New York State Integrated Pest Management Program
Cornell Cooperative Extension

Soybean Oil Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

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Label Display Name: Soybean oil

Active Components: Soybean oil

CAS Registry #: 8001-22-7

U.S. EPA PC Code: 031605

CA DPR Chem Code: 2335

Other Names: Soy oil; Glycine soja oil; Soyabean oil, Vegetable oil, Partially Hydrogenated Soybean Oil (PHSBO)

Other Codes: EINECS—232-274-4

Summary: Soybean oil is derived from *Glycine max*, a legume cultivated for food, feed, and industrial uses and is a common food grade oil used throughout the industry for products such as vegetable oil and mayonnaise. As a pesticide, it is also used as an insecticide, acaricide, plant growth regulator, and herbicide.

Pesticidal Uses: Soybean oil has a non-toxic mode of action but works as a pesticide primarily by suffocating small soft-bodied insects and mites. The major target pests for soybean oil are mites, aphids, scales, beetles, caterpillars, and whiteflies. Soybean oil also has some efficacy as a fungicide and fungistat. Its phytotoxic effects make it somewhat effective as a herbicide and plant growth regulator, but it is more commonly applied as an adjuvant with other herbicides where it improves herbicidal activity by increasing penetration and increasing active ingredient persistence.

Formulations and Combinations: Formulated with other vegetable and essential oils, and widely used as a carrier with oil soluble active ingredients, including various botanicals such as neem oil. Used in combination with various emulsifiers, adjuvants and spreader stickers.

Basic Manufacturers: ADM, Bunge, Cargill, ConAgra, DuPont, Huber Group, Louis Dreyfus, AG Processing.

Safety Overview: It has a non-toxic mode of action, is readily biodegradable, and is not expected to cause any adverse human health effects or environmental impacts.

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.

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Background

Soybean (*Glycine max*) is a widely-planted legume used as oilseed, for animal feed, and in a wide range of food and non-food uses. Soybean oil may be produced by a variety of different methods. However, the prevalent technology for commercial production involves the drying, tempering, cracking, dehulling, and crushing of the soybeans. The oil solvent is then extracted by various means, most often by hexane (Muth et al. 1998; Hammond et al. 2005). Various refining steps, such as steam stripping, are used to remove other impurities.

Unrefined soybean oil is a complex mixture of triglycerides, phospholipids, sterols, tocopherols, hydrocarbons, and free fatty acids (Hammond et al. 2005). Soybean oil can be refined to be composed of over 99% triglycerides (Wang 2002). The prevalent triglyceride, linoleic acid, is used as a proxy for the chemical and physical characteristics of soybean oil, because the chemical and physical properties of soybean oil can vary widely (Hasenhuettl 2000; Wang 2002; Hammond et al. 2005). The principle fatty acids in soybean oil (and their average composition by weight) are linoleic acid (53.2%), oleic acid (23.4%), palmitic acid (11.0)%, and linolenic acid (7.8%) (Wang 2002). Oleic (C18:1), linoleic (C18:2), and linolenic (C18:3) acids are unsaturated, and the main saturated fats are palmitic (C16:0) and stearic (C18:0) acids (Wang 2002). Free fatty acids are usually less than 1%, with phospholipids—primarily the emulsifier lecithin—making up 1.5-4% (Merck 2015). Lecithin is usually recovered by vacuum drying (Hasenhuettl 2000). Another 0.8% consists of stigmasterol, sitosterols, and tocopherols (Merck 2015).

Soybean oil is used as a salad and cooking oil, as well as to make margarine, shortening, mayonnaise, and a wide range of processed foods (Merck 2015). Other non-food uses include soap, paints, varnishes, resins, plastics, lubricants, and as biodiesel fuel.

Soybean oil was first registered as a pesticide in 1959 (US EPA 1993) and is commonly used as an adjuvant with other herbicides. No study was found showing soybean oil's efficacy by itself as an herbicide. Soybean oil is more viscous than petroleum oils, which makes it stick longer to leaf surfaces, even under conditions of heavy rainfall (Bondada et al. 2000). Because it is relatively safe, non-persistent, and has almost no significant adverse effects on humans or the environment, soybean oil is eligible to be used as an active ingredient in pesticides that are exempt from regular pesticide product registration procedures by the EPA (Matthews 2010).

