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Flax: New Uses and Demands

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Flax (*Linum vistatissimum* L., Linaceae) and certain perennial species has been used in food in Europe and Asia since 5000–8000 BCE, and the fiber of flax stem has been used for linen cloth, and many other uses. Approximately 200 species of *Linum* (flaxseed or linseed) are known (Carter 1993). Flax was first brought to North America for its stem fiber to use in making of linen and paper. The stem fiber of flax makes a fine parchment paper. In the Northern Great Plains region of the United States and Canada, flaxseed has been grown as a commercial oilseed crop for over 100 years. Linseed oil is pressed from flaxseed and further extracted with a petroleum solvent. Industrial linseed is not useable for food or feed, although the linseed meal remaining as a by-product after oil extraction is used for animal feed rations. Use is increasing for flaxseed as a food. Approximately 2,340,000 bu [60,000 tonnes (t)] of flaxseed are used for food annually in Germany (Prentice 1990). Although cold-pressed flaxseed oil is not considered suitable for frying at high temperatures, flaxseed oil is used for low-temperature stir-frying in hundreds of villages in the flax-growing region of the People's Republic of China (Pan 1990).

CROP AREA AND PRODUCTION

Flax has been grown in North Dakota, South Dakota, Minnesota, and Montana since the early 1900s. North Dakota is the flax production leader with over 95% of crop area planted in 2001. In 2001 North Dakota farmers planted 214,120 ha of oilseed flax whereas the United States total flax crop area was 224,600 ha (NASS-USDA 2001). Total flax area in the United States has greatly increased in the past six years, from 38,800 ha in 1996 to 224,600 ha this past growing season. The Canadian prairie provinces produce a very large amount of oilseed flax. In 2001, 661,000 ha were planted in Canada which is approximately three times the crop area planted in the United States. Total 2000 production of oilseed flax in the United States was 273,000 t. In Canada, 2000 oilseed flax production was reported to be 707,000 t.

FLAX AS A FOOD

Flaxseed and flaxseed oil have been used for food for centuries in Asia, Europe, and Africa. More recently flaxseed has come onto its own in North America. Flaxseed has three major components making it beneficial in human and animal nutrition: (1) a very high content of alpha linolenic acid (omega-3 fatty acid) essential for humans; (2) a high percentage of dietary fiber, both soluble and insoluble; and (3) the highest content of plant "lignans" of all plant or seed products used for human food. Lignans appear to be anti-carcinogenic compounds (Lay et al. 1989). Scientific literature over the last 30 years supports the many expected health benefits of consuming flaxseed and cold-pressed flaxseed oil. Some of the benefits were studied directly by feeding flaxseed to people in controlled studies, and some were studied indirectly by feeding laboratory animals including mono-gastric animals which are consumed as meat or eggs. The National Cancer Institute has evaluated flaxseed, along with a number of other potential food ingredients, as a component of "designer foods" (Stitt 1990). Designer foods may be defined as those foods composed of one or more ingredients that contribute essential nutrients for health but also protect against certain diseases such as cancer and coronary heart disease. Several universities in US and Canada plus the Food and Drug Administration have conducted research on feeding flaxseed, with its high fiber and omega-3 fatty acid in its oil, to people or animals to evaluate potential health benefits. The apparent results have been positive.

Several authors have published details of flaxseed composition. The average composition of 11 flax cultivars are shown in Table 1 (Hettiarachchy et al. 1990).

The North Dakota flaxseed cultivar 'Omega', a yellow or golden flaxseed is preferred in Europe and also sold in Japan, Korea, and in United States food markets. Its yellow color when ground blends well as a food ingredient. Ground or whole flaxseed can be added to almost any baked product and adds a nutty flavor to bread, waffles, pancakes, and other products if it composes 6%–8% of the dry components of the recipe or formula. Some other food uses of flaxseed are: ready-to-eat breakfast cereals, breakfast drinks, salad dressings made with cold-pressed flaxseed oil, salad toppings, biscuits, meat extenders, crackers, soups, bagels,

fiber bars, and cakes. Flaxseed flour is used commercially in breads in the United States by one or more large bakeries selling thousands of loaves per day (Burckhardt 1989) and by many bakeries and chain stores in Canada.

Table 1. Composition of whole flaxseed produced in North Dakota, average of 11 cultivars.

Component	Content (%)
Moisture	7.1–8.3
Lipids (DW basis)	31.9–37.8
Protein	26.9–31.6
Total dietary fiber	36.7–46.8
Insoluble	30
Soluble	10
Fatty acid composition	
Palmitic	4.6–6.3
Stearic	3.3–6.1
Oleic	19.3–29.4
Linoleic	14.0–18.2
Linolenic	44.6–51.5

FLAXSEED IN ANIMAL AND POULTRY FEED

Flaxseed once ground or processed can be fed as an ingredient to poultry. So-called "Omega eggs" are being produced by two companies in the US and 11 companies in Canada (Henkes 1999). "Omega eggs" contain increased amounts (300 mg/egg) of omega-3 fatty acids and decreased amounts of saturated fatty acids (Scheideler and Lewis 1997). The increase in yolk polyunsaturated fatty acid (PUFA) is accompanied by substantial decrease in saturated fatty acid, resulting in a healthy fat profile and more nutritional egg. Omega eggs have been consistently lower in cholesterol content from 210 mg/egg (Standard USDA egg level) to 180 mg/egg (Omega egg).

