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New York State Integrated Pest Management Program | Cornell Cooperative Extension

Sesame and Sesame Oil Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

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Active Ingredient Name: Sesame (including ground plant) and Sesame Oil

Active Components: Lignins; Sesamin and Sesamolin

CAS Registry #: 8008-74-0 (Sesame Oil)
607-80-7 (Sesamin)
526-07-08 (Sesamolin)

U.S. EPA PC Code: 072401 (Sesame oil)
128970 (Sesame plant)

CA DPR Chem Code: 2585 (Ground Sesame)
1221 (Oil of Sesame)

Other Names: Sesame, Oil of Sesame, Ground Sesame Plant, Sesame Oil, Benne Oil, Benniseed, Gingilli Oil, Sextra, Teel Oil, Sesame indicum L.

Other Codes: Caswell 733; RTECS 3940000

Summary: Sesame is an extensively grown food plant producing both edible seeds and oils. Various parts of the plant are used as pesticides. Sesame oil may be used as an insecticide with suffocating and synergistic modes of action. Ground sesame stalks, sesame chaff, and the sesame cake that is a by-product of oil manufacturing are either mixed into soil before planting or applied as a mulch around growing plants to control harmful nematodes.

Pesticidal Uses: Nematicide, insecticide, antimicrobial, fungicide, herbicide, rodenticide.

Formulations and Combinations: Used as a synergist with pyrethrins and synthetic pyrethroids. Sesame oil may be formulated with essential oils, such as thyme oil; with other vegetable oils, such as corn, soybean and cottonseed oil; and with emulsifiers, such as lecithin. Sesame chaff and ground sesame cake may be combined with diatomaceous earth.

Basic Manufacturers: Primary/basic manufacturers: Sesaco, Joyva (US); Dipasa (Mexico); A-Dalamai; Chee Seng, Iwai, Oh Aik Guan, Marathon Globe (Asia). Fediol, Unilever (Europe).

This document profiles an active ingredient currently eligible for exemption from pesticide registration when used in a Minimum Risk Pesticide in accordance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) section 25b. The profile was developed by the New York State Integrated Pest Management Program at Cornell University, for the New York State Department of Environmental Conservation. The authors are solely responsible for its content. The Overview Document contains more information on the scope of the profiles, the purpose of each section, and the methods used to prepare them. Mention of specific uses are for informational purposes only, and are not to be construed as recommendations. Brand name products are referred to for identification purposes only, and are not endorsements.

Safety Overview: The EPA concluded that given sesame's long history as a food crop and edible oil, no adverse effects are expected from use of ground sesame stalks as an active ingredient mixed into soil or applied as a mulch. No harmful effects have been reported in humans, in livestock that feed on leftover stalks, or as a result of mixing the stalks into soil after harvesting the seeds (US EPA 2001).

Background

The sesame plant (*Sesamum indicum*) is cultivated in tropical and subtropical regions of the world. Both the seeds and the oil are used for food. Other species of *Sesamum* include *S. alatum, S. orientale* and *S. radiatum.* Sesame is an important food plant, both as a cooking oil and for edible seeds.

In 2013, the leading countries for the production of sesame were China, India, Myanmar and Sudan (FAO 2015). The US is a minor producer of sesame, with about 17,500 acres planted in 2012 (USDA NASS 2015). Texas was the leading state for production; other states that produced sesame include California, Oklahoma, Alabama, Florida and South Carolina. Sesame oil ranks the eighth most produced edible oil in the world (Hwang 2005).

Sesame oil can be extracted a number of different ways, but the traditional method is hot water flotation. Seeds are ground into a paste and heated to 80-90°C, then boiling water is poured over it. The oil floats to the top, where it is physically separated from the water (Warra 2011). Another method is to cold press the seed and expel the oil. Industrial scale production generally involves the use of hexane as a solvent for extraction, although supercritical carbon dioxide can also be used.

Both the seed coat and the oil are rich in polyphenolic compounds with anti-oxidant properties known as lignans (Grougnet et al. 2011; Sacco and Thompson 2011). Lignans do not react to strong bases to make salts of fatty acids, and are thus part of the unsaponifiable portion of the oils. The lignan found in greatest quantity in sesame is sesamin, which makes up about 0.1-0.6% of sesame oil (Kamal-Eldin 2011). Sesamin is considered one of the more biologically active constituents with respect to insects and nematodes, as discussed further in the efficacy section. For this reason, where values are missing for the parameters and available for sesamin, the values of sesamin are reported.