Chemical and Physical Properties

The composition of soybean oil varies according to the degree of saturation, temperature, and other factors related to production of soybeans and their processing (Pryde 1980; Hammond et al. 2005). The physical and chemical properties of soybean oil appear in Table 1.

Table 1

Physical and Chemical Properties of Soybean Oil

Property	Characteristic/Value	Source(s)
Molecular Formula:	N/A	
Molecular Weight:	N/A	
Percent Composition:	Triglycerides of linoleic acid triglycerides: 49%, of oleic acid triglycerides: 26%, of linolenic acid 11%, of saturated acids 14%. Phospholipids (lecithin) 1.5-4%; stigmasterol, sitosterols, and tocopherols: 0.8%.	(Merck 2015)
Physical state at 25°C/1 Atm.	Liquid	(Merck 2015)
Color	Pale yellow to brownish-yellow	(Merck 2015)
Odor	Slight characteristic odor	(Merck 2015)
Density/Specific Gravity	0.916-0.922	(Merck 2015)
Melting (solidifying) point	−10 to −16°C	(Merck 2015)
Boiling (Smoke) point	Crude: 185°CRefined & Bleached: 228-234°C	(Pryde 1980)
Solubility	Emulsifies on contact with water. Slightly soluble in water and alcohol; soluble in hexane and other non-polar hydrocarbon based solvents.	(Pryde 1980; Matthews 2010)
Vapor pressure	2.61 x 10^{-17} mm Hg	(Yuan et al.2005)
pH	7.5	(Matthews 2010)
Octonol/Water (K_{ow}) coefficient	22.65	(EPI 2012)
Viscosity	60 η, mPa^{-1} s	(Hasenhuettl 2000)
Miscibility	Miscible with absolute alcohol, ether, petroleum ether, chloroform, carbon disulfide	(Merck 2015)
Flammability	Flash point: 328°CFire point: 363°C	(Pryde 1980)
Storage stability	Stable	(Matthews 2010)
Corrosion characteristics	Not found	
Air half life	0.229 hrs	(EPI 2012)
Soil half life	1,800 hrs	(EPI 2012)
Water half life	900 hrs	(EPI 2012)
Persistence	1,060 hrs	(EPI 2012)

Human Health Information

Along with other flower and vegetable oils reviewed as active ingredients in registered pesticides, the EPA concluded that soybean oil posed no human health risks of concern (McDavit 2010).

Acute Toxicity

The acute toxicity of soybean oil appears in Table 2.

Table 2

Acute Toxicity of Soybean Oil

Study	Results	Source(s)
Acute oral toxicity	Mouse LD_{50}: 22,100 mg/kgRat LD_{50}: 16,500 mg/kg	(NLM 2016)
Acute dermal toxicity	Negative	(REACH 2008)
Acute inhalation	Not found	
Acute eye irritation	Negative	(REACH 2008)
Acute dermal irritation	Negative	(REACH 2008)
Skin sensitization	Not a sensitizer	(REACH 2008)

Sub-chronic Toxicity

The sub-chronic toxicity of soybean oil appears in Table 3.

Table 3

Sub-chronic Toxicity of Soybean Oil

Study	Results	Source(s)
Repeated Dose 28-day Oral Toxicity Study in Rodents	NOAEL > 5,000 mg/kg/day	(REACH 2008)
90 day oral toxicity in rodents	Not found	
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	NOAEL > 2,000 mg/kg/day	(REACH 2008)
Combined repeated dose toxicity with reproduction/ development toxicity screening test	Not found	
Prenatal developmental toxicity study	Not found	
Reproduction and fertility effects	Not found	

Less than one percent of the population is believed to have allergies to soy. However, soybean oil is not allergenic to soybean-allergic individuals (Bush et al. 1985). This was confirmed in a subsequent study that involved soybean sensitive individuals in Switzerland, the Netherlands, and Germany. When exposed to soybean oil orally and dermally, all subjects except one did not have severe allergic reactions (EFSA 2007). Soybean allergy is caused by certain proteins in the soybean. Those proteins are in very low concentrations in refined soybean oil, thus soybean oil does not evoke allergic reactions among soybean-sensitive people (OECD 2012).

