EXTENSION

FAPC-256

Properties of oils produced from uncommon oilseed crops part I: Camelina, Crambe and Meadowfoam

March 2025

Introduction

Vegetable oils are produced from the seeds or fruits of various plants and have been mostly used in food and animal feed. However, for thousands of years, plant-based oils have also been used in many non-food applications, such as soaps, fuel for lighting and lubricants. Over the years, petroleum-based ingredients replaced most of the plant-based components in many products. Growing consumer demand for biobased products produced through sustainable practices has intensified the pressure on the current vegetable oil supplies. Search for new vegetable oil sources, especially for use in nonedible industrial products and fuel production, has led to evaluation of many uncommon oilseeds as potential resources to ease the demand on the commodity oils commonly used in food applications. This fact sheet, which is the first of a series, highlights properties of the oils from unconventional oilseed crops and their suitability for various applications.

1. Camelina

Camelina (*Camelina sativa* L.) is an annual oilseed plant that belongs to the *Brassicaceae* family. It is native to Europe and was widely cultivated until the beginning of the 20th century. Later, it was replaced by the more productive oilseed crop rapeseed. Increased interest in growing this crop in North America and Europe is partly due to its short life cycle (85 to 100 days) low fertilizer and water requirements, and cold and drought tolerance. Both winter and spring Camelina biotypes and many different cultivars and genotypes within each biotype are currently available.

1.1 Seed and oil properties

One of the drawbacks of Camelina is its small seed size, 1,000 seeds weighing only 0.7 to 1.8 grams. Seed yield varies with both climate at the growth location and cultivar. *Camelina sativa* seeds are rich in oil (28 to 50 of seed weight percent) and protein (24 to 31 of seed weight percent). Oil content varies from about 32% to 50% in spring types and 36% to 43% in winter types and is significantly affected by genotype-environment interaction (Zanetti et al., 2021). Seed oil contains both omega-3 and omega-6 fatty acids at a favorable ratio of 1.3 to 2.6 (see fact sheet FAPC-135 for more information on omega–3 fatty acids and Table 1 for fatty acid profile). Camelina seed oil also contains minor amounts (usually less than 1%) of tocopherols, carotenoids, vitamins, phospholipids and phytosterols that are shown to enhance health outcomes when incorporated in the diet (see fact sheet FAPC-196 for more information). Gamma tocopherol accounts for about 90% of the total tocopherols. The amount of erucic acid, which is not desirable in edible oils, is naturally quite low in Camelina oil (less than 4%). Genetically modified lines contain extremely low levels or no erucic acid.

The proteins in Camelina seeds are rich in essential amino acids, leucine, valine, lysine, phenylalanine and isoleucine. Other amino acids present in Camelina include glutamic and aspartic acids, arginine, proline and serine. Phosphorus, manganese, calcium and iron are the major minerals present in Camelina seeds.

1.2 Potential applications

High contents of mucilage, crude fiber and lignin in Camelina seeds could have beneficial effects to gastrointestinal processes in humans. Bread enriched in Camelina seeds is available in supermarkets in some of the European countries (Samarappuli et al., 2020). High polyunsaturated fatty acid (PUFA) content in Camelina seed oil (Table 1) makes it valuable as an ingredient in functional foods and nutraceuticals. The composition of Camelina oil is suitable for use as biofuel, either after conversion to biodiesel (fatty acid methyl/ethyl esters, see OSU fact sheet FAPC-150) or directly as vegetable oil. Recent increased attention in Camelina seed oil is due to its potential as a feedstock for conversion to sustainable (low carbon score) jet fuel (Jolliff, 1987).

The presence of a high amount of PUFA in Camelina seed oil allows for easy chemical modification and use in industrial applications. For example, epoxidized Camelina oil can be used in the production of adhesives, coatings, and resins. Photopolymerization of Camelina oil produces polymers that can be used in various applications, including food packaging and films. Cosmetic products, facial and body creams, shampoos and other hair care products formulated with Camelina oil are already commercially available (Arshad et al., 2022).

