Basrah University

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THE EFFECTS OF SESAME SEED ON HUMAN HEALTH

بحث التخرج للمرحلة الخامسة للعام الدراسي

٢٠١٥ ـ ٢٠١٦

اشراف الدكتور : يوسـف نعيـم

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Introduction

Sesame (Sesamum indicum L.) is believed to be one of the most ancient crops cultivated by humans (1). It was first recorded as a crop in Babylon and Assyria over4000 years ago. The seeds of the crop are used both as condiment and oil source .The Babylonians made wine and cakes with sesame seeds, whereas sesame oil was used for cooking, medicinal, and cosmetic purposes. Ancient Indians used Sesame oil as lighting oil, and sesame seeds were commonly used in the religious rites of Hindus. The Chinese believed that sesame seeds could promote health and longevity .Sesame seed has higher oil content (around 50%) than most of the known oilseeds although its production is far less than the major oilseeds such as soybean or Rapeseed due to labor-intensive harvesting of the seeds. Sesame oil is generally regarded as a high-priced and high-quality oil. It is one of the most stable edible oil despite its high degree of unsaturation. The presence of lignan type of natural antioxidants accounts for both the superior stability of sesame oil and the beneficial physiological effects of sesame .In Asia, sesame oil is obtained by pressing the roasted oilseeds and consumed as a naturally flavored oil without refining. In the western world, sesame oil is extracted by a multiple-step mechanical expeller and either the virgin oil or the refined oil is used for salad dressing. After pressing out oil, the remaining sesame Meal contains high-quality protein suitable for human consumption as well as animal feed. It is also a good source of water-soluble antioxidants .In this chapter, the properties and processing of sesame oil will be presented, and the anti-oxidative components and their effects on oil stability and health will be summarized.

BOTANY OF SESAME

Sesame (Sesamun indicum. L., synonymous with Sesamun orientale L.), also known as benniseed (Africa), benne (Southern United States), gingelly (India), gengelin (Brazil), sim-sim, semsem (Hebrew), and tila (Sanskrit), is the world's oldest oil crop. It belongs to the Tubiflorae order, Pedaliaceae family, which comprises of 16 genera and some 60 species (2). There are 37 species under the Sesamum genus (3). Among the 37 species, only Sesamum indicum is widely cultivated.

The wild species such as S. angustifolium, S. calycium, S. baumii, S. auriculatum, S. brasiliense, S. malabaricum, S. prostratum, S. indicatum, S. radiatum, S. occidentale, and S. radiatum are cultivated in Africa, India, or Sri Lanka in small areas.

The wild species, although low in oil contents, may contribute to favorable agronomic characters (such as resistance to disease, pests, and drought) when used in plant breeding. Sesame grows in tropical and subtropical area. Sesame indicum L. is the commonly cultivated species of sesame. It has 26 somatic chromosomes. Sesame is an annual, erect herb that may grow between 50 cm and 250 cm in height, depending on the variety and growing

Conditions. The stems (Figure 1) may have branches and are obtusely quadrangular, longitudinally furrowed, and densely hairy. The extent of hairiness on the Stem can be classified as smooth, slightly, and very hairy; it is related to the variety of sesame.

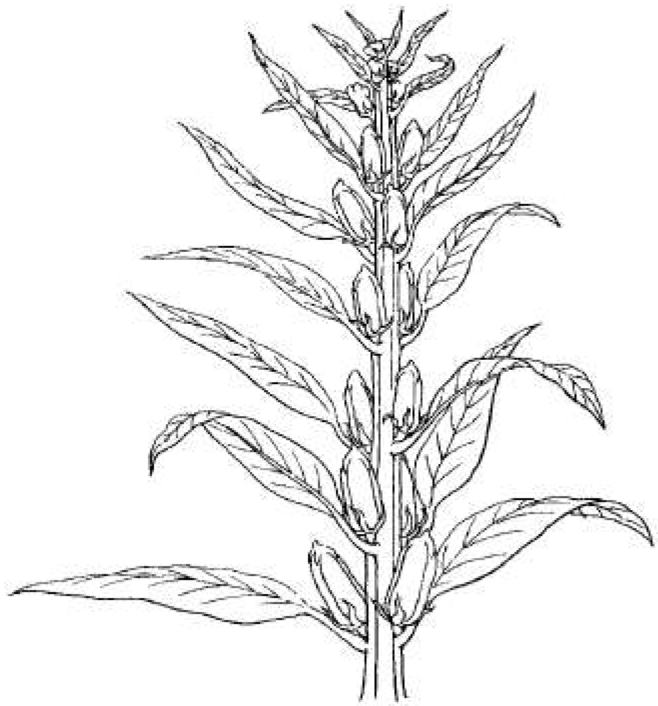


Figure 1. *The plant of sesame.*

Sesame leaves are hairy on both sides and are highly variable in shape and size not only among different varieties but also on the same plant.. Sesame has large, white, bell-shaped flowers. The flowers are zygomorphic, in axils of upper leaves. The fruit of sesame is a capsule (2–5 cm long and 0.5–2 cm in diameter), and it is erect, oblong, brown or purple in color, rectangular in section, deeply grooved with a short, triangular beak (Figure 2). The capsules may have four, six or eight Rows of seeds in each capsule (Figure 2). Most of the sesame capsules have four Rows of seeds, with a total of 70 seeds per capsule.

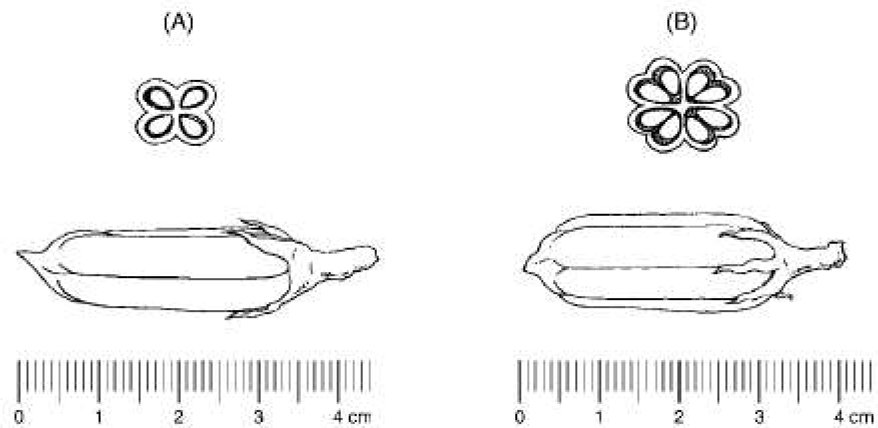


Figure 2. *Sesame fruits with four (A) or eight (B) rows of seeds in each capsule.*

The degree and type of branching of the stem are also important varietal Characters. Sesame seeds are small (3_4 mm long and 1.5–2 mm wide), flat, ovate (slightly thinner at the hilum than at the opposite end), smooth, or reticulate. The color varies from white, yellow, gray, red, brown, to black. The weight of 1000 seeds is around 2.5 to 3.5 g. Sesame seeds consists of testa (exo and endo), endosperm, and cotyledon
(Figure 3).

