New York State Integrated Pest Management Program
Cornell Cooperative Extension

Linseed Oil Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

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Label Display Name: Linseed oil

Active Components: Linseed oil: α-linolenic acid and other oleic acids

CAS Registry #: 8001-26-1 (raw)
68553-15-1 (boiled)

U.S. EPA PC Code: 031603

CA DPR Chem Code: 2644

Other Names: Flax oil, Flaxseed oil, LSO, BLO, BLSO, Leinol, Linseed fatty acids, Huile de lin (French)

Other Codes: RTECS OI9690000

Summary: Linseed oil is an edible oil derived from the flax plant. It is high in α-linoleic acid and has unique hydrophobic properties that help it to reduce moisture and seal porous surfaces. These properties are believed to be responsible for its effective reduction of microorganisms and fungal infections. The primary pesticidal use of linseed oil is to control fungi and other decay organisms in wood. Linseed oil is also a commonly used carrier, adjuvant, and inert ingredient in pesticide formulations. The EPA last reviewed the registration of linseed oil in 1993, prior to its being listed as a 25(b)-eligible active ingredient in 1996. Despite its long history, there is very little data on its safe use.

Pesticidal Uses: Antimicrobial, fungicide, herbicide, insecticide, and rodenticide. Also used as an inert ingredient and adjuvant.

Formulations and Combinations: When used as a wood preservative treatment, linseed oil is often combined with various metallic catalysts and other synthetic chemicals. Turpentine oil and various naphthenic compounds may also be used in wood preservative treatments, although these formulations are not 25(b) exempt. Formulations sometimes combine linseed oil with beeswax or various essential oils. Non-exempt pesticide formulations may include other fungicides, as well as aromatic petroleum solvents. In particular, formulations of pressure treated lumber using copper chromium arsenate or creosote will use linseed as a penetrating and drying oil to enhance the efficacy of the active ingredients declared on the label.

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.

Basic Manufacturers: Arista, Ferro/Bedford, Penta, Ruger, Spectrum Chemical.

Safety Overview: Very little toxicity data is available for linseed oil, though it can harm skin and be allergenic.

Background

Linseed oil is commonly marketed as a food under the name flaxseed oil. It is derived from the dried ripe seeds of the flax plant, *Linum usitatissimum,* and consists of the glycerides of linolenic, linoleic, oleic, stearic, palmitic, and myristic acids (Merck 2015). The presence and relatively high levels of α-linolenic acid (ALA) make it the only terrestrial plant food that has relatively high levels of omega-3 fatty acids. Linseed oil also contains antioxidant tocopherols, as well as phosphatides and sterols. The fatty acids in linseed oil will polymerize when exposed to air.

Evidence of the cultivation of flax and the crushing of its seeds to make linseed oil dates back at least to the Bronze Age (Thomas 2000) and possibly earlier. Ancient Egyptians used linseed oil in paints and preservatives (Hasenhuettl 2000). Flax became one of the first oilseeds produced on an industrial scale, with many non-food as well as food uses (Vaisey-Genser and Morris 2003).

Linseed oil is one of the oldest wood preservatives. Other applications include varnishes, paints, putties, and use in the manufacture of linoleum.

The extraction process for industrial linseed oil usually involves pre-expression followed by hexane extraction of the press cake (Thomas 2000). Food grade flaxseed oil is cold pressed and filtered to remove impurities (Peterson 2008). Waxes and gums may be removed by chilling and skimming, a process known as 'winterization' (Hasenhuettl 2000). These products are all considered raw or native linseed oils.

Linseed oil can be further processed in numerous ways. One of the oldest is boiled linseed oil, where linseed oil is heated to a temperature in excess of 100°C, usually in the presence of a metal catalyst such as cobalt, lead, or manganese (Poth 2001). The treatment significantly shortens drying time and increases the polymerization needed to create a tight seal. Because of environmental regulations, lead use was restricted, but manganese or cobalt catalysts are still widely used (Wicks 2000). Other chemical treatments may be applied, such as bleaching, epoxidation, maleation, and vinylization (Hasenhuettl 2000; Wicks 2000; Thomas 2000). For the purposes of this profile, only data for raw linseed oil is presented unless specified otherwise.

The last EPA registration review for linseed oil took place in 1993 before it was made an eligible active ingredient for minimum risk pesticides (US EPA 1993). At that time, there were no EPA-registered products that contained linseed oil as an active ingredient and no manufacturer submitted data in support of continued registration as an active ingredient. Linseed oil was also mentioned in the original scope document for 'fruit and vegetable oils' in the most recent flower and vegetable oils registration review (Moore 2010). However, subsequent documents in that docket do not refer specifically to linseed oil. Furthermore, no currently EPA-registered pesticides with linseed oil as an active ingredient were found in the EPA's database (US EPA 2016).