Chronic Toxicity

The chronic toxicity of soybean oil appears in Table 4.

Table 4

Chronic Toxicity of Soybean Oil

Study	Results	Source(s)
Chronic toxicity	Not found	
Carcinogenicity	Negative	(Duthie et al. 1988; REACH 2008)
Combined chronic toxicity & carcinogenicity	Negative	(Duthie et al. 1988)

Rats fed partially hydrogenated soybean oil over multiple generations did not reveal any carcinogenic or non-carcinogenic differences (Duthie et al. 1988). The authors concluded that the study confirmed the safety of soybean oil and other partially hydrogenated edible oils based on the lack of chronic effects. No studies were found that performed the Ames test on crude or refined soybean oil. However, the smoke condensates of soybean oil—produced from cooking conditions and not used as pesticides—have been tested for mutagenicity using the Ames test, with negative results (Young-hua 1986). Soybean oil caused a small, but significant increase in multiple wing hairs and mutant spots on *Drosophila* as somatic mutations. The number of spots increased an average of 0.5% (Demir et al. 2012).

Human Health Incidents

No human health incidents involving the use of soybean oil alone as a pesticide active ingredient had been reported to EPA as of 2010, based on a review of registered pesticides having soybean oil labeled as an active ingredient (US EPA 1993; McDavit 2010). However, between April 1, 1996 and March 30, 2016, the National Pesticide Information Center (NPIC) received three reports of human health incidents that involved soybean oil formulated with other pesticide active ingredients (NPIC 2016). These products were presumably exempt from registration because they did not have registration numbers and had multiple active ingredients also eligible for exemption. All involved accidental inhalation, with two asymptomatic and the third having 'atypical moderate' symptoms.

Environmental Effects Information

EPA does not anticipate any adverse effects to the environment due to the use of registered pesticide products containing soybean oil because of low use volume and rapid degradation in the environment by normal biological, physical, and chemical processes in the areas where soybean oil is used. No ecological incidents involving soybean oil had been reported to EPA as of 2010 (Matthews 2010).

Effects on Non-target Organisms

The EPA regards soybean oil as practically non-toxic to non-target mammals, birds, and plants (Matthews 2010). No studies were found regarding aquatic toxicity of soybean oil, or its impact on honeybees or other pollinators. NPIC received two reports of animal incidents that involved soybean oil between April 1, 1996 and March 30, 2016 (NPIC 2016). One involved a registered pesticide with another active ingredient ineligible for exemption, the other did not have a narrative description of the incident.

Environmental Fate, Ecological Exposure, and Environmental Expression

No leaching or photodegradation studies for soybean oil were found. Soybean oil is considered readily biodegradable (REACH 2008).

Environmental Incidents

Between April 1, 1996 and March 30, 2016, NPIC received five calls that involved soybean oil. They did not involve human health or animals (NPIC 2016).

Efficacy

Published studies have evaluated soybean oil's efficacy as an insecticide, acaricide, fungicide, herbicide and plant growth regulator.

Insecticidal and Acaricidal Activity

Like corn and cottonseed oils, soybean oil has a suffocating mode of action. Because of its low price and widespread availability, it is a common carrier for various essential oils used as pesticides. In a laboratory study of the efficacy of various commercial repellents to the mosquitos *Aedes albopictus*, *Culex nigripalpus*, and *Ochlerotatus triseriatus*, two formulations with soybean oil and other active ingredients were used (Barnard and Xue 2004). One was Bite Blocker, containing glycerin, lecithin, vanillin and the oils of coconut, geranium, and soybean. The other was GonE!, comprised of *Aloe vera*, camphor, and oils of eucalyptus, lavender, rosemary, sage and soybean. GonE! failed to repel *A. albopictus* and *O. triseriatus*, and repelled *C. nigripalpus* for less than two hours. On the other hand, Bite Blocker effectively repelled all three species for over 7 and almost 8 hours (Barnard and Xue 2004). Bite Blocker for Kids repelled *Aedes aegypti* for over 90 minutes, and was the only natural repellent with efficacy comparable to diethyl toluamide (DEET) (Fradin and Day 2002). The articles did not state whether these soybean oil-based commercial formulations were EPA registered or exempt from registration.