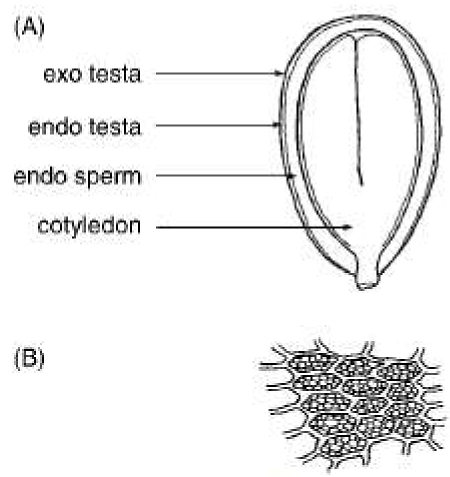


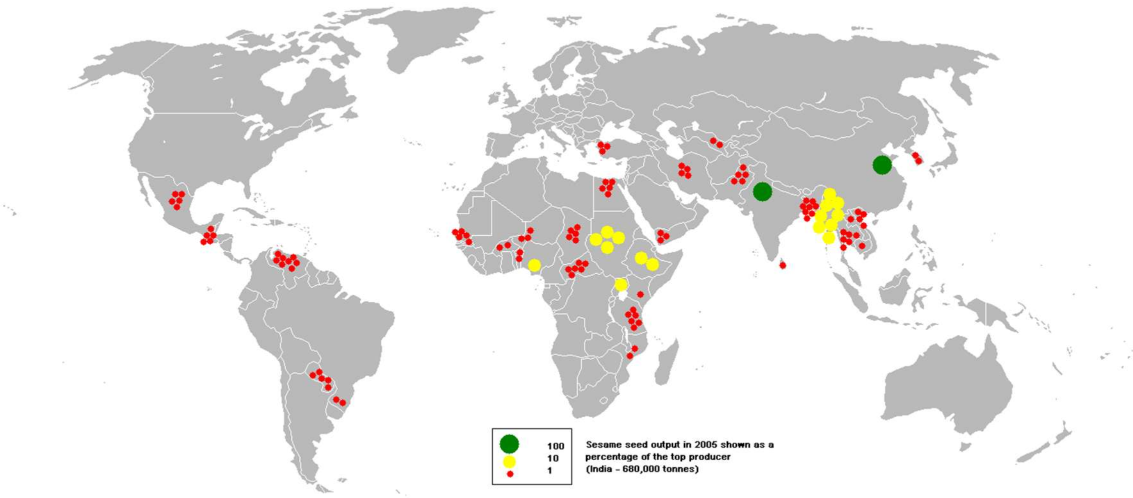
Figure 3. *Structure of the sesame seed (A) and the oil drops in cotyledon (B).*

The oil drops are located in the cotyledon. It is generally believed that the light-colored seeds with thin coats are higher in quality and oil content than the dark-colored seeds. Although sesame seeds are higher in oil contents than most other oilseeds and sesame oil has good flavor and oxidation stability, sesame seeds have never been a major oil source. The low yield (400–500 kg/ha) of sesame seeds and the labor-intensive harvesting procedure are the limiting factors.

WORLD PRODUCTION

Sesame Seed

China, India, Sudan, Myanmar, and Uganda are the world's major sesame seed producing countries



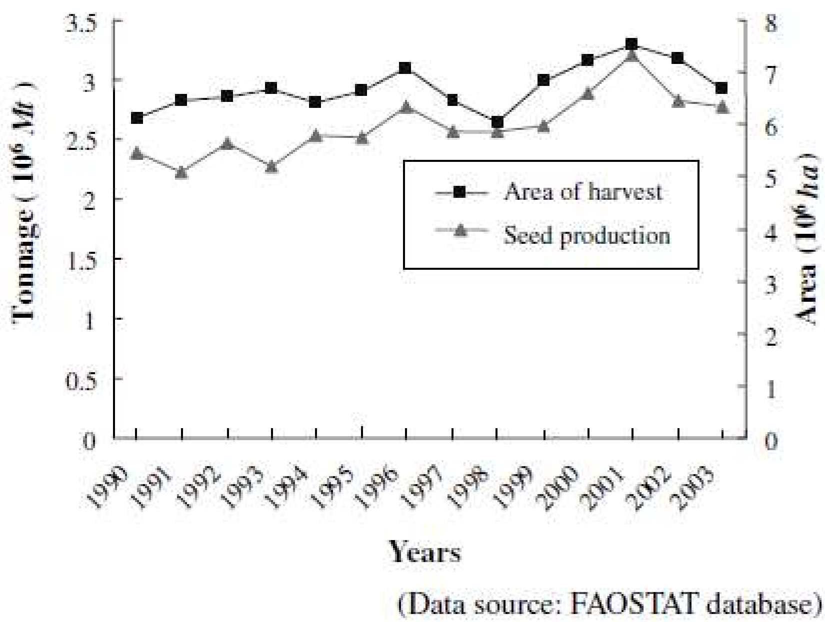


Figure 4. *World production of sesame seed (1990–2003). (This figure is available in full color at http://www.mrw.interscience.wiley.com/biofp.)*

TABLE 1. Production of Sesame Seed in the Five Continents in 2003.[1]

Continent	Seed Production (1000 *Mt*)		Area of Harvest (1000 *ha*)		Yield (*kg/ha*)
Africa	603.827	(21.835%)[2]	1840.382	(27.547%)	328.099
Asia	2014.492	(72.846%)	4602.432	(68.889%)	437.702
Europe	1.575	(0.057%)	0.317	(0.005%)	4968.454
North and Central America	65.870	(2.382%)	127.254	(1.905%)	517.626
South America	79.655	(2.880%)	110.485	(1.654%)	720.958
World Total	2765.419	(100%)	6680.870	(100%)	413.931

[1]Based on FAOSTAT database (2003).
[2]Data in parenthesis are the percentage of total.

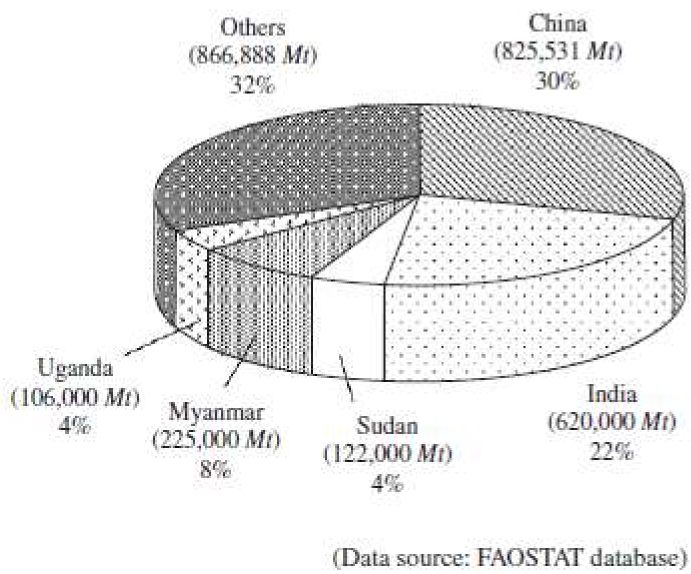


Figure 5. *Major sesame seed-producing countries and their percentage shares of the world production in 2003.*

Sesame Oil

Each year, the world consumes close to 120 million MT of edible fats and oils. Soybean oil is the leading oil that accounts for 30% of the world production of Edible fats and oils.

CHEMICAL COMPOSITION

Sesame seed contains high levels of fat and protein. The chemical composition of sesame seed varies with the variety, origin, color, and size of the seed. The fat content of sesame seed is around 50% whereas the protein content is around 25%.
Table 2 lists the proximate composition of sesame seeds from different sources.

TABLE 2. Proximate Composition of Sesame Seed (%).

Sesame	Crude Fat	Crude Protein	Carbohydrate	Crude Fiber	Ash	Moisture	Reference
Black sesame	35.8	17.2	9.19	19.6	4.01	4.73	15
White sesame	34.6	20.8	9.19	14.2	10.1	4.14	15
Brown sesame	41.3	20.2	10.3	18.6	5.19	4.12	15
Yellow sesame	53.8	22.0	6.85	13.0	6.09	4.28	15
Black sesame	48.4–56.7	22.8–30.3	3.4–10.8	2.8–7.2	4.4–5.5	4.6–6.4	16
White sesame	50.1–51.7	22.6–24.1	7.9–13.2	5.3–7.5	4.2–4.5	4.4–4.7	16
Brown sesame	46.3–53.1	21.8–27.6	4.7–13.6	3.7–7.3	3.9–5.4	5.0–8.2	16
Nigerian sesame whole seed	51.5	20.0	12.5	6.0	5.0	5.0	17
Dehulled seed	55.0	24.3	10.4	2.0	3.0	5.3	17

Content of Oil

TABLE 3. Oil Content of Sesame Seed.