The oil can be applied to foliage. The chaff created from separating the seeds, as well as the sesame cake that is a by-product of removing the oil from the seed, can both be soil applied to suppress soilborne pests and diseases.

Chemical and Physical Properties

The chemical and physical properties of sesame, sesame oil, and the active constituent sesamin are summarized in Table 1.

Table 1
Physical and Chemical Properties of Sesame, Sesame Oil and Sesamin

Property	Characteristic/Value	Source
Molecular Formula:	Sesamin: $C_{20}H_{18}O_6$	(ChEBI 2015)
Molecular Weight:	Sesamin: 354.35 g/mol	(Sigma-Aldrich 2014)
Percent Composition:	Sesame seed: 50% oils, 23% carbohydrates, 18% protein, 12% total dietary fiber Sesame oil: Triacylglycerols (95%), diacylglycerols (2.6%), free fatty acids (0.1%), other lipids, including phospholipids and other unsaponifiables (2.3%)	(Sacco and Thompson 2011; Kamal-Eldin 2011)
Physical state at 25°C/1 Atm.	(Oil) liquid (Ground plant) solid	(Merck 2015)
Color	Pale yellow	(Merck 2015)
Odor	Almost odorless	(Merck 2015)
Density/Specific Gravity	Relative Density (Oil): 0.920 g/mL @ 25˚C	(Sigma-Aldrich 2015)
Melting point/Solidification point	(Sesame oil) -5°C (Sesamin) 123° C	(USP 2008; Royal Society of Chemistry 2015)
Boiling point	(Sesamin) 504°C	(Royal Society of Chemistry 2015)
Solubility	Soluble in petroleum ether, slightly soluble in alcohol, insoluble in water	(Merck 2015)
Vapor pressure	(Sesamin) 2.07 x 10^{8} mm Hg at 25°C	(EPI 2012)
pH	Not found	
Octonol/Water (K_{ow}) coefficient	0.68	(EPI 2012)
Viscosity	η = 60 mPa□s	(Thomas 2000)
Miscibility	Miscible with chloroform, solvent hexane, carbon disulfide	(Merck 2015)
Flammability	Flash Point: >255˚C	(US EPA ACTOR 2015)
Storage stability	Stable, incompatible with strong oxidizing agents, unstable in excess heat or light.	(Sigma-Aldrich 2014)
Corrosion characteristics	Not corrosive in presence of glass	(ScienceLab 2013)
Air half life	(Sesamin) 2 hr	(EPI 2012)
Soil half life	(Sesamin) 1,900 hrs	(EPI 2012)
Water half life	(Sesamin) 900 hrs	(EPI 2012)
Persistence	(Sesamin) 997 hrs	(EPI 2012)

Sesame oil is relatively high in unsaponifiable matter, meaning that, when reacted with a strong alkali solution such as sodium or potassium hydroxides, a significant portion of between 2 and 3% does not react to form soap (Hwang 2005). These lipids are in the form of sterols and lignans. Roasting the seeds before extraction increases the yield and saponifiable matter, but also reduces the amount of antioxidants and turns the oil brown.

Human Health Information

The EPA reported no harmful effects have been reported from the use of ground sesame stalks despite sesame's long history as a cultivated crop, and no risks to humans are expected from such use (US EPA 2001). Sesame oil has a long history of use as a food.

Acute Toxicity

The acute toxicity values of sesame oil are reported in Table 2.

Table 2

Acute Toxicity of Sesame Oil

Study	Results	Source
Acute oral toxicity	LD50-mouse: >50g/kg bw	(EPA ACTOR 2015)
Acute dermal toxicity	LD50-rabbit- >2000mg/kg	(Sigma Aldrich Co. 2015 MSDS)
Acute inhalation	Not found	
Acute eye irritation	Not found	
Acute dermal irritation	Skin irritation/corrosion-human-mild irritation-3h	(Sigma Aldrich Co. 2015 MSDS)
Skin sensitization	Not found	

Sub-chronic Toxicity

The sub-chronic toxicity values of sesame and sesame oil are reported in Table 3.