Soybean oil was one of the less effective of five vegetable oils against the sweetpotato whitefly (*Bemisia tabaci*). Compared with castor, peanut, cottonseed and sunflower oils, soybean oil reduced oviposition by only 23%, compared with 43% for sunflower oil, and 100% for peanut, castor and cottonseed oils (Fenigstein et al. 2001). The same study found that soybean oil was less effective than peanut or castor oil in preventing *B. tabaci* eggs from hatching. A field study confirmed that a 5% solution of soybean oil reduced eggs, adults and feeding damage of *B. tabaci* on cotton (*Gossypium hirsutim*), but not as much as a 10% solution of cottonseed oil (Butler et al. 1991).

A nano-particle emulsified soybean oil, Bionatrol was evaluated in field tests for insecticidal efficacy on two spotted spider mites (*Tetranychus urtiae*), cotton aphids (*Aphid gossypii*), and whiteflies (*Trialeurodes vaporariorum*) on greenhouse grown English cucumber (*Cucumis sativus* ssp. kasa). Bionatrol applied with an air blast sprayer at concentrations of 0.3% reduced respective survival population of spider mites, aphids, and whiteflies by 88, 92, and 95%; and at 0.2% concentration by 75, 86, and 88%, respectively (Lee et al. 2005). Phytotoxicity did not occur at 0.2 and 0.3% application rates.

A study determined that soybean oil was effective in reducing the populations of terrapin scale (*Mesolecanium nigrofasciatum*), San Jose scale (*Quadraspidiotus perniciosus*) and European red mite (*Panonychus ulmi*). Apple (*Malus domestica*) and peach (*Prunus persica*) stems dipped in a 7.5% solution of degummed soybean oil for one second resulted in 93% mortality of terrapin scales (Pless et al. 1995). No red mites survived at a rate of either 5% or 7.5% soybean oil, making its efficacy comparable to petroleum oil. The same article reported field tests where over 95% of San Jose scale died on apple trees sprayed with one application of 2.5% petroleum oil or 5.0% soybean oil. One application of 5.0% soybean oil and 0.6% emulsifier (Latron AG 44M; remaining formula not disclosed) killed 85% and two applications killed over

98% of the terrapin scales (Pless et al. 1995). Two applications of 2.5% soybean oil killed only 72% of the San Jose scales. A subsequent study looked at apple trees infested with San Jose scale and treated with 3% petroleum oil and 6% degummed soybean oil with 0.6% emulsifier (Latron B-1956). Both sprays significantly reduced the numbers of first- and second-generation crawlers by more than 90% over two seasons compared to the no treatment control, and were not significantly different from each other (Hix et al. 1999). Given the proprietary nature of the emulsifiers and non-disclosure of all ingredients in the articles, it is not possible to tell if these treatments are eligible for 25(b) exemption.

An emulsified soybean oil formulation, Golden Pest Spray Oil, effectively reduced the number of gypsy moths (*Lymantria dispar*) hatched by 96% compared with a no treatment control (Williamson 2004). Golden Pest Spray Oil is an EPA registered pesticide with 93% soybean oil and 7% undisclosed inert ingredients (US EPA 2016)

Soybean oil sprayed on apple trees in the summer at a rate of 1% reduced European red mite populations by 94%, a rate comparable to the efficacy of a petroleum oil (Moran et al. 2003). Higher rates of 4% and 6% did not result in any greater European red mite control, but resulted in significantly greater phytotoxicity.