Camelina meal (residual seed after oil extraction) contains approximately 45% protein, which is rich in amino acids threonine, methionine, glycine, lysine and cysteine. Camelina meal contains anti-nutritional compounds, such as glucosinolates, phytate, sinapine and other phenolic acids, limiting its direct use as animal feed. Yet, it can be added to various feed formulations. It has been reported that Camelina meal is approved in Canada for broilers and layers (at a 12% inclusion rate) and aquaculture, but swine feed Camelina meal inclusion rate is lower (i.e. approved in the U.S. at 2%) (*Meadowfoam*, 2023).

2. Crambe

Crambe (*Crambe abyssinica Hochst*) is an oilseed crop that belongs to the *Brassicaceae* family and is native to the Mediterranean region. It is an annual herbaceous crop that grows to a height of about 1 to 1.20 meters. Although it is not common, presence of Crambe plants with 2 meters maximum height has been reported (Falasca et al., 2010). Its short life cycle (90 to 110 days after sowing), low fertilizer requirement, resistance to pest and diseases, and relative drought and soil salinity tolerance make Crambe a good rotation crop. The unique seed oil fatty acid composition (one of the main sources of erucic acid) and high oil content of Crambe are valuable attributes for oil-based industrial bioproduct manufacturing. Crambe is being grown semi-commercially on several thousand acres in the U.S. (North Dakota, Texas, California and Connecticut) and a few other countries (Samarappuli et al., 2020).

2.1 Seed and oil properties

Crambe seeds are enclosed in small capsules. Each capsule holds one seed and generally hull stays around the seeds even after harvest. Hull accounts for 25% to 30% of seed volume. Mature Crambe seeds are greenish brown in color and 0.8 to 2.6 millimeters in diameter. The weight of 1,000 seeds is about 6 to 10 grams. The seed yield varies with the crop growth location and agronomic conditions, i.e., 1,125 to 1,622 kg per hectare (1,004 to 1,450 pounds per acre) in Russia and 450 to 2,522 kilograms per hectare (400 to 2,250 pounds per acre) in the U.S. (usually vary between 600 to 4,000 pounds per acre, and on average, 600 to 2,400 pounds per acre). Higher seed yields, 5 tons per hectare (4,050 pounds per acre), have been reported for Crambe grown on irrigated, nitrogen treated and weed-free fields (Buchanan & Duke, 1981).

The oil content of Crambe seeds varies significantly, depending on the variety and agronomic conditions (35% to 60%, and in general the range is 35% to 45%). Since the oil is rich in euricic acid (50% to 60% of the fatty acids present in the oil) (Table 1), which is a monounsaturated long-chain, nonedible fatty acid, Crambe is considered an industrial crop, not suitable for edible applications. It also contains a significant amount of glucosinolates that are not desirable in food and feed formulations.

2.2 Potential applications

Crambe is considered a specialty niche crop because of its very high content of erucic acid, which is important to industrial bioproduct manufacturing. For example, Crambe seed oil is a feedstock for production of erucamide, a key ingredient used by the plastic industry. Crambe oil is also used as an ingredient in various personal care products. Erucic acid has attracted wide interests as raw material for hydraulic fluids, oleochemicals, lubricants, additives and as a starting material for new fibers, resins, plastics and lacquers. The oxidative stability of Crambe oil-derived biodiesel is reported to be higher than that of soybean based biodiesel (Wazilewski et al., 2013).

Crambe seed meal has been reported to have insecticidal qualities or insecticidal attributes due to the presence of two compounds, phenylethyl cyanide and 2-(S)-1-cyano-2-hydroxy-3-butane, which are shown to be effective against house flies and plant-parasitic roundworm. Crambe seed meal has also been studied as a soil amendment to minimize soil pathogens and weed seedbank (Coltro-Roncato et al., 2016). Although Crambe seed meal contains high amounts of protein and fiber, it is not recommended as animal feed because of its high glucosinolates content. Glucosinolates are toxic to monogastric animals. Yet, it has been reported that if the seeds are processed properly, the meal may be used for beef cattle feeding (Vanetten et al., 1977), and FDA clearance for its use in interstate commerce was requested (Princen, 1979). Crambe seed meal and hulls also have potential as an adsorbent material to remove toxic compounds from contaminated water (Rubio et al., 2015).