Sesame Species	Color of Seed Coat	Oil Content (% Seed)	Reference
Sesamum indicum L.			
Sudan strains[a]	Black	50.7	20
Sudan strains	Brown	52.3	20
Sudan strains	White	47.4–55.5	20
Japanese strains[b]	Black	43.4–51.1	21
Japanese strains	Brown	50.5–56.5	21
Japanese strains	White	51.8–58.8	21
Turkish strains[c]	Black	43.3–48.2	22
Turkish strains	Brown	42.8–46.9	22
Turkish strains	White	43.1–46.3	22
Sesamum alatum T.[d]	Brown	28.1–29.8	20
Sesamum radiatum S. and T.[d]	Black	30.3–33.4	20
Sesamum angustifolium E.[d]	Black	29.2–29.7	20

Fatty Acid Composition

Sesame oil belongs to the oleic-linoleic acid group. It has less than 20% saturated fatty acid, mainly palmitic (7.9_12%) and stearic (4.8_6.1%) acids. Oleic acid and linoleic acid constitute more than 80% of the total fatty acids in sesame oil.

TABLE 5. Fatty Acid Composition of Sesame Oil (% Total Fatty Acids).

Fatty Acid	Codex(24)	O'Connor(25)	Kamal-Eldin and Appelqvist(20) Cultivated[a]	Wild[b]
Myristic (C14:0)	ND[c]-0.1	<0.5		
Palmitic (C16:0)	7.9–12.0	7.0–12	9.0–9.6	8.2–12.7
Palmitoleic (C16:1)	0.1–0.2	<0.5	0.1–0.2	0.2–0.3
Heptadecanoic (C17:0)	ND-0.2			
Heptadecenoic (C17:1)	ND-0.2			
Stearic (C18:0)	4.8–6.1	3.5–6.0	5.6–6.4	5.6–9.1
Oleic (C18:1)	35.9–42.3	35–50	41.9–45.2	34.3–48.1
Linoleic (C18:2)	41.5–47.9	35–50	38.0–41.6	33.2–48.4
Linolenic (C18:3)	0.3–0.4	<1.0	0.5–0.6	0.6–0.9
Arachidic (C20:0)	0.3–0.6	<1.0	0.3	0.2–0.8
Eicosenoic (C20:1)	ND-0.3	<0.5	0.1	0.1
Behenic (C22:0)	ND-0.3	<1.0	0.1	0.1
Lignoceric (C24:0)	ND-0.3		trace	trace

Sterols

TABLE 6. Levels of Desmethylsterols in Sesame Oil.[a]

Desmethyl Sterol	Codex (24)	Kamal-Eldin and Appelqvist (27) Cultivated Sesame[b]	Wild Sesame[c]
Cholesterol	0.1–0.5	0.1–0.2	0.2–0.3
Brassicasterol	0.1–0.2	—	—
Campesterol	10.1–20.0	12.5–16.9	10.3–20.5
Stigmasterol	3.4–12.0	6.0–8.7	4.4–14.2
β-sitosterol	57.7–61.9	57.5–62.0	33.9–60.2
Δ^5-avenasterol	6.2–7.8	8.1–11.5	12.4–23.5
Δ^7-stigmasterol	0.5–7.6	0.4–3.1	0.1–3.0
Δ^7-avenasterol	1.2–5.6	0.3–1.3	0.9–3.7
Others	0.7–9.2	3.6–6.1	4.6–7.3
Total sterols (mg/kg)	4500–19000	4335–6764	3420–10005

Tocopherols

Sesame oil is well known for its oxidative stability; one of the reasons for this extra-stability is attributed to its tocopherol content. The total tocopherol content of sesame oil ranges from 330-mg/kg to 1010-mg/kg oil according to the Codex Standard. Sesame oil from black sesame seeds contains less Tocopherols than oils from brown or white sesame seeds (Table 7).

TABLE 7. Levels of Tocopherols in Sesame Oil.

Sesame Species	Color of Seed Coat	Tocopherol (mg/kg Oil) α	γ	δ	Total	Reference
Sesamum indicum L.						
Japanese strains[a]	Black	5.2	468.5	12.2	485.9	26
	Brown	6.2	517.9	13.6	537.7	26
	White	3.8	497.8	20.5	522.1	26
Sudan strains[b]	Black	ND[d]	527.0	12.6	540	27
	Brown	4.8	663.7	11.6	680	27
	White	3.1	603.9	13.0	620	27
Sesamum alatum T.[c]	Brown	2.9	310.1	7.0	320	27
Sesamum radiatum S. and T.[c]	Black	6.5	800.3	3.2	810	27
Sesamum angustifolium E.[c]	Black	ND	754.7	5.3	760	27
Codex standard	—	ND–3.3	521–983	4–21	330–1010	24

Protein

The protein content of sesame seed is approximately 25% with a range of 17_31% Depending on the source of the seed. Sesame protein is low in lysine (3.1% protein), But it is rich in sulfur-containing amino acids methionine and cystine (6.1%), which are often the limiting amino acids in legumes. Comparing with the standard values recommended by FAO and WHO for children, sesame protein is borderline deficient in other essential amino acids such as valine, threonine, and isoleucine. Sesame seed protein, however, contains an adequate amount of tryptophanm, which is limiting in many oilseed proteins. Because of its characteristic amino acid composition, sesame seed protein is regarded as an excellent protein source for supplementing many vegetable proteins such as soybean and peanut to increase their nutritional value.

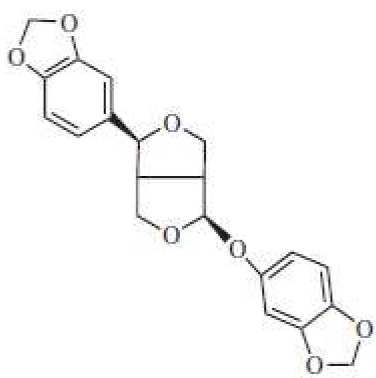
SESAME LIGNANS AND LIGNAN GLYCOSIDES

Lignans

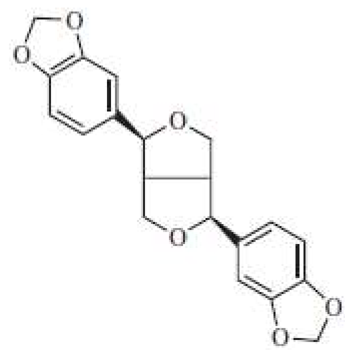
Sesame oil contains high levels of unsaturated fatty acids (more than 80% of total fatty acids); however, it is highly resistant to oxidative deterioration as compared with other edible vegetable oils. The superior oxidative stability is not only attributed to the presence of Tocopherols, but it is mainly associated with the unique group of compounds-Lignans. Lignans are compounds formed by oxidative Coupling of r-hydroxyphenylpropane two types of lignan compounds existed in sesame seeds, the oil soluble lignans and the water soluble lignan glycosides in raw sesame seed, sesamin and sesamolin are the two major lignans. Sesamin has been found in other plants, whereas sesamolin is characteristic of sesame and has not been found in plants other than Sesamum.

