

Corn Gluten Meal Profile

Active Ingredient Eligible for Minimum Risk Pesticide Use

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Label Display Name: Corn gluten meal

CA DPR Chem Code: 2481

Active Components: Corn gluten meal

Other Names: Corn proteins; Maize meal; Zea mays meal; Corn protein meal; Corn gluten feed; Hydrolyzed corn protein

CAS Registry #: 66071-96-3

U.S. EPA PC Code: 100137

Other Codes: EINECS 266-116-0

Summary: Corn gluten meal is derived from the wet milling of corn and is mostly used as a livestock feed ingredient. As a pesticide, it has been shown to inhibit germination of both grassy and broad-leaf weeds and may be used as a pre-emergent herbicide. The product is edible and no incidents of adverse incidents to human health, non-target species, or the environment have been reported when corn gluten meal has been used as an active ingredient.

Pesticidal Uses: Herbicide, attractant or bait for rodents.

Formulations and Combinations: Bone meal; sunflower ash; other lawn fertilizer ingredients.

Basic Manufacturers: ADM; Bunge; Cargill; Consolidated Grain; Gavilon (formerly ConAgra); Ingredion (formerly Corn Product International), Grain Processing Corporation; Louis Dreyfus; Tate & Lyle.

Safety Overview: Corn gluten meal is an edible product used more often in livestock feed than in human food. While a small percentage of the population is allergic, the proteins found in corn do not have 'gluten' in the same sense as wheat, barley, and rye.

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.

Background

Corn gluten meal (CGM), otherwise known as corn protein meal, is a by-product of the wet milling of corn (*Zea mays*) [21 CFR 184.1321] (Corn Refiners Association 2006). The wet milling process begins by soaking shelled and clean corn kernels in a 0.1-0.2% solution of sulfur dioxide, where it is steeped for 24 to 48 hours (Corn Refiners Association 2006). A number of enzymes, primarily α -amylases, may be used in the aqueous solution to induce liquefaction and increase yield (Kirk et al. 2004). Solvents are then used to extract the oil (Corn Refiners Association 2006). The corn gluten meal is separated from the starch by centrifugal force and dried (Andersen et al. 2011). Corn gluten is also produced as a byproduct during the conversion of the starch in whole or various fractions of dry milled corn to various other products, such as corn syrups [21 CFR 184.1321]. The primary use of CGM is as a food and livestock feed for dairy and beef cattle, cats, minks, foxes, sheep, horses, swine, poultry, trout, salmon, catfish, guinea pigs, hamsters, monkeys, mice, rats, rabbits, and dogs (Reilly et al. 2003). It is high in protein and rich in the sulfur containing amino acids, including methionine (Neumann et al. 1984). Derivatives of CGM are also polymerized into biodegradable plastics (Bassi et al. 1997). CGM may also be used in cosmetics (Andersen et al. 2011).

As a pesticide, CGM is mainly used as a pre-emergent herbicide to suppress weed populations in turfgrass (US EPA 2002). It is also used in various baits as an attractant for certain pests, and in rodenticide formulations.

Chemical and Physical Properties

The physical and chemical properties of CGM appear in Table 1:

Table 1
Physical and Chemical Properties of Corn Gluten Meal

Property	Characteristic/Value	Source
Molecular Formula:	N/A	
Molecular Weight:	N/A	
Percent Composition:	71.4% crude protein, 4.1% fat, 0.8% fiber, 1.2% ash, 12.4% starch, 10.1% other carbohydrates	(Neumann et al. 1984)
Physical state at 20°C/1 Atm.	Solid Powder/Granular	(Reilly et al. 2003)
Color	Golden Yellow to Brown	(Reilly et al. 2003)
Odor	Cereal odor	(Reilly et al. 2003)
Density/Specific Gravity	1.26 g/cm ³	(Ramanzin et al. 1994)
Melting point	N/A	
Boiling point	N/A	
Solubility	<1% by weight	(Reilly et al. 2003)
Vapor pressure (gas volume)	0.04 ml/g of dry matter	(Ramanzin et al. 1994)
pH	5.5	(Down to Earth 2012)
Octonol/Water (K _{ow}) coefficient	Not found	
Viscosity	N/A	
Miscibility	N/A	
Flammability	Non-flammable	(Down to Earth 2012)
Storage stability	Stable	(Down to Earth 2012)

