Feature

Meadowfoam:

New source of long-chain fatty acids

Meadowfoam, a wildflower native to the Pacific Coast of North America, is seen by the Oregon Meadowfoam Growers Association as an alternate domestic source of industrial long-chain fatty acids. Recent efforts in the Pacific Northwest have focused on cultivating meadowfoam and promoting usage of the oil. In this article, Richard H. Purdy, technical consultant from Novato, California, and Charles D. Craig, program coordinator for the Oregon Meadowfoam Growers Association, review the history, current status and outlook for meadowfoam as a commercial crop. The address for the Oregon Meadowfoam Growers Association is 866 Lancaster Drive S.E., Salem, Oregon 97301.

Meadowfoam is a low-growing herbaceous winter annual wildflower native to the Pacific Coast of North America. The name "meadowfoam" was derived from its beautiful canopy of creamy white flowers at full bloom. Although one species of the genus was taken to England and grown as an ornamental in the 1800s, its potential industrial importance was not recognized until 1959, when U.S. Department of Agriculture (USDA) scientists at the Northern Regional Research Center in Peoria, Illinois, were searching for new raw materials from native American plants. The value of meadowfoam oil was apparent immediately because of its unique composition of fatty acids, over 95% of which have chain lengths of 20 carbon atoms or longer (1).

(Photo courtesy of Gary Jolliff, Department of Crop Science, Oregon State University, Corvallis, Oregon)

Commercial meadowfoam oil's fatty acid distribution is compared with those of rapeseed and crambe oil in Table 1. Meadowfoam oil has over 35% more long-chain fatty acids than rapeseed oil and 25% more than crambe oil. Its content of methylene interrupted diene (linoleic acid), essential for oxidative stability in industrial products, is significantly low. The high level of monoene is predominated by the unusual Δ5 double bond position, which also is present in the nonmethylene interrupted Δ5,13 diene. Pollard and Stumpf (2) have studied the biosynthesis of these unique fatty acids in the developing meadowfoam seeds.

Seed development

Meadowfoam seeds are pear-shaped, consisting of a thin brown striated hull surrounding a relatively soft, light-colored dicotyledon kernel. The seeds, measuring about 2 × 3 mm, average 150 to the gram. The kernels contribute about two-thirds of the total weight and contain

TABLE 1

Typical Compositions of Long Chain Fatty Acid Sources

	Meadowfoam	Rapeseed	Crambe
18:1	2	17	15
18:2	0.5	14	8
18:3	–	7	4
Other < C:20	1	3	3
20:0	0.5	0.5	1
20:1 (Δ5)	62.5	–	–
20:1 (Δ13)	–	9	4
22:1 (Δ5)	2.5	–	–
22:1 (Δ13)	12	48	59
22:2 (Δ5, Δ13)	18	–	–
Other > C:18	0.5	0.5	6
Total C:20+	96.5	60	70

essentially all of the oil. Commercial meadowfoam produced during 1985 and 1986 contained about 27% oil, although oil contents as high as 35% have been attained in experimental test plots.

In the early 1960s, field trials, germ plasm accessions and agronomic evaluations at a variety of locations concluded that the Willamette Valley of Oregon provided the perfect conditions for seed production (3). The species *Limnanthese alba*, variety *alba*, appeared to have the best potential because of superior seed retention, upright growth and plant height. Experimental yields were sufficient to suggest promise as a new oilseed crop.

The Oregon State Agricultural Experiment Station in 1967 initiated a crop improvement and agricultural production program. In 1980, this program showed an increased level of effort as a result of funding from the Oregon grass seed industry, which was searching for alternative crops to grass seed for the poorly drained soils of the Willamette Valley and for a way to lessen the pollution resulting from field burning required after harvesting. Two cultivated meadowfoam varieties were released by the agricultural station, including "Mermaid" which was released exclusively as a proprietary variety to the Oregon Meadowfoam Growers Association. This variety is currently the only known variety in commercial production.

Thirty-five acres planted in 1979 resulted in the production of 2,000 pounds of greenish black oil. Samples were provided to industry under contract by an Oregon wood products firm. The poor quality of the oil, its high price and lack of availability sharply limited interest. However, meadowfoam intrigued the Japanese cosmetic industry and its industrial potential promised by its long-chain fatty acid composition sustained development activity.

Extraction and refining

The first attempt at commercial production of meadowfoam oil was by full expeller pressing. Unfortunately, yield was considered more important than quality during the operation, resulting in an oil very difficult to clean up but acceptable to the Japanese. Less yield-efficient expeller pressing using a small Hander EX-100 unit required only pretreatment with phosphoric acid and activated bleaching earth, followed by physical refining, to attain a color of 0.3 lovibond red. About 1,000 pounds were produced using pilot plant equipment for sampling potential customers.