TABLE 8. Lignan Contents in Different Strains of Sesame Seeds.[a,b]

Strain no.	Color of Seed Coat	Sesamin	Sesamolin	Sesamolin/ Sesamin	Sesamol	P1	Sesamolinol	Sesaminol
48	White	821.3	441.2	0.537	2.0	1.6	1.0	1.4
611	White	410.6	441.2	0.537	2.5	1.3	1.0	1.0
630	White	522.7	123.5	0.236	2.5	2.3	0.9	0.3
638	White	885.2	476.5	0.538	ND[c]	2.9	1.1	1.0
643	White	464.0	229.4	0.494	5.0	2.0	1.1	1.0
785	Yellow	453.3	247.0	0.545	Trace	2.0	0.9	0.3
673	Violet	464.0	317.6	0.684	2.5	1.8	1.5	1.1
675	Brown	528.0	264.6	0.501	Trace	3.8	0.6	0.7
126	Brown	682.7	458.8	0.672	4.0	2.9	1.2	1.0
201	Black	502.5	441.2	0.878	3.6	2.5	1.2	1.1
601	Black	314.3	235.3	0.749	10.8	1.6	1.9	1.1
631	Black	362.7	229.4	0.632	2.5	1.5	0.8	0.5
792	Black	154.7	152.9	0.988	4.9	1.5	0.9	0.9
801	Black	293.3	294.0	1.002	6.5	1.6	1.1	1.2
Mean		490.6	300.4		3.4	2.1	1.1	0.9
SD		198.6	113.6		2.9	0.7	0.3	0.3



Sesamolin



Sesamin

Lignan Glycosides

Lignan glycosides are the glycosylated forms of lignans; they are water soluble. Although most lignans are found in the oil-soluble part of sesame seed, lignan glycosides are present in sesame meal. Sesaminol, sesamolinol, and pinoresinol glycosides are the major lignan glycosides in sesame.

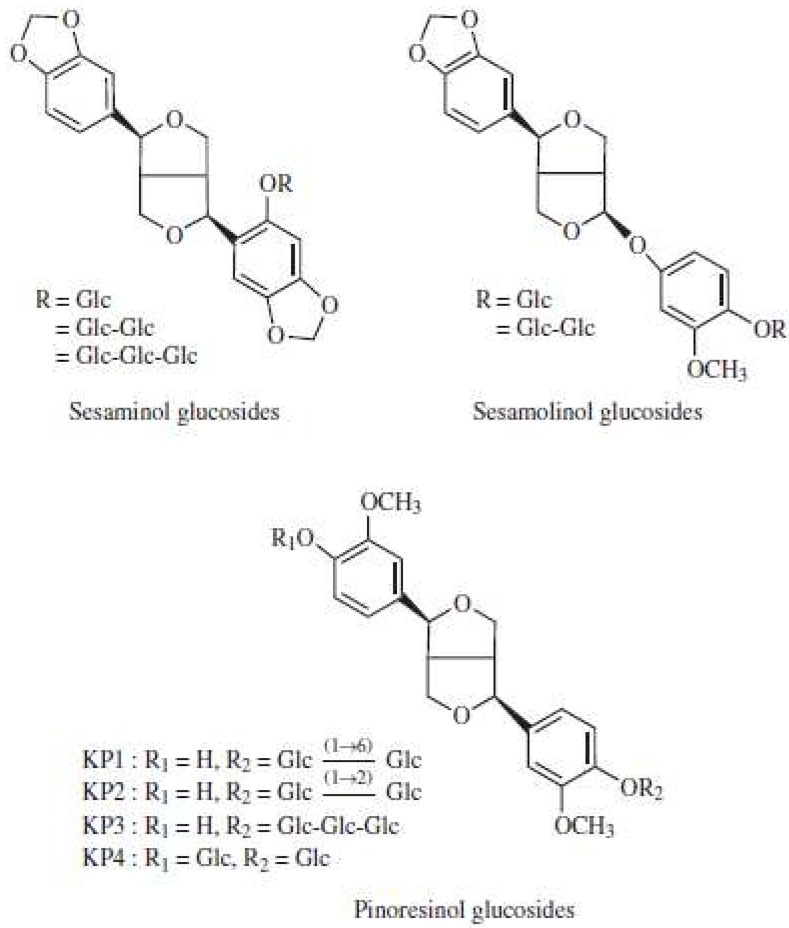


Figure 8. *Structures of lignan glycosides.*

Processing methods of sesame seed and products Sesame seed

processing is basically done to clean and dehull seed as well as to extract oil from seed. Sesame can be processed to several different stages, such as simply cleaning, or cleaning and dehulling, cleaning/dehulling/drying, cleaning/dehulling/drying/crushing for oil, etc. Generally, sesame seeds are cleaned, dehulled (important because of presence of tannins which are located in hulls). In Nigeria, dehulling is done by soaking in a salt solution overnight. Seeds are rubbed in a mortar to loosen pericarp and then kernel is separated from oat by sedimentation washing (NAERLS, 2010). After dehulling, seeds are washed and then dried usually with sun-drying.
Conditioning of oil seeds is an important operation in the production line of sesame oil.

These activities include roasting, flaking, size reduction, cooking, pre-pressing and drying.

Dehydrating and roasting of sesame seeds before oil expression improves sesame oil yield and quality. Also the oxidative stability of oil and by-products has been reported to depend on processing techniques and variety of seeds (Akinoso et al., 2010). Beniseed oil extraction is done traditionally in Nigeria by pounding the seeds in a mortar and pouring water into it (Tunde-Akintunde and Akintunde, 2007). The oil floats to the surface from where it can be removed by skimming. This method is slow and laborious and results in low oil yield. Other traditional methods involve crushing to paste using a local grinding machine. Boiling water is added to the paste, stirred and left for 24h. The oil floating on top of the paste is decanted and the process is repeated until negligible oil is formed (Fariku et al., 2007).

Another oil extraction method is to roast seeds for 5 – 19 minutes at 180 – 210 C$^{\circ}$ and then mill. Oil is pressed out by adding water to the milled product (NAERLS, 2010). After oil extraction, the cake is dried by sun drying and milled to obtain defatted flour. The processing of sesame products in the US is similar but the facilities used are different (Hansen, 2011). After harvesting, the seeds are cleaned and hulled. The seeds pass through an air separation stage to remove any foreign Particles. About 10 percent of this "cleaned natural seed" moves directly into food use as whole seed to be blended into flour for baked Goods. Next, a combination of water and friction work together as the seeds are passed against the chamber of the hulling machine to separate the hull from the seeds. This dust-free de-hulled seed makes up 30 percent of domestic production and has a 99.97 percent purity for the baked goods market. Once the seeds have been hulled, they are passed through an electronic color-sorting machine that rejects any discolored seeds to ensure perfectly colored sesame seeds. Immature or off-sized seed is removed but saved for oil Production. Sesame oil is extracted by pressure in a mechanical Expeller and is tolerant of only minimal heating by the extraction process. This pure, mechanically expressed oil is called “virgin” oil and is preferred by many food handlers. The oil is often blended with Other vegetable oils for salads and other food uses. Sesame oil should be kept refrigerated. Sesame seeds can become rancid if exposed to prolonged heat. If properly stored, the packed seeds have a 2-year shelf life with little reduction in quality (Hansen, 2011). A Dehulling method used for sesame in India is usually done by soaking the seeds

overnight in water, followed by drying and rubbing against a rough surface. The separated hulls are removed by winnowing. This method is also laborious, time consuming and suitable for processing small quantities only. A more convenient dehulling technique has been developed through addition of 3% Sodium Chloride (salt) and soaking overnight (Chemonics, 2002). The dehulled seed can be expeller pressed for obtaining good quality oil. The cake is further subjected to solvent extraction to recover the residual oil and the protein rich cake is used for protein fortification of various food preparations. An oil extraction process in India involves preliminary cleaning and grading,
Placing in a boiling solution of sodium hydroxide for a prescribed time and then thoroughly washing by a stream of water. The hulls are removed by washing and brushing seeds under a current of water. The dehulled wet seeds are then dried in a cross-flow or fluidized bed drier Sesame oil can be extracted from sesame by solvent extraction or mechanical expression. A solvent extraction procedure (soxhlet method) was reported by Nzioku et al. (2010). Dried sesame seeds w ere ground in the dry mill of a blender. 50 g of ground seeds were placed into a cellulose paper cone and extracted using light petroleum ether (b.p 40-60ºC) in a Soxhlet extractor for 8 h. The oil was then recovered by evaporating of the solvent using rotary evaporator and residual solvent was removed by drying in an oven at 60ºC for 1 h and flushing with 99.9% nitrogen. The hot
pressed oils are usually refined before consumption to remove free fatty acids, residues and all aromatic compounds resulting in a
Bland colorless oil. Refined oils are suited tothe cooking of the Western hemisphere where highly aromatic oils are not appreciated.