Chemical and Physical Properties

The physical and chemical properties of linseed oil appear in Table 1.

Table 1

Physical and Chemical Properties of Linseed Oil

Property	Characteristic/Value	Source
Molecular Formula:	N/A	
Molecular Weight:	N/A	
Percent Composition:	5-6% saturated fatty acids, 93-94% unsaturated fatty acids, <1% phosphatides, tocopherols and sterols	(Thomas 2000)
Physical state at 25°C/1 Atm.	Liquid	(Merck 2015)
Color	Yellowish	(Merck 2015)
Odor	Peculiar odor, bland flavor	(Merck 2015)
Density/Specific Gravity	0.925-0.935	(Merck 2015)
Melting point	-19°C	(Milne 2004)
Boiling point	343°C	(Milne 2004)
Solubility	Slightly soluble in alcohol; soluble in chloroform, diethyl ether and carbon disulfide	(Merck 2015; Milne 2004)
Vapor pressure	1.66×10^{-17} mg Hg at 25°C	(EPI 2012)
pH	N/A	
Octonol/Water (K_{ow}) coefficient	22.22	(EPI 2012)
Viscosity	η = 48 mPa·s at 20°C	(Thomas 2000)
Miscibility	chloroform, ether, petroleum ether, carbon disulfide, oil turpentine.	(Merck 2015)
Flammability	Not flammable or combustible	(Sigma-Aldrich 2014)
Storage stability	Stable, but polymerizes gradually on exposure to air.	(Cargill 2009)
Corrosion characteristics	Not found	
Air half life	0.175 hrs	(EPI 2012)
Soil half life	1,800 hrs	(EPI 2012)
Water half life	900 hrs	(EPI 2012)
Persistence	1,060 hrs	(EPI 2012)

Linseed oil is described as a drying oil (Milne 2004), and its highly hydrophobic nature is believed to be a mode of action, particularly as a wood preservative fungicide. Linseed oil's high concentration of omega-3 fatty acids gives it a distinct fishy odor. When exposed to sunlight, linseed oil oxidizes and quickly becomes rancid.

Human Health Information

Acute Toxicity

No acute toxicity data for linseed oil was found.

Raw flaxseed is essentially free of compounds that cause acute toxicity (Muir and Westcott 2003). A search of HSDB, ToxNet, and various other sources found no evidence that raw linseed oil has ever had acute toxicity testing performed. Although considered edible when extracted without further treatment, some fractions of boiled linseed oil were found to be fatally toxic to mice (HSDB 2015). However, no LD_{50} figures were given in the study report. Exposed skin can become sensitive on contact with raw linseed oil (Sigma-Aldrich 2014).

Sub-chronic Toxicity

The sub-chronic toxicity of linseed oil appears in Table 2.

Table 2

Sub-chronic Toxicity of Linseed Oil

Study	Results	Source
Repeated Dose 28-day Oral Toxicity Study in Rodents	Not found	
90 day oral toxicity in rodents	Rats: No Adverse Effects Observed at 10% of diet over 130 days.	(HSDB 2015)
90 day oral toxicity in non-rodents	Not found	
90 Day dermal toxicity	Not found	
90 Day inhalation toxicity	Not found	
Reproduction/development toxicity screening test	Chickens: Reduced growth when fed boiled linseed oil.	(HSDB 2015)
Combined repeated dose toxicity with reproduction/ development toxicity screening test	Not found	
Prenatal developmental toxicity study	Rats: Higher than normal mortality when fed boiled linseed oil. Survivors had atrophied livers.	(HSDB 2015)
Reproduction and fertility effects	Not found	

When measuring dietary cholesterol in rats and mice, studies found a diet containing linseed oil had lower levels than a diet of other vegetable oils or animal fats, and a fish oil diet produced the lowest levels (HSDB 2015).

Like other plant-derived compounds, flaxseed can cause allergic reactions. Most of the incidents reported in the literature are from the ingestion of flaxseed, flaxseed meal or exposure to the dust from the processing of flax fiber (Muir and Westcott 2003). However, one incident involved a 40-year-old woman who swallowed a spoonful of linseed oil as a laxative. She had an anaphylactic reaction within ten minutes (Alonso et al. 1996). A number of the studies looked at boiled linseed oil, which appears to have a different toxicity profile than raw linseed oil.

Chronic Toxicity

The chronic toxicity of linseed oil appears in Table 3.

