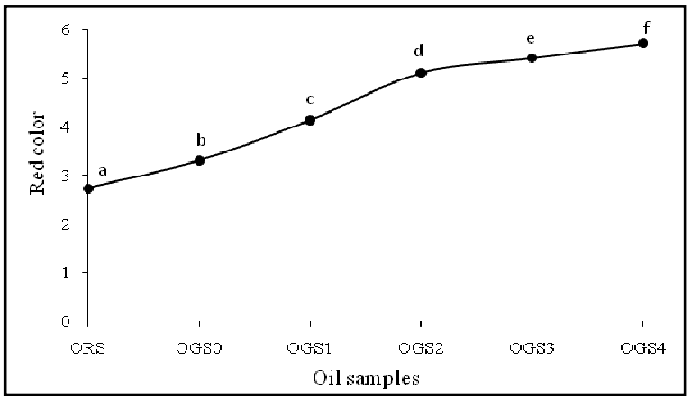

Fig. 6. Changes of red color from sesame seeds oil raw and sprouted

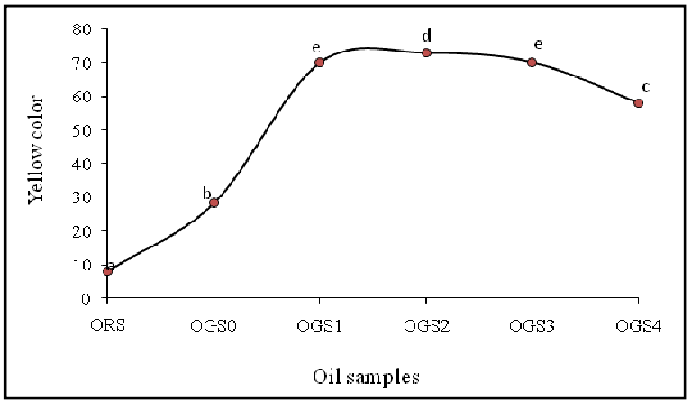

Fig. 7. Changes of yellow color from sesame seeds oil raw and sprouted

sparingly soluble in water and soluble in organic solvents (Noui, 2013). The relative decrease in the unsaponifiable content observed during the germination period may possibly be due to the initial loss lipids and other major reserves of the seed. The chromatographic profile of the unsaponifiable fraction of ungerminated and germinated sesame oils reveals the presence of provitamin A(vitamin A) and vitamin E (α-tocopherol). In vegetable oil, vitamin A obtained from β-carotene which plays an important role in human health by acting as a biological antioxidant (Zeb and Mehmood, 2004). It is an essential nutrient needing in small amounts by humans for the normal functioning of visual system, growth and development, maintenance of epithelial cell integrity, immune function and reproduction (Blomhoff, 1991).

Vitamin A content increases during germination of1.73±0.12µg/g (OGS_0) to 4.80±0.35µg/g (OGS_4).The germination increase significantly ($p<0.05$) the content vitamin A of sesame seeds oil. The consumption of sesame seeds oils could cover the daily vitamin A requirements of the child from 0 to 6 months estimated at 0.375 mg/kg (FAO, 2001). Vitamin E, play role in the protection against oxidative deterioration of polyunsaturated fatty acids, are natural lipophilic antioxidants mainly found in vegetable oils (Gharby *et al.,* 2015). The results obtained show a significant variation in the vitamin E content of the oils which goes from 0 mg/100g (ORS) to 57.77 mg/100g (OGS_4) (Table 2). The increase of α-tocopherol during germination indicates this process provide abundant vitamin E that could be readily absorbed by human body (Hahm *et al.,* 2009). Fatty acid composition is a major determinant of oilseed crop quality. The fatty acid composition of sesame seeds oil is summarized in Table 3 and shows nine identified fatty acids. The result indicated that sesame seeds oil contained the high content of monounsaturated fatty acids (MUFA; Oleic acid (C18:1) with more than 45% was the predominant unsaturated fatty acid followed by linoleic acid (C18:2) more than 37%.Palmitic acid (C16:0) was the major saturated fatty acid with more than 9%. The detected unsaturated fatty acids confer a dietary and an industrial importance to sesame seed oil. Indeed, oleic acid has many beneficial effects on human health like decrease LDL levels in blood, suppress tumergenesis, ameliorate inflammatory diseases and decrease blood pressure (Dhakal *et al.,* 2014). Ungerminated sesame (ORS) oil was comprised of 16.72% SFAs, while germinated sesame oil varied to 16.66% (OGS1) to 16.43% (OGS4). Germination decreased the oil content of SFAs.Linoleic acid (C18:2) and α-linolenicacid (C18:3) were present as polyunsatured fatty acids (PUFAs). The PUFAs contents was affected by germination, particularly α-linolenic acid which increased from 0.12% to 0.59% for ungerminated and germinated (OSG4) respectively. It could be concluded that sesame seeds sprouts were rich in polyunsaturated fatty acids.

Conclusion

The present study has shown that germination process impact significantly the parameters biochemical and nutritional of sesame seeds oil sprouted. Germination has significantly increased the levels of vitamins A and E of sesame seeds sprouted. *Sesamum indicum* L. seed oil is unsaturated type and contains mainly the fatty acids oleic and linoleic. The oil can be classified in the oleic-linoleic acid group. High unsaponifiable matters content guarantees the use of oils in cosmetic industry. The oil extracts exhibited good physicochemical and biochemical parameters and could be useful for industrial applications.

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Abbreviation

ORS: Oil extracted from Raw Sesame Seeds;
OGS_0: Oil extracted from Sesame Seeds soaked for 24hrs;
OGS_1: Oil extracted from Germinated Sesame Seeds for 1 day;
OGS_2: Oil extracted from Germinated Sesame Seeds for 2 days;
OGS_3: Oil extracted from Germinated Sesame Seeds for 3 days;
OGS_4: Oil extracted from Germinated Sesame Seeds for 4 days.
NTU: Nephelometric Turbidity Units

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