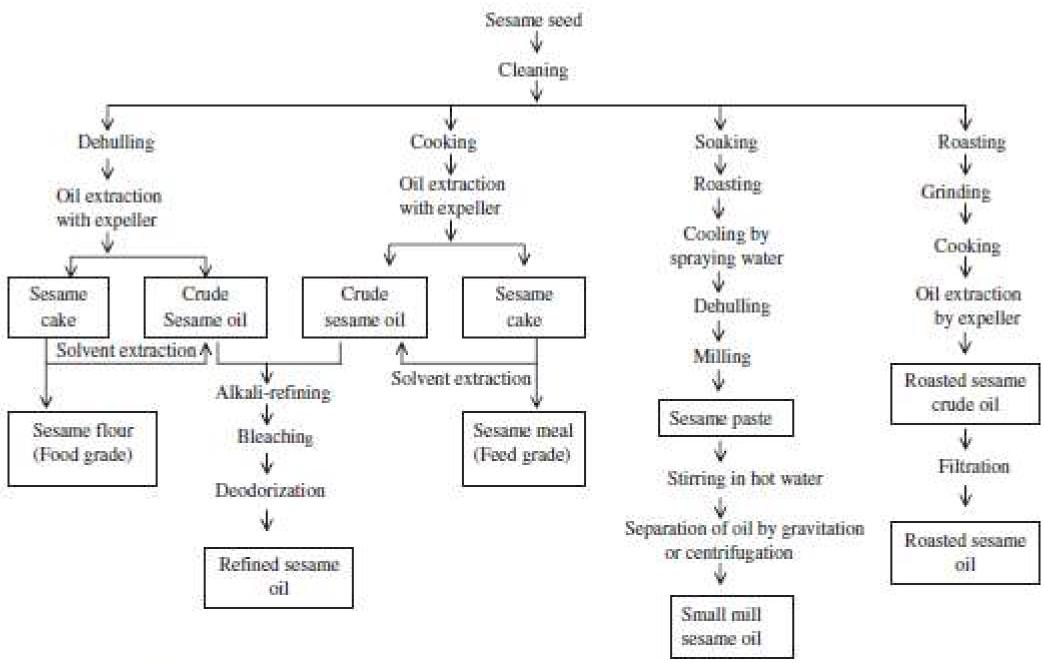


Figure 9. *Flow diagram showing the processing of different sesame oils.*

Extraction of Oil

The modern commercial methods of oil extraction from oilseeds include (1) batch hydraulic pressing: Oil seeds are expressed by hydraulic pressure to yield oil; (2) continuous mechanical pressing: Oil seeds are squeezed through a tapering outlet and oil is expressed by the increasing pressure; and (3) solvent extraction: Oil seeds are extracted with solvent followed by removal of solventto yield oil. These methods are also employed in the extraction of sesame seeds with some modification.

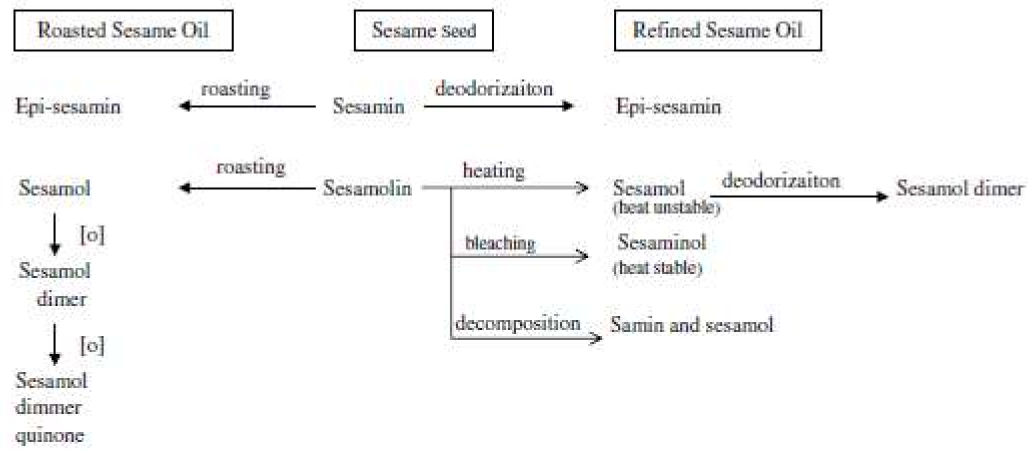


Figure 11. *Changes of sesame lignan during processing.*

Effect on Polyunsaturated Fatty Acid Metabolism

Linoleic acid and a-linolenic acid are essential fatty acids and are the important fatty acids involved in the metabolic pathway of prostaglandin synthesis. Converting linoleic acid to g-linolenic acid and dihomo-g-linolenic acid (DGLA) is catalyzed by _6-desaturase, whereas _5-desaturase catalyzes the transformation of
DGLA to arachidonic acid. Shimizu et al. reported that sesame oil could cause an accumulation of DGLA acid in the cell. Sesamin was discovered to be the active component in sesame oil; it can inhibit the activity of _5-desatursase. When rats were fed sesamin, there was an accumulation of DGLA in liver phospholipids and the ratio of DGLA to arachidonic acid increased. Arachidonic acid is the precursor of eicosanoids such as 2 series' prostaglandin and 4 series' leukotriene.
Consequently, sesamin tended to reduce the production of eicosanoids from arachidonic acid, and the plasma concentration of PGE2 was decreased. Sesamin lowered intestinal absorption of cholesterol by precipitating cholesterol from the bile acid micelles, and thus the serum cholesterol level is reduced .liver cholesterol concentration was also significantly lowered when rats were fed a sesamin-containing diet because of the reduction in the activity of liver microsomal 3-hydroxy-3-methylglutaryl coenzyme A reductase (HMGCoA reductase), the key enzyme in the cholesterol synthesis pathway of liver.

Sesamin thus possess a unique function in that it can simultaneously inhibit cholesterol synthesis and absorption. It is, therefore, a potential hypocholesterolemic agent of natural origin.

TABLE 13. Effect of Sesamin on the Concentrations of Serum Cholesterol, Liver Cholesterol, and the Liver Enzyme Activity.[1,2]

Diet	Serum Cholesterol (mg/dl)	Liver Cholesterol (mg/g liver)	Liver HMG-CoA Reductase (pmol/min/mg protein)
Exp. I			
Purified diet	108 ± 4^{a}	2.54 ± 0.13^{a}	203 ± 12^{a}
Diet + sesamin (0.5%)	110 ± 5^{a}	1.95 ± 0.06^{b}	151 ± 11^{b}
Diet + cholesterol (0.5%)	136 ± 8^{b}	20.8 ± 2.2^{c}	51.6 ± 2.0^{c}
Diet + cholesterol (0.5%) and sesamin (0.5%)	102 ± 5^{a}	9.13 ± 1.02^{d}	29.0 ± 2.4^{d}
Exp. II			
Commercial chow	69.1 ± 5.2^{a}	2.86 ± 0.19^{a}	269 ± 27^{a}
Chow + sesamin(0.5%)	55.5 ± 3.0^{b}	1.82 ± 0.04^{b}	172 ± 13^{b}

The combination of a-tocopherol with sesamin has a practical value for the treatment of hypercholesterolemia.

The cholesterol-lowering effect of sesamin has also been demonstrated in humans with dietary supplementation of sesamin at 64.8-mg/day level. The hypocholesterolemic effect of sesamin could be enhanced by a-tocopherol. Data shown in Table 14 clearly indicated that rats fed sesamin together with tocopherol (1%), the serum cholesterol-lowering effect of sesamin, could be demonstrated at a much lower level (0.05%). This synergistic effect was found to be related to both the levels of sesamin and cholesterol in the diet. The combination of a-tocopherol with sesamin has a practical value for the treatment of hypercholesterolemia.