Table 3

Chronic Toxicity of Linseed Oil

Study	Results	Source
Chronic toxicity	Negative	(HSDB 2015)
Carcinogenicity	Not found	
Combined chronic toxicity & carcinogenicity	Not found	

Linseed oil is not identified as a carcinogen by the International Agency for Research on Cancer (IARC, World Health Organization 2014); is not on the California Proposition 65 list of known carcinogens (Cal-EPA 1997); and does not appear on the Toxics Release Inventory (TRI) Basis of OSHA Carcinogens (US EPA Toxics Release Inventory Program 2015).

A review of the literature suggests that linseed oil and its constituents may reduce the risk of certain kinds of cancer. When rats were exposed to a substance linked to breast cancer, those fed flaxseed and linseed oil had a lower incidence of mammary tumors than the control group (Thompson et al. 1996). The same study found that the lignan in flaxseed, secoisolariciresinol-diglycoside (SD), had the greatest inhibitory effect of the constituents. A follow-up developmental study on gestating rats found that the oil without SD had no significant inhibitory effect (Tou and Thompson 1999).

Human Health Incidents

Linseed oil had no human health incidents reported to the National Pesticide Information Center between April 1, 1996 and March 30, 2016 (NPIC 2016).

Environmental Effects Information

Effects on Non-target Organisms

The effects of linseed oil on non-target organisms are summarized in Table 4.

Table 4

Effects of Linseed Oil on Non-target Organisms

Study	Results	Source
Avian Oral, Tier I	Not found	
Non-target plant studies	Not found	
Non-target insect studies	Ladybird beetle *(Adalia bipunctata),* Rove beetle *(Aleochara bilineata):* No significant difference from a no-treatment control. Ground beetle *(Bemdion lampros):* zero mortality. Aphid parasitic wasp *(Aphis rhopalosophi):* 35% mortality	(Jansen et al. 2010)
Aquatic vertebrates	Not found	
Aquatic invertebrates	Not found	

When compared with two other active ingredients allowed for the control of aphids in organic production, linseed oil caused the lowest larval and pre-imaginal mortality of beneficial ladybird beetles (*Adalia bipuntata*). Whereas pyrethrins (both with and without piperonyl butoxide and rapeseed oil as synergists) and potassium salts of fatty acids (insecticidal soap) both significantly increased ladybird beetle mortality, linseed oil was not significantly different from a no-treatment control (Jansen et al. 2010). Similar results were obtained for beneficial rove beetles (*Aleochara bilineata*). Linseed oil also resulted in zero mortality of ground beetles (*Bembidion lampros*), another beneficial insect. However, the same study found that linseed oil at a dose equivalent to 12.0 L/Ha (1.28 gal/A) over a 48 hour period resulted in a 35% mortality of the aphid parasitic wasp, *Aphis rhopalosiphi* (Jansen 2010). Linseed oil repelled the red dwarf honey bee (Gupta 1987), but no studies were found on its effects on other honey bees (*Apis mellifera*) or other pollinators.

Linseed oil had no animal incidents reported to the National Pesticide Information Center between April 1, 1996 and March 30, 2016 (NPIC 2016).

Environmental Fate, Ecological Exposure, and Environmental Expression

Raw linseed oil on filter paper mixed with soil and immersed in water was 90-100% biodegraded into CO_2 after 65 days at 30°C (Shogren et al. 2004). Biodegradation of linseed oil was more rapid and complete than the authors predicted based on the structure of the fatty acids.

Vegetable oil spills and petroleum spills in water and wetlands can have comparable adverse effects on marine and aquatic life (McKelvey et al. 1980), although biodegradation mitigates the impacts under certain conditions (Salam et al. 2012). An experimental spill of linseed oil in a small area of a salt marsh showed that it degraded in a two-stage process. First, linseed oil was degraded by anaerobic organisms, followed by aerobic decomposition (Pereira et al. 2002). In the salt marsh, linseed oil biodegraded more rapidly than sunflower oil in a paired comparison, with 40% of the linseed oil remaining after two months (Pereira et al. 2003).

No leaching or photodegradation data was found on linseed oil.

Environmental Incidents

Linseed oil had no incidents of any kind reported to the National Pesticide Information Center between April 1, 1996 and March 30, 2016 (NPIC 2016).

Efficacy

Fungicidal Activity

The primary pesticidal use of linseed oil is to control fungi and other decay organisms in wood. As an antimicrobial, linseed oil is relatively less effective than cedar oil or various essential oils such as rosemary and thyme, but its action as a drying oil is thought to reduce the opportunities for fungal infection (Milne 2004). Stakes made of wood from seven different tree species were tested in Sweden and Hawai'i, comparing linseed oil with standard wood preservatives and other vegetable oils. Linseed oil performed relatively well in inhibiting decay, but the wood was judged to have a poor appearance at the end of five years of exposure (Edlund and Jermer 2007). Scots pine (*Pinus sylvestris)* impregnated with linseed oil showed increased durability of the heartwood and sapwood, but brown rot fungus (*Coniophora puteana)* was inhibited only in the heartwood (Ulvcrona et al. 2012).