Property	Characteristic/Value	Source
Corrosion characteristics (liquid)	Not corrosive	(PMRA 2013)
Air half life	Not found	
Soil half life	Not found	
Water half life	Not found	
Persistence	Not found	

Human Health Information

In a biopesticide registration review document, the EPA waived all required toxicology data for CGM and decided that, for the following reasons, no additional toxicological data was needed (Reilly et al. 2003): “1) the product is naturally occurring, 2) possesses a non-toxic mode of action, 3) corn gluten meal is considered GRAS (Generally Recognized As Safe) by FDA under 21 CFR §184.1321, and can be used without limitations, other than current Good Manufacturing Practices, and 4) under 40 CFR §180.1164, corn gluten is exempted from the requirements of a tolerance on food when used as a herbicide; and under 40 CFR §180.1001(d), corn gluten meal is exempted from the requirement of a tolerance when used as an attractant on crops” (Reilly et al. 2003). An acute dermal irritation study found that CGM caused irritation to 3 of 85 participants, but did not result in any allergic reactions (Andersen et al. 2011).

Acute Toxicity

The acute toxicity of CGM appears in Table 2.

Table 2
Acute Toxicity of Corn Gluten Meal

Study	Results	Source
Acute oral toxicity	Not found	
Acute dermal toxicity	Negative	(Andersen et al. 2011)
Acute inhalation	Not found	
Acute eye irritation	Not found	
Acute dermal irritation	Irritation in 3.5% of participants	(Andersen et al. 2011)
Skin sensitization	No adverse reaction	(Andersen et al. 2011)

CGM is toxic to rodents and other non-emetic (incapable of vomiting) animals when treated with a dehydrant ingredient, but non-toxic to humans and other emetic animals (Perry 2013).

Sub-chronic Toxicity

No data on the chronic or sub-chronic toxicity of CGM was found. Given its widespread use as an animal feed and the human consumption of corn, CGM is unlikely to pose any chronic or sub-chronic health risks, and the EPA has waived these data requirements (Reilly et al. 2003).

Chronic Toxicity

No data on the chronic toxicity of CGM was found. Given its widespread use as an animal feed and the human consumption of corn, CGM is unlikely to pose any chronic health risks, and the EPA has waived these data requirements (Reilly et al. 2003).

Human Health Incidents

No human health incidents involving CGM as a pesticide active ingredient were reported to National Pesticide Information Center (NPIC) between April 1, 1996 and March 30, 2016 (NPIC 2016).

Environmental Effects Information

Effects on Non-target Organisms

No data on the effects of CGM on non-target species was found.

The EPA waived all requirements for environmental impacts, including those for honey bees and other non-target species, because CGM is naturally occurring and has a non-toxic mode of action (Reilly et al. 2003). As justification, the EPA's fact sheet on CGM states: "[n]o toxic effects have been identified in mammals, birds, or fish. In fact, corn gluten meal is commonly used in feed for cattle, fish, poultry, pets, and other animals. No harmful effects are expected if users follow the application rates and use directions on the label." (US EPA 2002). CGM was reported as unlikely to have adverse effects on bees (Mader and Adamson 2009). There were no animal incidents involving corn gluten meal reported to NPIC between April 1, 1996 and March 30, 2016 (NPIC 2016).

Environmental Fate, Ecological Exposure, and Environmental Expression

CGM is readily biodegradable (Bassi et al. 1997). The EPA concluded that no significant exposure is expected from use of CGM as a registered herbicide in the aquatic environment when used according to label instructions. However, the label for the one EPA-registered formulation includes mitigating language to reduce potential risk to aquatic organisms. In a registration review, EPA concluded that "[g]iven that the active ingredient is used as a fish food and feed supplement, it is unlikely that the [one registered] product will have any adverse effects on fish or other aquatic organisms." (Reilly et al. 2003). The primary concern related to release into the aquatic environment and groundwater appears to be elevated nitrate levels. No studies were found related to direct release into surface water. However, nitrate leaching in turfgrass was significantly higher where CGM was applied as an herbicide and fertilizer than in the no-treatment control. These levels were one-quarter of the nitrate released from an application of urea applied as a fertilizer—at even lower levels of total nitrogen applied (Kao-Kniffin 2012).

Environmental Incidents

Between April 1, 1996 and March 30, 2016, NPIC received two incident reports involving CGM that were not related to animal or human health (NPIC 2016). One was an inquiry about the possible effects, and the other did not contain a narrative.