TABLE 14. Combined Effects of Sesamin and α-Tocopherol on Serum Cholesterol Levels of Rats.[1,2]

Group	Serum Cholesterol (mg/dl)
Cholesterol diet	490 ± 94^{a}
Diet + 1.0% tocopherol	460 ± 70^{a}
Diet + 0.05% sesamin	437 ± 76^{a}
Diet + 0.05% sesamin + 1.0% tocopherol	$244 \pm 23^{b,c}$
Diet + 0.2% sesamin	$371 \pm 28^{a,c}$
Diet + 0.2% sesamin + 0.2% tocopherol	243 ± 5^{c}
Diet + 0.2% sesamin + 1.0% tocopherol	149 ± 9^{c}

Effect on Vitamin E

Sesame seed has long been regarded as a health food for longevity. Namiki et al. (113–115) examined the effect of sesame seed in aging by using a senescenceaccelerated mouse, and they have found that the advancement of senescence was suppressed by long-term feeding of sesame seed. Vitamin E is recognized as a food component that may exert an anti-aging effect (116). Sesame seed, however, contains mainly g-tocopherol whose Vitamin E activity is only 6–16% that of a-tocopherol (117, 118), although it exhibits a stronger antioxidative activity in vitro than a-tocopherol (119, 120). The effects of sesame seed and sesame lignans on Vitamin E activity were, therefore, studied extensively to elucidate if sesame is a good source of Vitamin E.

Yamashita et al. (121) first reported that sesame seed and its lignans could raise the bioactivity of g-tocopherol to almost the same level as a-tocopherol in rats. Later, they reported that sesame seed lignans could also act synergistically with a-tocopherol to enhance its Vitamin E activity in rats fed a low a-tocopherol diet

(122). Kamal-Eldin et al. (123) showed that feeding rats with sesamin, a lignan from sesame oil, increased g-tocopherol and g-/a-tocopherol ratio in the plasma, liver, and lung. Sesamin appears to enhance the bioavailabity of g-tocopherol in rat plasma and tissues, and this effect persists in the presence of a-tocopherol. Dietary sesame seed can also elevate the tocotrienol concentration in the adipose tissue and skin of rats fed tocotrienol-rich diet (124). The effect of sesame lignans on the Levels of tocopherols was also demonstrated in humans. In a study with 40 healthy Swedish women (mean age 26), serum g-tocopherol concentrations were raised significantly after consuming a diet that contained 22.5 g/day of sesame oil (125).

Coonery et al. (126) gave muffins containing equivalent amounts of g-tocopherol from sesame seeds, walnuts, or soy oil to nine volunteers; they observed that consumption of as little as 5 mg of g-tocopherol per day over a 3-day period from sesame seeds but not from walnuts nor soy oil significantly elevated serum g-tocopherol levels in the volunteers.

Effect on Blood Pressure

Sesamin, the most abundant lignan present in sesame seed and sesame oil, was demonstrated to suppress the development of hypertension in rats induced by deoxycorticosterone acetate (DOCA) and salt (127). Dietary sesamin was also reported to effectively prevent the elevation of blood pressure and cardiac hypertrophy in two-kidney, one-clip (2k, 1c) renal hypertensive rats (128). In the strokeprone spontaneously hypertensive rats (SHRSP), sesamin feeding was much more effective as an anti-hypertensive regimen in salt-loaded SHRSP (with 1% salt in drinking water) than in unloaded SHRSP (129).

Antioxidative Effect in Biological System

In the development of atherosclerosis, oxidative modification of low-density lipoprotein (LDL) is the critical step and is therefore a target for interventions aimed at slowing down the progression of atherogenesis (130). Antioxidants such as Vitamin E, probucol, and N, N0-diphenylphenylenediamine (DPPD) were suggested to prevent the oxidation of LDL (131–133). Sesame oil is highly resistant to oxidative deterioration because of the presence of endogenous antioxidants such as sesaminol, sesamolinol, pinoresinol, and P1. Sesaminol exerted a strong inhibitory effect on the 2, 20-azobis (2, 4-dimethylvaleronitrile) (AMVN)-induced peroxidation of LDL by acting as a chain breaker in the lipid peroxidation cascade in vitro (134). In inhibiting either Cu2-induced or 2, 20-azobis (2-amidinopropane) dihydrochloride (AADH)-induced lipid peroxidation in LDL, sesaminol was found to be more effective than a-tocopherol and probucol. Sesaminol was also the strongest antioxidant among the sesame lignans (sesamolinol, pinoresinol, and P1) for protecting LDL from oxidative modification (135). The reason for the strong antioxidative effect of sesaminol is possibly because of its highly lipophilic nature that makes it act within the LDL particle to exert a sparing effect on tocopherol (122, 123). The in vivo antioxidative activity of sesame lignan was examined in an animal model (136). When SD rats were fed a diet containing 1% sesamolin, the lipid peroxidation activity (measured as 2-thiobarbituric acid reactive substances, TBARS) in the liver and kidney was significantly lowered. The amount of 8-hydroxy-20-deoxyguanosine, a DNA base-modified product generated by reactive oxygen species and a good marker for oxidative damage (137), was also significantly lower in the sesamolin-fed rats. Sesamolin is one of the major sesame lignans present in the oil fraction of sesame; however, it does not possess any appreciable in vitro antioxidant activity (138). The significant in vivo antioxidative activity of sesamolin came from its metabolites, sesamol and sesamolinol, when sesamolin was supplemented in rats diet (136). Feeding rats with a diet containing 40% of dietary energy as either sesame, soybean, olive, or canola oils for 7 weeks, sesame oil was shown to be the most effective one in lowering lipid peroxidation (139). Sesame seeds rich in sesame lignans, sesamin and sesamolin, could lower the activities of enzymes involved in fatty acid synthesis, and thus the serum triacylglycerol levels were lower in rats fed diets high in sesame lignans (140). Sesame seeds contain two types of lignans, the oil-soluble lignans such as sesamin and sesamolin and the water-soluble lignan glycosides including pinoresinol glucosides (141) and sesaminol glucosides (142). Both of the glucosides were lower in peroxyl radical scavenging activity than their corresponding aglycones because of the lack of phenolic group. Using hypercholesterolimic rabbit as the animal model, Kang et al. (143) were able to demonstrate that dietary defatted sesame flour (containing 1% sesaminol glucoside) could decrease the peroxidation in liver and serum. Sesaminol, the principal metabolite of sesaminol glucoside and the active antioxidant, was found in abundant quantities in the serum and liver of rabbit (143).In an insulin-resistance animal model, rats were fed with high fructose diet in order to develop insulin-resistance, which was accompanied by a high oxidative stress status (144). When the insulin-resistant rats were given 1.0 g/kgBW of crude lignan glycosides, liver TBARS were significantly lowered and the insulin sensitivity was improved, indicating an alleviation of oxidative stress (145).