Table 3

Sub-chronic Toxicity of Sesame and Sesame Oil

Study	Results	Source
Repeated Dose 28-day Oral Toxicity Study in Rodents	Rats: Elevated tocopherol levels (Sesame seed).	(Ikeda, et al. 2002)
90 day oral toxicity in rodents	Not found	
90 day oral toxicity in non-rodents	Swine: Adverse effects observed at 500 mg/kg. (Sesame oil)	(HSDB 2015)
90 Day dermal toxicity	Not found	
90 Day inhalation toxicity	Not found	
Reproduction/development toxicity screening test	Not found	
Combined repeated dose toxicity with reproduction/development toxicity screening test	Not found	
Prenatal developmental toxicity study	Not found	
Reproduction and fertility effects	Not found	

Sesame oil has been studied extensively for its use as a carrier, adjuvant and excipient used in pharmaceuticals. Several studies noted that sesame oil and its lignans act as anti-hypertensives (HSDB 2015).

Rats fed roasted white sesame seeds and the lignans sesamin and sesaminol had significantly lower levels of tocopherols (Ikeda et al. 2002). Another study found that rats fed a diet containing sesamin at levels above 0.5% frequently showed enlargement of the liver, although no abnormal tissue changes were observed (Namiki 1995). A 17-week (119 day) experiment feeding swine brominated sesame oil noted marked lethargy, ataxia, and elevated levels of blood serum enzymes linked to cellular breakdown at the highest dosage rate of 500 mg/kg body weight per day. Males fed the highest doses showed marked testicular atrophy (Farber et al. 1976). According to the authors, some of the toxic effects may have been due to the accumulation of bromine rather than the sesame oil.

A segment of the population is known to be allergic to sesame (Teuber 2011). The emergence has been relatively recent, with the first US case reported in 1950 (Rubenstein 1950). World-wide sesame allergies seem to be increasing both in incidence and severity (Gangur et al. 2005). Sesame allergies are characterized as similar in exposure and symptoms to allergies to peanuts and tree nuts. Symptoms include abdominal pain (Caminiti et al. 2006; Dano et al. 2015), contact dermatitis (Neering et al. 1974; Pecquet et al. 1998; Oiso et al. 2008), asthma (Gangur et al. 2005; Dano et al. 2015) and in extreme cases anaphylaxis (Asero et al. 1999; Chiu and Haydik 1991; Malish et al. 1981). One death by anaphylactic shock in the UK was attributed to exposure to sesame (Pumphrey and Gowland 2007). Among the most sensitive members of the population, the threshold dose may be as low as two seeds (Dano et al. 2015).

Chronic Toxicity

The chronic toxicity values of sesame oil are reported in Table 4.

Table 4

Chronic Toxicity of Sesame Oil

Study	Results	Source
Chronic toxicity	Ames Test: Negative	(HSDB 2015)
Carcinogenicity	Equivocal	(Sheftel 2000)
Combined chronic toxicity & carcinogenicity	Not found	

Sesame and sesame oil are not identified as a carcinogen by the International Agency for Research on Cancer (International Agency for Research on Cancer, World Health Organization 2014). Neither appear on the California Proposition 65 list of known carcinogens (Cal-EPA 1997) or the Toxics Release Inventory (TRI) Basis of OSHA Carcinogens (US EPA Toxics Release Inventory Program 2015).

However, sesame oil and its constituents are equivocal carcinogens. While most animal model studies have been negative, some show potential carcinogenicity. Sesame oil injected into mice at 2 g/kg bw/day for a week yielded the determination it was an equivocal carcinogen by RTECS criteria (Sheftel 2000). An earlier study found that some rats fed the sesame lignan sesamol developed malignant tumors, while the control group had no lesions (Ambrose et al. 1958). A broader survey of the literature of sesame and cancer found mixed results (Mak et al. 2011).

Sesame and its components also have been correlated with reduced cancer incidents. Male rats fed a diet with 250 and 500 ppm sesamol had results that suggested lower levels of colon cancer (Sheng et al. 2007). An epidemiological study in Korea showed an inverse relationship between sesame oil consumption and stomach cancer, but the study noted a number of other foods with similar correlations (Lee et al. 1995).

Human Health Incidents

One human health inquiry involving sesame oil was received by the National Pesticide Information Center (NPIC) between April 1, 1996 and March 30, 2016 (NPIC 2016). The incident was with a registered pesticide and involved another active ingredient; sesame oil was a synergist.