Efficacy

Herbicidal Activity

The primary pesticidal use of CGM is as an herbicide. Specifically, CGM was first identified as a pre-emergent treatment that could be used to prevent germination of grassy annual weeds (Christians 1991). Subsequent greenhouse studies showed CGM had herbicidal activity on 19 selected monocotyledonous and dicotyledonous species, with germination and growth of all species inhibited by CGM application at rates ranging between 0 and 8 g/dm² (Liu and Christians 1997). The most susceptible species were black medic (*Medicago lupulina*), buckhorn plaintain (*Plantago lanceolata*), creeping bentgrass (*Agrostis palustris*), purslane (*Portulaca oleracea*), and redroot pigweed (*Amaranthus retroflexus*). At application rates of 1 g/dm², these species exhibited over 70% reduction in root length, 60% reduction in plant survival, and 52% reduction in shoot length. Common lambsquarters (*Chenopodium album*), curly dock (*Rumex crispus*), dandelion (*Taraxacum officinale*), giant foxtail (*Setaria faberi*), large crabgrass (*Digitaria sanguinalis*), and yellow foxtail (*Setaria lutescens*) all exhibited more than 50% reduction in root length and plant survival at the same rate. Annual bluegrass (*Poa annua*), barnyardgrass (*Echinochloa crusgali*), green foxtail (*Setaria viridis*), orchardgrass (*Dactylis glomerata*), perennial ryegrass (*Lolium perenne*), quackgrass (*Agropyron repens*), and velvetleaf (*Abutilon theophrasti*) were mostly susceptible at 2 g/dm². All species had zero surviving plants at a rate of 1,785 lb/A (2 g/dm²), except annual ryegrass (*Lolium multiflorum*), which had 10% of all plants survive (Liu and Christians 1997).

Another greenhouse study evaluated the herbicidal activity of CGM on six monocotyledon and six dicotyledon weed species grown in two different media: a commercial potting mix and sandy soil (Abouziena et al. 2009). Two applications were made: one early post-emergent, the other late post-emergent, with the timing of the two applications depending on average plant height. CGM was more effective against germinating dicotyledons, particularly redroot pigweed, velvet leaf and sicklepod (*Senna obtusifolium*). Among the monocotyledons tested, crowfootgrass (*Dactyloctenium aegyptium*) was the species with seedlings most susceptible to CGM (Abouziena et al. 2009). However, CGM was ineffective against plants with mature root systems. Registration status of the CGM product tested was not reported.

CGM is commonly used in turfgrass settings for control of crabgrass and other grassy and broadleaf weeds. However, the herbicidal activity shown in greenhouse studies may sometimes be overshadowed by CGM's high (10%) nitrogen content. In a long-term study, CGM provided no additional benefit in reduction of crabgrass (*Digitaria ischaemum*), dandelion (*Taraxacum officinale*), and clover populations in Kentucky bluegrass turf compared to urea fertilizer (Christians and Dant 2005). Similarly, no differences in field efficacy for control of common dandelion and smooth crabgrass populations in Kentucky bluegrass and tall fescue lawn plots were found when comparing CGM with two fertilizers (Milorganite and urea) of equivalent nitrogen content (St John and DeMuro 2013). However, another study found that GCM-treated plots had significantly less crabgrass cover than untreated turfgrass plots when CGM was applied in split applications, and usually had less crabgrass cover than those receiving equivalent nitrogen from methylene urea and a turkey litter-based composted fertilizer (Sustane) (Dernoeden 2001). Although significantly better than fertilizer alone, the CGM-treated level of crabgrass control was not considered commercially acceptable by the author.

Experiments also suggest that CGM can increase the efficacy of other herbicides. Crabgrass treated with 49-147 g/m² (437-13,123 lb/A) CGM was more susceptible to the herbicide pendimethalin at rates between 29 and 117 mg/m² (0.25-1.04 lb/A) than crabgrass treated with pendimethalin alone, and the

results suggested that the rate of pendimethalin applied could be reduced to half or even a third of the recommended rate without a significant increase of crabgrass survival (Gardner et al. 1997). Field experiments showed CGM was effective at reducing weed populations in strawberry fields, achieving over 50% control at a rate of 98 g/m² (874 lb/A) and 92% control at a rate of 490 g/m² (4,372 lb/A). (Nonnecke and Christians 1992). Efficacy in matted-row strawberries varied widely over a four year period, where CGM reduced weed cover by 59% in one year and actually increased weed cover from 3% in treated plots to 7% in CGM treated plots another year of the same field trials (Miller 2007). Registration status of the CGM product tested was not reported in the article.