Feeding flaxseed to laying hens increases the omega-3 fatty acid in the egg by 6 to 8 times, making one egg equal to 113 g (4 oz) of cold water fish as a source of the omega-3 fatty acids. Further, research supported by the North Dakota Oilseed Council in Nebraska and Texas indicates consumption of up to 14 flax eggs/week improves the nature of blood lipids. If 5% of the laying hens in the US were fed 10% flaxseed in the ration then 60,000 ha more flax would be needed to supply the increased demand.

Several researchers have looked at the use of flaxseed in dairy cattle diets in an attempt to influence milk-fat composition. However, more research is needed before feeding flaxseed to dairy cattle will be a commercial reality. Researchers suggest that feeding flaxseed to breeding chickens and sows can increase the level of unsaturated fatty acids in the young chick and piglet. It is felt that these young animals may have tissue deficiencies in omega-3 fatty acids. Their health and livability may improve as a consequence of receiving more omega-3 fatty acids via their mothers. In the pet food industry, flaxseed is attracting attention from researchers. Feeding flaxseed may improve pet health in a similar manner as it does human health.

Gain and efficiency were greatest for cattle fed diets containing flax, and were substantially improved ($P<0.05$) relative to diets containing full-fat soybeans (Drouillard et al. 2000). No notable differences were evident in terms of the percentage of cattle treated for bovine respiratory disease, though cattle tended to require fewer retreatments when fed the diet containing flax. Death losses among stressed feeder calves were numerically highest for cattle fed beef tallow, and were lowest for those fed the diet containing flax. Growth performance and immunity can potentially be influenced by the source of dietary lipid.

FLAXSEED OIL FOR INDUSTRIAL USE

The principal use of oilseed flax in the past has been for its linseed oil which is used in paints and coatings and other industrial uses. The use of modified other vegetable oils and petroleum products in place of linseed oil led to the reduced flax crop area. Paints and coatings containing linseed oil still are the highest quality and most durable of products. The linseed oil meal (LSOM) by-product left from oil extraction was and is used as an animal feed.

Linseed oil has recently been used as a diluent in paints and coatings. Linseed oil is a drying oil, a vegetable oil which undergoes oxidation and forms a natural, plastic-like film. The reactivity of linseed oil can be improved by the addition of metal catalysts, called driers, which promote oxidation, and by partially pre-oxidizing the linseed oil through exposure to the air. The use of linseed oil in this capacity is limited. Linseed oil has a comparatively slow curing rate, and has a tendency to soften paint films. As a diluent it cannot reduce volatile organic compound (VOC) levels to the degree required by proposed VOC regulations while still providing the desired film properties for many applications. Dilulin, a new linseed oil based reactive diluent manufactured by Cargill (Minneapolis, Minnesota), overcomes these problems.

OILSEED FLAX FIBER USES

Oilseed flax stem fiber is now being processed and used for a number of products. In addition to cigarette paper, flax fibers are being used for pulp and paper, erosion control mats, reinforcing materials in plastics and particle composite products (Domier et al. 2000). The value-added potential of oilseed flax straw is usually just burned or left in the field and sold to the three companies for $6.00 to $9.00/t. In Europe there is considerable interest in the use of natural fibers (such as oilseed flax) in interior panels, visors, and other parts of automobiles. Natural fibers like flax are blended with polypropylene or other synthetic fibers then needle-punched into a mat, a cover material can be added and then the composite can be hot pressed in one operation. North American manufacturers have started to use composites made from natural fibers. One company manufactures automotive head liners made from natural fibers (flax, hemp, jute) sandwiched between polyurethane foam. General Motors has Canadian oilseed flax fibers in the rear parcel shelf of selected models. Other vehicles also have some oilseed flax fibers in some of their interior components. Panels and molded products made from oilseed flax fiber/polypropylene mats may be very suitable for hygienic applications such as dairy plants, abattoirs, food processing facilities, etc. This composite material should combine excellent strength and durability characteristics with moisture resistance. Mats made from oilseed flax fibers with or without the addition of other materials such as polypropylene, polyethylene, cotton, wool, may be suitable for use as insulation, filters, upholstery padding, carpet backing, geotextiles for erosion control, and horticultural applications.

CONCLUSIONS

It is likely that the use and demand for oilseed flax will continue to increase and be utilized as a healthful food additive plus its use for animal feeding. New industrial uses of both the linseed oil and the fibers of oilseed flax also will increase the demand for this multi-use oilseed crop.

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