Environmental Effects Information

Effects on Non-target Organisms

No data was found regarding the effects of sesame and sesame oil on non-target organisms. No incidents involving non-target organisms exposed to sesame oil were received by NPIC between April 1, 1996 and March 30, 2016 (NPIC 2016).

No harmful effects for sesame stalks have been reported for wildlife and none are expected (US EPA 2001).

Environmental Fate, Ecological Exposure, and Environmental Expression

Table 5
Environmental Fate, Ecological Exposure, and Environmental Expression of Sesame and Sesame Oil

Study	Results	Source
Leaching series	Not found	
Photodegradation in water	Not found	
Photodegradation in air	Not found	
Photodegradation in soil	Not found	
Ready biodegradability	Expected to be readily biodegradable	(HSDB 2015)

Environmental Incidents

No studies were found that suggest sesame or sesame oil used as pesticides have any adverse environmental impacts. Between April 1, 1996 and March 30, 2016, NPIC received one report of an incident involving a misapplication of sesame oil in a registered pesticide (NPIC 2016).

Efficacy

Insecticidal Activity

Data on sesame oil's efficacy as a stand-alone insecticide is limited. However, there is a large body of literature about the efficacy of sesame oil and its active constituents sesamin and sesamolin as synergists. Sesame oil was first recognized as a synergist with the botanical insecticides pyrethrin and rotenone on the common housefly (*Musca domestica*) (Eagleson 1940). The synergistic effect was enhanced by various solvents (Simanton 1949). The active components were later discovered to be sesamin (Haller et al. 1942) and sesamolin (Beroza 1954). Synthetic analogs of sesame were subsequently developed and formulated to be used with both natural pyrethrins and synthetic pyrethroids (Beroza 1956). More efficient means were later discovered to concentrate the sesamin and sesamolin (Tracy 1958). While sesame oil is used in both of these cases as the feedstock, the products of these processes are chemically different.

Nematicidal Activity

Sesame's effectiveness at suppressing nematodes when used as a rotation crop has been studied in a number of tropical and subtropical farming systems. Sesame planted in rotation with nematode-susceptible peanuts and soybeans reduced populations of the peanut root knot nematode (*Meloidogyne arenaria* Chitwood), the southern root knot nematode (*M. incognita* Chitwood), the soybean cyst nematode (*Heterodera glycines* Ichinohe), and inhibited reproduction of the root lesion nematode (*Pratylenchus brachyurus*) (Rodriguez-Kabana et al. 1988). Okra (*Abelmoschus esculentus*) intercropped with sesame had reduced *M. incognita* penetration compared with a monoculture control (Tanda and Atwal 1988. The effectveness of sesame chaff as a nematicide is documented. Its mode of action against nematodes does not appear to be biocidal, and one source posited that it would be more correctly referred to as a root protectant (McKenry 1994).

Standards and Regulations

EPA Requirements

Both the ground sesame plant and sesame oil can be used as active ingredients in pesticide products that are exempt from registration [40 CFR 152.25(f)]. Because there are no EPA-registered products made with sesame plants or ground sesame stalks, the agency announced it was not conducting a registration review [73 FR 16677].

Sesame and sesame stalks are exempted from the requirement of a tolerance in or on the following raw agricultural commodities: Almonds, pecans, walnuts; cotton (undelinted seed and gin byproducts); soybeans (seed, forage and hay); beets (sugar roots and tops); potatoes, tomatoes, bell pepper, eggplant; squash, cucumbers, melons; strawberry; carrots, radishes, turnips, onions; peas (dry and fresh); grapes; walnut; apples, grapes, oranges, grapefruit; apricots, cherry, peaches, plums; blackberries, cranberries, loganberries, mulberries; and aspirated grain fractions [40 CFR 180.1087]. In 2008, EPA affirmed that the exemptions from tolerance were compliant with the law and further risk assessments and submission of data were not necessary (Andersen 2008).

FDA Requirements

Sesame seeds and sesame oil are considered foods. The FDA does not require it to be labeled as an allergenic food, even in trace quantities (Teuber 2011).

Other Regulatory Requirements

Sesame and sesame oil are non-synthetic and are not on the list of prohibited synthetic substances, therefore they are allowed under the USDA's National Organic Program standards [7 CFR 205].

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