As a pre-plant herbicide, there is the issue of the selectivity and the survival of crop seedlings. A study on the effectiveness of CGM as a pre-plant herbicide for vegetables also looked at crop survival rates. At a pre-plant application rate of 100 g/m² of CGM, weed suppression was significant but not complete; and a rate of 200 g/m² was the most effective in this study (McDade and Christians 2000). However, the rates of survival for direct seeded onions (*Allium cepa*), carrots (*Daucus carota*), beans, (*Phaseolus vulgaris*), and peas (*Pisum sativa*) were very low—8%, 11% and 29% respectively at 100 g / m². At 200 g / m², survival rates for onions, carrots and peas were 3%, 11% and 19% respectively. Survival rates for beets (*Beta vulgaris*) and radishes (*Raphanus sativa*) were also significantly reduced by the use of CGM at the same rates. Sweet corn survival was not negatively impacted at rates of 100 and 200 g/m², but was at a rate of 300 g/m². Thus, CGM is not recommended as a pre-emergent weed control for direct seeded vegetables. However, transplanted broccoli (*Brassica oleraceae* var. *italica*) and cauliflower (*Brassica oleraceae* var. *botrytis*) had no significant differences in growth or yields, so CGM can be an effective weed control for transplanted vegetables (McDade and Christians 2000). Application method can also make a difference. Broadcast application of CGM at rates of 250-750 g/m² (2,230-6,691 lb/A) resulted in a 75% decline in survival of squash (*Cucurbita pepo*) compared to a no-treatment control, while banding between rows at the same rates resulted in a 65% decline in survival (Webber et al. 2010). Both granulated and powdered forms were used, with no significant difference between the two forms. There was no difference whether the CGM was incorporated or unincorporated. Registration status of the CGM product tested was not reported in the article.

There are also reports that CGM is ineffective in certain conditions. In one study, CGM used in peanut fields failed to achieve any weed control (Johnson 2013). In a trial managing roadside vegetation, CGM inhibited germination and scored as well as mulch on a 1-10 visual scale for the first two weeks, but was no different from an untreated control after 10 weeks (Barker and Probst 2009). A study commissioned by the California Department of Transportation concluded that CGM was not a viable alternative for managing roadside vegetation along rights of way (Young 2003). The study cited poor efficacy and high costs.

The main active substance in CGM is thought to be the dipeptide alaninyl-alanine (Ala-Ala), which was isolated from hydrolyzed CGM along with four other dipeptides also identified as being inhibitory compounds for weed seed germination (Unruh et al. 1997). These were alaninyl-asparagine, alaninyl-glutamine, glutaminyl-glutamine, and glyciny-alanine. The mode of action is not entirely clear, but the researchers conjecture that the dipeptides stimulate weed growth at a rate that cannot be supported. Corn gluten meal can also be applied in a way that physically damages weeds through abrasion by propelling CGM as grits through a sandblasting nozzle at air pressures of 500-750 kPa (Forcella et al. 2011).

Rodenticidal Activity

Corn gluten meal may also be used as a rodenticide with other active ingredients exempt from registration. In particular, CGM may be used as a bait formulated with drying oils such as linseed and dehydrated castor oils (Perry 2013). The commercial formulation Corn Gluten RatX (ConSeal International 2012) has corn gluten meal as the only ingredient, and claims 25(b) exemption. As CGM is used as a food for rats and mice, the formulation apparently depends on other dehydrating agents that cause CGM to become lodged in the rat's esophagus. Because rats are non-emetic, they are unable to expel the CGM from their esophagus by vomiting, effectively choking the rat.

Standards and Regulations

EPA Requirements

Corn gluten meal is exempt from the requirement of a tolerance [40CFR 180.950(a)].

FDA Requirements

Corn gluten meal is considered GRAS (Generally Recognized As Safe) by the FDA when used as food, under 21 CFR §184.1321.

Other Regulatory Requirements

Corn gluten meal is allowed by the USDA's National Organic Program (NOP) [7 CFR 205]. However, some applications may be subject to requirements related to the exclusion of genetically engineered products from organic production [7 CFR 205.105(e)].

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