Effect on Cancer

Antioxidants are well recognized to play an important role in the defense against oxidative stress, which may cause damage to membrane, nucleic acid, and protein resulting in circulatory ailments, senility, mutation, and cancer (146). As sesame lignans possess antioxidative ability, their effect on the model systems for in vivo peroxidation, such as the peroxidation of ghost membranes of rabbit erythrocyte and the peroxidation of rat liver microsome, were investigated (147). Sesame lignans were found to suppress lipid peroxidation equal to or stronger than tocopherol in these systems. One of the sesame lignan, sesaminol, was observed to be as strongly suppressive as tocopherol in mutagenicity of E. Coli WP2s induced by peroxidation of membrane lipid of erythrocytes (147). As mentioned earlier that sesame lignans, especially sesamin and epi-sesamin, could influence the metabolism of polyunsaturated fatty acid and the production of prostaglandins. As prostaglandin is one of the most influential factors for mammary carcinogenesis, Hirose et al. (99) studied the effect of sesamin on dimethylbenzanthracene (DMBA)-induced mammary cancer. Their results showed that sesamin at a dietary level of 0.2% considerably reduced the cumulative number and mean number of mammary cancer; the effectiveness of sesamin was similar to atocopherol. The anti-tumor promotion activity of topically and orally admistered sesame components was tested in ICR mice using a two-stage skin tumorigenesis model (148). Skin tumor was initiated with 7, 12-dimethylbenz [a]-anthracene (DMBA) and promoted with 12-o-tetra-decanoylphorbol-13-acetate (TPA). The sesame components applied topically after TPA treatment were able to delay the formation of papilloma remarkably. It was suggested that sesame components had radical scavenging ability toward the reactive oxygen species or peroxidized molecules generated by TPA. Therefore, the inhibition of tumorigenesis by sesame components was the result of metabolic inactivation. When sesame components were admistered orally, the formation of skin papilloma was also inhibited effectively, indicating that the sesame components could be absorbed and remained active even after passing through digestive organs (149).

Sesamin, however, did not significantly reduce the number of N-nitrosobis-(2-oxopropyl)- amine(DOP)-induced pancreatic cancer in hamsters (150). It was noticed that 2% sesamol in the diet exerts forestomach carcinogenic activity in rats and mice (151). Fortunately, human beings do not have a forestomach and daily ingestion of sesamol is much lower than 2%.

Effect of sesame oil on CNS

Sesame seeds (*Sesamum indicum*, Linn, Pedaliaceae) have long been categorized as a traditional health food in Iran and other Asian countries. It has also been traditionally used to treat inflammatory disorders. A number of lipid-soluble antioxidants have been isolated from sesame seeds, including sesaminol, sesamolin, P1 and pinoresinol; sesame oil has been found to contain considerable amounts (up to 1.5%) of the sesame lignans, sesamin and sesamolin (Kang *et al.*, 1998).

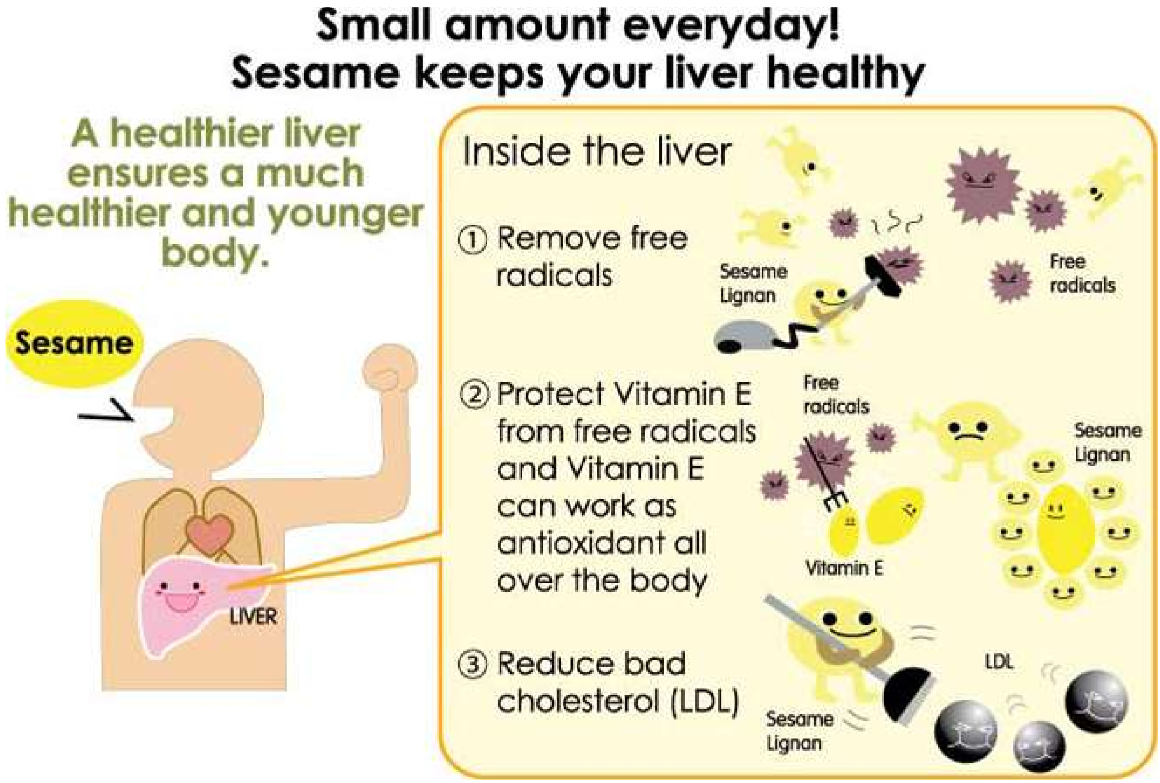
The lignans present in sesame oil are thought to be responsible for its antioxidant and anti-inflammatory properties. However, no previous study has examined the use of sesame oil in the treatment of MS or other TH1 cell-mediated inflammatory diseases of the CNS. In the present study, we examined the effect of sesame oil on the day of onset and severity of EAE, NO production, total antioxidant capacity and leukocyte infiltration into the brain.

Effect on Liver Function

Sesamin fed to rats at a level above 0.5% caused a temporary liver enlargement because of an increase in liver phospholipids; no specific histological changes were observed, and the activities of serum GOT and GPT remained unchanged (99, 106). It was suggested that sesamin could act as a stimulus to the liver function, particularly in the endoplasmic reticula. When mice were exposed to a high concentration of carbon tetrachloride or continuously inhaled ethanol to cause liver damage, sesamin was able to improve the liver function (152). Furthermore, rats previously given sesamin were found to reduce their plasma ethanol levels more rapidly than the control rats. This effect of sesamin on alcohol metabolism was studied in human trials. Male adults given sesamin (100 mg/day for 7 days) were found to have a significantly faster rate of ethanol reduction in their blood (153).

The effect of dietary sesamin and sesaminol on the ethanol-induced modulation of immune indices related to food allergy has also been studied. Although chronic ethanol drinking would increase the plasma IgA, IgM, and IgG concentrations,

0.2% sesamin in the diet could suppress this increase of IgA and IgM, whereas sesaminol was not effective. In addition, the increase in relative liver weight because of ethanol consumption was alleviated by dietary supplementation of sesamin but not by sesaminol (154).



Effects of sesame oil against after the onset of acetaminophen-induced acute hepatic injury in rats

BACKGROUND:

Acetaminophen (APAP) is a safe and effective analgesic and antipyretic when used at therapeutic levels. However, an acute or cumulative overdose can cause severe liver injury with the potential to progress to liver failure in humans and experimental animals. Much attention has been paid to the development of an antioxidant that protects against APAP-induced acute hepatic injury. Hence, we aimed to investigate the effect of sesame oil against after the onset of acute hepatic injury in APAP-overdosed rats.

METHODS:

Male Wistar rats were first given 2 oral doses (1,000 mg/kg each) of APAP (at 0 and 24 hours) and then 1 oral dose of sesame oil (8 mL/kg at 24 hours).

RESULTS:

After 48 hours, APAP increased aspartate and alanine aminotransferase levels in the rats' serum and centrilobular necrosis in liver tissue. In addition, APAP significantly decreased the rats' glutathione levels and mitochondrial aconitase activity, but increased superoxide anion, hydroxyl radical, and lipid peroxidation levels. Oral sesame oil (8 mL/kg, given at 24 hours) reversed all APAP-altered parameters and protected the rats against APAP-induced acute liver injury.

CONCLUSION:

We hypothesize that sesame oil acts as a useful agent that maintains intracellular glutathione levels and inhibits reactive oxygen species, thereby protecting rats against after the onset of APAP-induced acute oxidative liver injury.