Evaluation of extraction techniques, comparing pre-press/hexane extraction and direct hexane extraction with and without prior extrusion, was conducted at the Texas A&M Engineering Experiment Station using a 4.5-inch Anderson extruder and a one ton/day pilot Crown continuous extractor. The data indicated that direct extraction with prior extrusion was feasible based on meal oil content residuals of less than 1%. Extracted oil quality from all three processes required phosphoric acid pretreatment prior to alkali refining, and the use of carbon and activated bleaching earth to achieve less than 1.0 lovibond red colors after deodorization.

Commercial seed and oil production

Approximately 250 tons of meadowfoam seed harvested in 1985 and 1986 were crushed in October 1986 by direct solvent extraction using the extruder for seed pretreatment. Residual oil contents of less than 2% in the meal were attained. This was considered quite satisfactory for such a short run. Oil quality, as judged by laboratory refining, was comparable to the pilot plant crude extract.

The resulting 135,000 pounds of crude oil were phosphoric acid pretreated, alkali-refined, vacuum bleached with activated clay and carbon, and deodorized, yielding approximately 125,000 pounds of oil with 0.7 lovibond red color, 0.03% free fatty acid and bland flavor and odor.

Oil characteristics

Commercially extracted crude oil (Table 2) is very dark with a heavy black muscilagenous sludge settling out during storage. The amount and nature of the phosphatides have yet to be determined, but probably could be estimated at 1 to 1.5% based on the difference between the neutral oil loss and the free fatty acids, moisture and impurities.

The crude oil free fatty acids are relatively low, as might be expected of longer carbon chain fatty acid triglycerides and the rather intact seed coat. An 0.8% value was obtained from extracted 1985 and

1986 harvested seed, half of which had been stored for over a year. Oil pressed from recently harvested seed usually runs less than .5%. Both density and viscosity parallel the fatty acid composition.

Refined meadowfoam oil remains clear and liquid at refrigeration temperatures, probably because of the melting point depressing effect of the 18% dieonic fatty acid. However, the non-methylene interrupted C-22, Δ5, 13 diene acts more like a monoene with regards to oxidative stability as evidenced by the unusually high activated oxygen method (AOM) value attained after deodorization.

The tocopherols in commercial crude and deodorized meadowfoam oils have been analyzed (Personal communication, Robert R. Lowry, Oregon State University, May 1987). The predominate tocopherol in crude oil is gamma tocopherol, at 0.05%. Alpha and beta tocopherols contribute an additional 0.01% each. Commercial deodorization reduces the gamma isomer by about 40%.

Meal characteristics

The somewhat low protein (25%) and high fiber (22%) levels of meadowfoam meal, in addition to its glucosinolate content, suggest utilization problems. Although somewhat low in methionine, the amino acid distribution (Table 3) very closely parallels those of rapeseed and crambe meals, with quite satisfactory levels of lysine. The glucosinolate level of 105 micromoles/gram (about 4%) is three to four times the level defined for low glucosinolate canola meal, but lower than crambe meal. About 90% is meta-methoxyl benzyl glucosinolate and the remainder is primarily 2-hydroxy-2 methyl propyl glucosinolate.

Feeding trial data are limited. However, Throckmorton (4) at Oregon State University reported that even raw uncooked meal is a satisfactory protein supplement for sheep and was accepted readily when added as a top dressing in a basal diet. He recommended it not be fed to pregnant ewes and newborn lambs until further studies relative to goiter problems are conducted.

TABLE 2

Analytical Characteristics of Meadowfoam Oil

	Crude	Deodorized
Free Fatty Acids, %	0.8	0.03
Moist. & Imp.,	0.2	nil
Color, Gardner	dark	2
Unsaponifiable, %	–	0.2
100 - Neutral Oil, %	2.4	–
Viscosity, cp @ 25 C	–	85
Density, g/ml @ 25 C	–	0.907
Cloud Point, °C	–	4.5
AOM, hr	–	150-200

Throckmorton's study with growing rabbits and broiler chicks (5) indicated "steam cooked" meal (presumably equivalent to desolventized-toasted meal) was satisfactory. Feeding trials using the 1986 commercial meal with rabbits involving several sequential litters of the same parent animals are in progress. No abnormalities have been observed after the first litter (Personal communication, Peter Cheeke, Oregon State University, August 1987).

Oil utilization

Utilization research on meadowfoam oil has been limited. Studies at the USDA laboratories in Peoria have explored lubricant uses, with emphasis on the preparation and evaluation of liquid wax esters and their sulfurized products (6). Hydrogenation of the triglyceride yielded a high melting point product comparable to carnauba and candelilla (7). Comparisons with other sulfurized vegetable oil triglycerides indicated meadowfoam derivatives to be superior as lubricant additives (8).

