Congress considers aflatoxin bill

Rep. Jim Jontz of Indiana in June introduced the Aflatoxin Food Safety Act of 1989 to Congress "to standardize and improve the accuracy and validity of tests for aflatoxin."

Directed at corn, the bill would require the Federal Grain Inspection Service to establish uniform standards for aflatoxin-testing equipment and uniform testing procedures and sampling techniques. The bill also calls for mandatory testing of all corn exports, research to determine safe levels of aflatoxin and indemnification to farmers for contaminated corn.

USDA okays field testing

In June, USDA's Animal and Plant Health Inspection Service told Monsanto Agricultural Co. it could plant genetically engineered soybeans in Whiteville, Tennessee, and Jersey County, Illinois, without preparing an environmental impact statement.

The agency ruled that field-testing soybean plants, which are modified to be tolerant to the herbicide glyphosate, would pose no significant impact to the quality of the human environment and would not present a risk of plant pest introduction. Details: *Federal Register*, June 7, 1989, pp. 24366-24368.

FGIS proposes rapeseed standards

The U.S. Department of Agriculture's (USDA) Federal Grain Inspection Service (FGIS) is accepting comments on its proposal to consider official U.S. standards for common rapeseed *(Brassica napus)* and turnip rapeseed *(Brassica campestris)*. Comments are due by Aug. 28.

"Official standards should facilitate and enhance trade of rapeseed and rapeseed products in domestic and international markets," FGIS said in its *Federal Register* notice. The agency noted that the economic importance of rapeseed is increasing in the U.S., and rapeseed oil imports are projected to increase from an estimated 330 million pounds in the 1987/1988 crop year to 440 million pounds in the 1988/1989 crop year.

If FGIS chooses to propose rapeseed standards for the U.S., it will consider using the Canadian term "canola" in standards for rapeseed varieties from which canola oil is derived. Details: *Federal Register*, May 30, 1989, p. 22924.

FOOD TECHNOLOGY

Applications for genetically modified oils

Various sources of triglyceride oils are used by technologists to achieve desired functional properties. The chemist, of course, has been able to manipulate oil characteristics through blending, rearrangement and hydrogenation. Now, manipulation of oil characteristics and the development of new oil types may be possible through genetic manipulation.

Genetically modified oils are not a new discovery but they are receiving more attention. Currently, modified rapeseed, sunflower and safflower oil are marketed for specific applications with implied functional or health benefits. Soybean oil also is being investigated for development of functional and nutritional characteristics.

The following article is a composite of three papers on genetically modified oils written at the request of Frank Orthoefer of Riceland Foods, who serves as Associate Editor for *JAOCS* News for Food Technology. The canola oil review was prepared by N.A.M. Eskin and M. Vaisey-Genser of the University of Manitoba; the sunflower review was written by R. Yodice of SVO Inc.; the soybean review was prepared by T.L. Mounts of the U.S. Department of Agriculture's Northern Regional Research Center. Particular emphasis is placed on the applications of the modified variants and the benefits obtained.

Canola oil

Canola oil is obtained from rapeseed modified through the work of Canadian researchers Keith Downey and Baldur Stefansson. This modification resulted in a marked reduction of erucic acid (C22:1) from 20-40% to a level of 2% and a corresponding increase in oleic acid (C18:1) from 23-34% to levels ranging from 55-64% depending on the cultivar (1). This change in fatty acid composition resulted in dramatic improvements in the nutritional characteristics of the oil without compromising yield. These nutritional benefits combined with the recent acceptance by the U.S. Food and Drug Administration (FDA) have brought recognition of canola oil in the North American market. Although canola is used extensively in Canada, information on its performance in frying and baking is sparse.

Early studies showed that finished canola and soybean salad oils were comparable in flavor stability under accelerated storage conditions (2). Recent studies by Warner and co-workers (3) in the U.S. reported canola oil to be inferior to soybean oil during accelerated storage. However, these results should be interpreted cautiously since both oils were processed under conditions typical for soybean oil only. It is important to note that in Canada, canola oil is deodorized at a slightly higher temperature (260–270°C) than soybean oil (250–260°C). Unlike soybean oil, canola oil without winterization remains clear and free-running under refrigerator conditions.

Like soybean oil, canola oil is used extensively to fry food. In a comparison of three canola oils with soybean, corn and sunflower oils regarding the quality of frozen french fries after shallow frying, two of the oils compared favorably in terms of oily flavor intensity and overall quality of fried potatoes (1). Extended deep-fat frying studies by Stevenson and co-workers (4) showed similar development of free fatty acids and polar compounds in both soybean and canola oils. Panelists reported that french fries cooked in either canola or soy liquid fats were very acceptable even after the fats had been used for 10 days.

Canola oil is a high-linolenic acid (C18:3) oil, and like soybean oil, develops a distinct room odor during frying. This is a lingering odor in the frying environment and not in the fried food. Room odor has not deterred the use of these oils in North America, but has been criticized in France and Brazil. A new cultivar of canola—Stellar—introduced by Scarth and co-workers (5) shows a reduction of linolenic acid content from 9–11% levels to 3%. In a study to be published shortly, it was found that room odor development in low-linolenic acid canola oil was substantially reduced but not totally eliminated (6).

The low-linolenic acid canola oil also showed remarkable stability during accelerated storage at 60°C (Schaal Oven Test) for 12 days with negligible changes in both sensory and chemical indices of rancidity compared with regular canola oil (7). Large-scale production of low-linolenic acid canola oil will depend on the relative benefits of flavor stability and any distinct nutritional advantages established for omega-3 fatty acids.