3. Meadowfoam

Meadowfoam (*Limnanthes alba Benth.*) is an annual herbaceous winter wildflower that grows 10 to 18 inches tall and is native to the Pacific Coast of North America. The name "Meadowfoam" refers to the large canopy of white flowers produced by the plant at full bloom. Search for new raw materials from American plants and extensive research carried out by the scientists at the National Center for Agricultural Utilization Research in Peoria, Illinois have established the potential of Meadowfoam as an industrial feedstock. Meadowfoam has been evaluated as an oilseed and a rotation crop for production on poorly drained soils in regions with cool and moist winters. The yield of Meadowfoam seeds is reported to be about 1,000 pounds per acre.

3.1 Seed and oil properties

Light-colored and pear-shaped Meadowfoam kernels/seeds are covered with a soft and thin brown striped hull. Weight of 150 seeds (each about 2 x 3 millimeters in size) is about 1 gram. The low protein (25%) and relatively high fiber (22%) and glucosinolate (about 4%) contents of Meadowfoam meal make it quite challenging for use in food and feed applications. Depending on the growth region and agronomic conditions, Meadowfoam seeds may contain 27% to 35% (of seed weight) oil (Nyunt, 1986).

Meadowfoam oil is unique because it has the highest 20:1 fatty acid content among known vegetable oils and is a unique source of C20 and C22 fatty acids at very high concentrations.

Meadowfoam oil is valued because of its unique composition of fatty acids, consisting of long chain (20 to 22 carbon) fatty acids (Table 1). Although fish and herring oils contain 40% C20 and C22 fatty acids, the amount of C22 fatty acids in Meadowfoam seed oil is much higher, in some cases reaching to over 90% (Table 1). High levels of monounsaturated and low levels of polyunsaturated fatty acid content in Meadowfoam oil provides oxidative stability (Emken et al., 1991).

3.2 Potential applications

In 1971, Meadowfoam seed oil was named as a substitute for sperm whale oil, which had been banned by the Endangered Species Conservation Act of 1969 (Petersen, 1999).

Refined Meadowfoam seed oil is preferred by the cosmetics industry as an emollient to soften or smooth skin because of its light color and good moisturizing properties. The oil also has potential industrial applications as a biodegradable lubricant, factices for rubber and biodiesel production, a dispersing agent for pigments, and a polymer additive (Erhan & Kleiman, 1990, 1993; Isbell et al., 1996). Use of Meadowfoam seed meal as a slow-release, organic nitrogen amendment in crop production systems appears to be promising (Türkmen & Myrold, 2018). Insecticidal, nematocidal, fungicidal and phytotoxic properties of glucosinolate-containing plant residues and seed meal are due to the glucosinolate breakdown products. It has been reported that seed meals with glucosinolate concentrations of 200 micromole per gram meal would effectively control a wide variety of plant pests (weeds, fungi, nematodes, insects) (Brown & Morra, 1995). Meadowfoam seeds contain about 3% to 4%, or 70 to 90 micromole glucosinolates per gram, of dry seed. There are studies on development of Meadowfoam seed meal with increased glucosinolate content and enhanced conversion of glucosinolates to bioactive degradation products through combination of breeding and postharvest processing techniques (Velasco et al., 2011).

Table 1. Fatty acid composition of Camelina, Crambe and Meadowfoam seed oil expressed as percentage of total fatty acids present (adapted from the references listed at the end of the text).

Seed type/fatty acid	Camelina	Crambe	Meadowfoam
Lauric (12:0)	0-0.1	-	-
Myristic (14:0)	0-0.1	-	-
Palmitic (16:0)	5-7	0.8-2	0-0.5
Palmitoleic (16:1)	0-2	0-0.3	-
Stearic (18:0)	2-3	0.5-1	
Oleic (18:1)	12-24	12-15	0-3.2
Linoleic (18:2)	15-20	8-13	0-0.5
Linolenic (18:3)	27-38	6-7	0-0.5
Arachidic (20:0)	0-1	1-2	0-1
Eicosenoic/Gadoleic/Gondoic (20:1)	14-16	3-4	58.6-69.8
Eicosadienoic (20:2)	0-2	-	-
Eicosatrienoic 20:3	1-2	-	-
Behenic (22:0)	0.2-0.3	0.2-2	
Docosenoic (22:1)	3-4	55-64	7.0-24.6
Docosadienoic (22:2)	-	0-1	7.9-27.7
Lignoceric (24:0)	0.2-0.3	0-0.4	-
Nervonic (24:1)	-	0-1	0-1.2

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