Meadowfoam oil fatty acids are liquid at room temperature as are the alcohols. The isopropyl ester exhibits a very low cloud point

TABLE 3

Amino Acids in Meadowfoam Protein

(g/16 g Nitrogen)			
Cysteine (half)	1.1	Lysine	5.1
Tyrosine	2.6	Arginine	7.4
Glycine	6.2	Methionine	1.3
Serine	3.9	Histidine	2.4
Alanine	4.0	Threonine	3.1
Aspartic acid	7.8	Leucine	6.4
Glutamic acid	16.4	Isoleucine	3.3
Proline	4.3	Valine	4.2
Ammonia	2.6	Phenylalanine	3.9

(−17 C) and low viscosity (10 cp at 25 C) and appears to be of interest to the cosmetic industry because of its "dryness" or very rapid adsorption into the skin. The mono/diglycerides (40% mono-) are semisolid at room temperature, but remain liquid for several days after melting, as opposed to distilled monoglycerides (90% mono-), which crystallize rapidly. The propylene glycol ester is a soft gel. These products should demonstrate unique functionality in many applications based on the long carbon chain length of their fatty acids.

Industrialization in the private sector has been inhibited by poor quality oil samples, lack of availability and acceptable prices. However, a recent survey of the ten most promising new crops estimated an overall demand for more than 100 million pounds of meadowfoam oil annually, if prices could be achieved in the 50-cents-per-pound range (9).

A credible and reliable production management and marketing organization exists. Successful routine commercial-scale extraction and refining have been accomplished. High value specialty uses such as cosmetics are increasing. Advances in crop production technology and cultivar yield improvement are currently in process on a modest scale, with a 50% yield increase likely within the next two years. A proposal to accelerate the commercial development of meadowfoam through an intensified cultivar development and comprehensive industrial utilization study involving a three-way state, federal and industry-funding mechanism appears to be receiving favorable review. The overall objective of this program is to make meadowfoam oil available for 50 cents per pound within the next five to ten years.

No serious biological barriers have been identified that would impede rapid progress toward this goal.

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Fats & Oils News

Italian firm to buy Central Soya

Shamrock Capital L.P., a limited partnership led by Shamrock Holdings Inc., announced it has signed an agreement to sell Central Soya Co. Inc. to Ferruzzi Agricola Finanziario, the holding company of the Ferruzzi Group based in Ravenna, Italy.

Under the agreement, which is subject to regulatory approval, Ferruzzi will acquire all the equity in Central Soya and assume subordinated term debt of $195 million in a transaction valued at approximately $170 million. The transaction, if completed by mid-October as expected, will represent the largest acquisition of a U.S. company by an Italian company.

Shamrock Capital L.P. acquired Central Soya in a leveraged buyout in July 1985. Central Soya, with annual net sales of approximately $1.5 billion, is one of the leading U.S. processors of soybeans and related products; it operates 65 plants and facilities in seven countries.

According to Stanley P. Gold, Shamrock president and Central Soya chairman, Central Soya will continue to operate as an autonomous business from its Fort Wayne, Indiana, headquarters under its existing management team headed by David H. Swanson, president and chief executive.

Founded in 1933, Ferruzzi is one of Europe's largest soybean, corn and sugar processors. It also is a major commodity trading company and owns approximately 40% of Montedison, the giant Italian chemicals conglomerate. Recently, Ferruzzi also acquired CICA, the largest fruit and vegetable processor in Brazil and has signed an agreement with CPC International to buy CPC's European corn wet milling businesses. Included in that transaction are 13 manufacturing facilities, a headquarters, office in Brussels and a research and development facility.

Central Soya, a leading international agribusiness company, markets products to customers in more than 60 countries. Its major businesses include feed manufacturing, soybean processing, grain merchandising, vegetable oil refining and the manufacture of soy proteins and lecithins.

ARS Scientist of the Year

AOCS member Richard F. Wilson has been designated "Distinguished Scientist of the Year" by the U.S. Department of Agriculture's Agricultural Research Service (ARS).

Wilson is being honored for "pioneering research on the biological regulation of lipid synthesis to improve the oil quality of soybean and for development of outstanding young scientists." Wilson, a member of AOCS since 1973, has been with ARS at North Carolina State University's Department of Crop Science since 1976. His research there has focused on developing biological systems for improving the quality and use of soybean oil through eliminating linolenic acid content.

ARS normally cites one "Distinguished Scientist" and three "Outstanding Scientists" each year after nominating one scientist from each regional area. This year, however, it selected Wilson and Thomas J. Sexton to each have that title. Sexton, an avian physiologist assigned to USDA's ARS facility at Beltsville, Maryland, was selected for his research in turkey breeding.

Wilson and Sexton, as well as two "Outstanding Scientists" and seven other area scientists were to be recognized in ceremonies Nov. 3, 1987, in Washington, D.C. Wilson and Sexton each will receive a $5,000 personal award and $40,000 in equipment and research funds.

Wilson earned his masters and doctoral degrees in agronomy from the University of Illinois at Champaign-Urbana. He has served as poster session chairman at AOCS World Conferences in 1985 in Cannes, France, and 1987 in Hamburg, West Germany.

P&G's Meyer retires

Walt Meyer, associate director of food product development for Procter & Gamble Co., retired the end of September after nearly 40 years with the company.

Meyer, whose responsibilities included regulatory, professional and safety concerns, will continue to do consulting work for P&G. However, retirement will mean