Effect of Sesame Oil on Diuretics or ß-blockers in the Modulation of Blood Pressure

In the present study, substitution of sesame oil lowered systolic and diastolic blood pressure remarkably in hypertensive patients. Studies reported that sesamin, a lignan from sesame oil, exerts antihypertensive action by interfering with renin-angiotensin system, as the lignan is more effective on the renin-independent DOCA (Deoxycorticosterone acetate) -salt hypertension than on the renin-independent 2K (two kidney), 1C (one clip) renal hypertensive model. In another study using the rat aortic ring, sesamin produced Ca^{2+} antagonistic vasodilatory activity. This pharmacological action, at least in part, may contribute to its antihypertensive activity

Precautions

Sesame oil is not known to be harmful when taken in recommended dosages, though it is important to remember that the long-term effects of taking sesame-derived remedies (in any amount) have not been investigated. Due to lack of sufficient medical study, sesame oil should be used with caution in children, women who are pregnant or breast-feeding, and people with liver or kidney disease. Because of its laxative effects, sesame oil should not be used by people who have **diarrhea** .Sesame oil is best kept refrigerated to protect it from oxidation. It should also be protected from light and heat. While the oil may be added to cooked food, it should not be employed during the cooking process because high temperatures can compromise its therapeutic effects. In other words, do not use it during frying, boiling, or baking. Sesame oil may be used in a low temperature sauté without losing much of its medicinal value, according to some authorities. No more than 10% of a person's total caloric intake should be derived from polyunsaturated fats such as those found in sesame oil, according to the American Heart Association .while some body builders inject themselves with sesame oil to enhance muscles, this practice is not recommended and may be potentially dangerous. According to a report published in the Journal of the American Academy of

Dermatology in 2000, injecting sesame or other plant-derived oils may lead to the development of cysts. Scarring, skin thickening, and scleroderma or other connective tissue diseases may also occur as a result of such injections.

Adverse effects

Though sesame seeds have a wide range of health and commercial benefits, they have some anti-nutritional properties. Sesame seeds contain a high amount of the phytic acid which is an anti-nutrient. Another disadvantage of the seed is that it produces allergic reactions in some people. The allergy may be mild and appear as hives, dermatitis and itching or be severe and lead to severe physical symptoms like vomiting, pain abdomen, swelling of lips and throat leading to breathing difficulty, chest congestion and death. The laxative effect of sesame also indicates that sesame oil should not be used by people who have diarrhea.

Allergic effect of sesame oil

As with numerous seed and nut foods, sesame oil may produce an allergic reaction, although the incidence of this effect is rare at approximately 0.1% of the population. Reports of sesame allergy are growing in developed countries during the 21st century, with The allergic mechanism from oil exposure expressed as contact dermatitis, possibly resulting from hypersensitivity to lignin-like compounds

Further studies

Based on different research studies carried out on sesame seed, the following studies can be further carried out on sesame seeds and its products to enhance its utilization especially in Nigeria:

- The seed could be further explored to develop a high crude oil yield variety that would be of immense nutritional and economic advantage (Adebowale et al, 2010)
- The high percentage of oil makes this seeda distinct potential for the oil industry (Nzikou et al., 2009).
- The high unsaponifiable matters content (1.87%) of sesame oil guarantees the use of the oil in cosmetics industry. The oil extracts

exhibited good physicochemical properties and could be useful for industrial applications (Nzikou et al., 2010).

•Extensive research work still needs to be carried out on sesame seed for its industrial utilization as a biofuel resource material in Nigeria (Fariku et al., 2007)

Conclusion

Sesame oil is derived from a plant species called *Sesamum indicum*, which is a herbaceous annual belonging to the Pedaliaceae family that reaches about 6ft (1.8 m) in height. Sesame has been used for millennia in Chinese and Indian systems of medicine. Though often recommended as a laxative, the herb was used as early as the 4th century a.d. as a Chinese folk remedy for toothaches and **gum disease**. In modern times, sesame has been embraced by Western herbalists for a variety of therapeutic purposes. The oil is also used in cooking and as an ingredient in margarine and salad dressings as well as in certain cosmetics and skin softening products. Native to Asia and Africa, sesame is primarily cultivated in India, China, Africa, and Latin America. Only the seeds and oil of the sesame plant are used for medicinal purposes. Sesame oil, which is also referred to as benne, gingili, or teel oil, is made from the black seeds of *Sesamum indicum*. The large round seeds are extracted by shaking the dried plant upside down after making an incision in the seed pods. The oil and seeds are believed by herbalists to have several important properties, including anticancer, antibacterial, and anti-inflammatory effects. Some of these claims have been supported by cell culture and human studies. Sesame may also have some power as an analgesic. In *The Green Pharmacy*, the prominent herbalist James Duke states that sesame contains at least seven pain-relieving compounds and is a rich source of **antioxidants** and other therapeutic agents. Some authorities believe that sesame also has weak estrogen-like effects. Sesame oil is high in polyunsaturated fat. When used in moderation, this type of fat can benefit the heart by helping the body to eliminate newly made **cholesterol**, according to the American Heart Association. Nutrition and digestion While not approved by the Food and Drug Administration (FDA) as a medication, sesame oil is reputed to have a number of therapeutic uses. Its centuries-old reputation as a laxative persists to this day. It is also used to treat blurred vision, **dizziness**, headaches, and to generally fortify the constitution during recuperation from severe or prolonged illness. When used in place of saturated fats, sesame oil may help to lower cholesterol levels and prevent **atherosclerosis**. The optimum daily dosage of sesame oil has not been established with any certainty. People generally take 1 tsp of the oil at bedtime to relieve **constipation** .Vaginal dryness associated with **menopause** may be relieved by following this procedure: Soak a quilted cotton cosmetic pad in sesame oil and then wring out the excess oil. A freshly treated cotton square may be inserted into the vagina overnight and removed each morning for seven days. After the first week, this treatment is typically used once a week (or as often as needed) as a form of maintenance therapy. To relieve **anxiety** or insomnia, place one drop of pure raw sesame oil into each nostril. Because sesame oil has been recommended for so many different purposes, and can be used internally and externally, consumers are advised to consult a doctor experienced in the use of alternative remedies or Chinese/Ayurvedic medicine to determine the proper dosage. Sesame seed possess many health promoting effects, some of which have been attributed to a group of compounds called lignans (sesamin, sesamolin, sesaminol and sesamolinol). Sesame seed also contains lignan aglycones in oil and lignan glucosides. Sesame seed is rich in oil, contains high amounts of (83-90%) unsaturated fatty acids, mainly linoleic acid (37-47%), oleic acid (35-43%), palmitic (9-11%) and stearic acid (5-10%) with trace amount of linolenic acid. The seeds are a rich source of antioxidants and bioactive compounds including phenolics, phytosterols, phytates, PUFA and short chain peptides. Sesame cake is a rich source of protein, carbohydrate and mineral nutrients. Sesame seeds have special significance for human nutrition on account of its high content of sulfur amino acids and phytosterols. The antioxidative agents (sesamin, sesamolin, sesamol, their glycosylated forms sesaminol glucosides and tocopherol make the oil very stable and therefore it has a long shelf life. Among the vitamins in the sesame seed, the presence of vitamin E is very interesting in relation to the effectiveness of sesame seed as a health food. Sesame seed is an oil-seed crop, with edible and odorless oil, and with good source of protein for man and livestock. Its utilization in Nigeria is however mainly for exports and limited local household use within regions in which it is grown in the nation. This is because the low level of information on the Nigerian variety has limited its utilization nationally but information available on international varieties has however made its utilization as an export crop more prominent than being used for home consumption. The greater water absorption capacity and oil absorption capacity indicated the suitability of defatted flour for the preparation of cake, biscuit, sausages, noodles and other macaroni products. Study on modification of protein to reduce the protein denaturation temperature through various method of processing will throw light on further value addition towards the preparation of high protein food supplement using defatted sesame flour like soy flour.

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