Summer sprays of soybean oil were effective in reducing populations of two spotted spider mites (*Tetranychus urticae*) on burning bush (*Euonymus alatus*) (Lancaster et al. 2002). Single sprays of 1, 2, or 3% degummed soybean oil emulsified with Latron B-1956 and diluted with water reduced two-spotted spider mite populations by 97–99% compared to water-sprayed controls. Single sprays of 2 or 3% soybean oil were not phytotoxic but suppressed photosynthesis for a short time. A second experiment that involved a single spray of 0.75, 1.0, or 1.5% degummed soybean oil reduced the two-spotted spider mite population by over 95% compared to a water control. A second spray of 0.25–1.5% emulsified degummed soybean oil resulted in ≥ 93% control of two-spotted spider mite compared to the water control, but a third spray provided little additional two-spotted spider mite control. Predaceous mites were not initially disrupted by a single spray of soybean oil. A single spray of ≤ 1.5% soybean oil did not significantly reduce photosynthesis. Soybean oil had efficacy against two spotted spider mite similar to that of a petroleum oil and had similar effects on photosynthesis. Soybean oil was less phytotoxic and caused less defoliation of stressed plants than the petroleum oil in one experiment but not in two other experiments.

Post-harvest handling applications include the application of soybean oil to protect corn (*Zea mays*) from the maize weevil (*Sitophilus zeamais*). Grain stored in jute bags for seven months and treated every two to three months showed significantly lower grain damage (0.2 to 13% damage) than the untreated control (>50% damage) (Koona and Njoya 2004). Soybean oil applied every two months was as effective as malathion applied at the same frequency.

Chickpeas (*Cicer arietinum*) treated with 10 ml of soybean oil applied post-harvest reduced bruchid pest damage by *Callosobruchus maculatus* for 90 days and *Callosobruchus phaseoli* for 60 days (Pacheco et al. 1995). However, soybean oil was not as effective as castor oil, which completely protected stored chickpeas from *Callosobruchus maculatus* for 150 days and *Callosobruchus phaseoli* for 90 days. Both oils conferred an off-flavor to chickpeas.

On the other hand, soybean oil provided disappointing results in the control of pulse beetle (*Callosobruchus chinensis)* in pigeon peas (*Cajanus cajan*) compared with mustard, groundnut, sesame, olive, sunflower and palm oils. Over 98% of progeny hatched within 66 days in pigeon peas treated with soybean oil and the soybean oil treatment had the highest percentage of damage of all the oils, with losses not significantly different from the no treatment control (Khalequzzaman et al 2007).

Fungicidal Activity

Vegetable oils are shown to have a physical and non-biocidal mode of action to prevent infection by various plant pathogens (Northover and Schneider 1996). Soybean oil has been shown to reduce the severity of powdery mildew (*Sphaerotheca fusca*) and downy mildew (*Pseudoperonospora cubensis*) infections in cucumbers (*Cucumis sativus*). Soybean, canola, safflower, sunflower, olive, and corn oils each independently emulsified with egg yolk showed over 95% control values for powdery mildew of cucumber leaf surfaces in a greenhouse test. The 95.2% control rate for soybean oil was not significantly different from canola oil, with an efficacy rate of 98.9% control of leaf surface areas (Jee et al. 2009). Soybean oil was less effective in controlling powdery mildews (*Oidium tuckeri* and *Unicula necator*) and downy mildew (*Plasmopara viticola*) in grapes (*Vitis vinifera* and *Vitis vinifera x labrusca*). More specifically, soybean oil applied to grapes had marginal control of the two species that cause powdery mildew in Ontario, and was ineffective against the downy mildew pathogen (Northover and Schneider 1996).

Plant Growth Regulator Activity

Soybean oil acts as a fruit thinner by reducing flower bud set of peaches (Moran et al. 2000). Used during the dormant period, soybean oil applications can reduce the cost of hand labor for thinning of the fruits later in the season.

Standards and Regulations

EPA Requirements

Soybean oil is exempt from the requirement of a tolerance [40 CFR 180.950(c)(1)].

FDA Requirements

Soybean oil is Generally Recognized As Safe (GRAS) by the FDA when used as food [21 CFR 173.340 and 182.70].

Other Regulatory Requirements

Soybean oil is allowed by the USDA's National Organic Program (NOP) [7 CFR 205.105]. Soybean oil is not subject to any OSHA or state worker right to know regulations (Sigma-Aldrich 2015).

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