Norway spruce (*Picea abies*) and beech wood (*Fagus sylvatica*) were treated with linseed oil and compared with an untreated control. The Norway spruce was exposed to three species of brown rot decay fungi *(Antrodia vaillantii, Serpula lacrymans,* and *Gloeophyllum trabeum),* while the beechwood was exposed to three white rot decay fungi species *(Trametes versicolor, Pleurotus ostreatus*, and *Hypoxylon fragiforme*) over a 12-week period. Spruce wood treated with linseed oil had mass losses of 5-10%, in contrast to mass losses of 24-34% for the no-treatment control. Beech wood losses were between 7-25% for the linseed oil treated wood and between 40-57% for the untreated wood (Humar and Lesar 2013).

In a different study, aspen (*Populus tremula*) wood was treated with linseed oil followed by heat at 220°C and then exposed to the pathogens *Coriolarus versicolor* and *Coniophora puteana*. Treated wood had 71-77% less mass loss than the no-treatment controls (Bazyar 2012).

Insecticidal Activity

Linseed oil was compared with cottonseed, castor, rosin, and petroleum spray oils for control of various citrus pests, particularly red scale (*Chrysomphalus aurantii)*. Linseed oil had a fatal immersion time of 30-1,300 minutes. Against scale, all the vegetable oils were equally or more toxic than the light petroleum distillate, with a fatal immersion time of 240-1,400 minutes. However, the vegetable oils were also more phytotoxic (DeOng et al. 1927). Thus, foliar application of linseed oil to growing plants is of limited use and research on insecticidal activity has been limited since the 1920s.

Regardless, other scale insects show susceptibility to linseed oil. A German study found that, under greenhouse conditions, linseed oil effectively reduced rose scale (*Aulacaspis rosae*) throughout the year. During the peak weeks, larval counts in the no-treatment control were nearly four times greater and adults nearly five times greater than the counts in the linseed oil treatment (Brendel 2013).

For wood-feeding insects, such as termites, ants, and borers, there was no evidence that linseed oil is directly toxic to any of these pests. Some termites appear to have a symbiotic relationship with fungi (Rouland-Lefèvre 2000), so inhibition of fungal decay has a secondary effect of reducing insect feeding and damage. In treating wood with the insecticide boric acid, linseed oil and heat were found to be the most efficient treatments for retaining the activity of the boric acid (Lyon et al. 2007).

In an old study, linseed oil resulted in 94% mortality of bedbugs (*Cimex lectularis*) kept 20 to a jar with paper strips (Scott et al. 1918). In another study, raw linseed oil had efficacy comparable to soybean and cottonseed oils, and superior to boiled linseed oil, peanut, blown castor, and coconut oils when sprayed against Japanese beetles (*Popillia japonica*) in wire cages. The median lethal concentration was 1.651 g/l (Fleming and Baker 1934).

Herbicidal Activity

Linseed oil was investigated as a possible herbicide, dessicant, or defoliant based on its phytotoxic activity (McLaren 1986), but no published results are available. Several Extension publications recommend linseed oil as an herbicide adjuvant, but not as a stand-alone herbicide (Mitich et al. 1973; Sprague and Hager 2000; Curran et al. 2009). Cotton defoliation experiments with the active ingredient thidazuron and using Bio-Veg (a blend of linseed and soybean oils as an adjuvant) produced results not significantly different from the best proprietary blends or petroleum oils (Carasso and Briggs 1981). However, the efficacy of Bio-Veg or linseed oil by themselves was not reported.

Rodenticidal Activity

Linseed oil combined with other dehydrating agents can be used to exterminate rats and other non-emetic animals by plugging their pharynx, larynx, and esophagus—thereby choking them to death (Perry 2013).

Standards and Regulations

EPA Requirements

Linseed oil is exempt from the requirement of a tolerance as it's a commonly consumed food commodity [40 CFR 180.950].

FDA Requirements

Although linseed/flaxseed oil is a common food ingredient. A manufacturer of flaxseed oil made a GRAS declaration to the FDA (Peterson 2008), which the FDA did not challenge (Tarantino 2009).

Other Regulatory Requirements

Occupational Health and Safety Administration (OSHA) has established a Permissible Exposure Limit (PEL) of 5 mg/m^3 respirable and 15 mg/m^3 total linseed oil to protect workers from inhalation risks (Cargill 2009). OSHA also rates linseed oil a Category 1 skin sensitizer (Sigma-Aldrich 2014).

Linseed oil is allowed by the USDA's National Organic Program (NOP) [7 CFR 205].

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