In Canada, baked products utilize salad oils, shortenings and margarines. As in the U.S., the trend is to replace the plastic fats with liquid oils in bread and cake baking. The poor volume and hard crumb may be overcome by the addition of surfactants (8).

In studies using a blend of hard monoglycerides, polysorbate 60 and sodium stearoyl lactylate, equivalent results were obtained with white layer cakes using a hydrogenated canola oil shortening (9). Acceptable cakes were obtained using oil levels as low as 10.5% of the flour content as long as sufficiently high levels of surfactants (9.5%) and water (169%) were incorporated. The low fat level makes these cakes particularly attractive in today's health-conscious society.

Bread products account for the highest consumption of all bakery products. Fats and oils are used in yeast breads to insure that the dough has good handling characteristics and desired loaf volume in the final baked product. The increased use of surfactant systems by commercial bakeries should permit greater utilization of canola oil.

Canola oil is the final product of years of research by plant geneticists in cooperation with food scientists, nutritionists and food processors. The desirable physical and nutritional properties of this oil have made it a valuable addition to the edible oil market.

Sunflower oil

Sunflowerseed is one of the world's major oilseed crops finding wide acceptance in Europe and, to a lesser extent, in the U.S. The oil is perceived to be of high quality and polyunsaturated. The fatty acid composition of the oil does vary with climate. Today, most of the oil produced contains approximately 70% linoleic acid and 20% or less oleic acid, with the remainder composed of stearic, palmitic and other minor fatty acids.

In the early 1980s, breeding programs were begun that culminated in the development of a series of patented hybrids that produced oils containing very high levels of oleic acid (C18:1). An additional feature of these hybrids was their relative insensitivity to climatic variation; seeds grown in northern climates produced oils chemically identical to seeds grown in southern climates. Typical fatty acid profiles on these seeds show oleic acid levels at 80% and linoleic acid at

9–10%. The remaining fatty acids are similar to normal sunflower oil.

Applications for high-oleic sunflowerseed oil are those requiring oxidative and flavor stability. The high-oleic sunflowerseed oil contains the lowest level of polyunsaturated fatty acids of any commercially available unsaturated oil. This combination permits the food formulator and processor to use a liquid oil with high stability (40–50 hour AOM) and relatively low melting point (40°F). The flavor is typically bland over long periods of time in a variety of applications. The fatty acid composition is similar to olive oil, but has the typical flavor of freshly deodorized vegetable oils.

Current applications of high-oleic sunflower oil include use as a salad and frying oil. It is used in partially hydrogenated form as an improved-stability spray coating; it also can be an intermediate for the production of a butter replacement.

Applications for high-oleic sunflowerseed oil are those requiring high oxidative and flavor stability.

As a salad oil, the modified sunflower oil may be used in the preparation of salad dressings or in deep-fat frying applications and in pan frying. Shelf stability is superior to other commercially available non-hydrogenated oils in both accelerated and room temperature stability studies. This product also can be used in sauces, infant formulas and baked goods.

Partial hydrogenation of the high-oleic sunflower oil reduces the linoleic acid concentration to less than 1% while the saturated fatty acid content is maintained. The melting point is 70°F, resulting in a liquid oil with extreme thermal stability. AOM values of more than 100 hours are obtained without the use of antioxidants. Addition of antioxidants provides AOM stabilities of more than 500 hours.

High stability of the partially hydrogenated product allows its use in deep-fat frying applications that require excellent stability and flavor characteristics. This product may also be used as a substitute for spray coating in place of highly saturated lauric oils, such as palm kernel and coconut oils. Further hydrogenation may be used to produce hard butters for applications such as imitation dairy products. Cocoa butter extenders may be advantageously produced from high-oleic sunflower oil. The triglyceride itself contains more than 90% oleic acid in the beta position similar to cocoa butter, making the oil adaptable to manipulation of the triglyceride structure.

High-oleic sunflower oil meets many of the criteria for healthy vegetable oils. Studies have shown that substitution for saturated fats results in decreased cholesterol and decreased levels of low-density lipoproteins while the beneficial high-density lipoproteins are maintained. This profile for cholesterol regulation is believed to decrease the risk of coronary and arterial disease.

Soybean oil

Soybean breeders employing hybridization and induced mutation techniques have developed new soybean varieties yielding oil with altered characteristics, i.e., fatty acid composition and enzyme profile. Most of the effort was in response to earlier soybean research on oxidative and flavor stability which identified the linolenic acid constituent as most susceptible to autoxidation.

Processors have typically improved the stability of soybean oil by reducing the linolenic acid content through catalytic hydrogenation. Oxidative stability during storage is improved, but not the flavor stability. Hydrogenation presents a distinct flavor and introduces positional and geometrical fatty acid isomers. Mutation breeding research at Iowa State University and at USDA/ARS-Purdue University was successful in developing lines which gave oils low in linolenic acid. Iowa State University also obtained a line with an oil high in stearic acid.

Evaluation of the genetic variants A5 (3.3% 18:3) and C1640 (4.2% 18:3) in comparison with a normal soybean oil (7.7% 18:3) and a commercial hydrogenated soybean cooking oil (3.0% 18:3) showed the development of peroxides generally decreased with decreasing linolenic acid content (10). The low-linolenic acid oils did not show improved flavor stability during accelerated storage at 60°C for four days, which is approximately equivalent to three months' storage in the dark at ambient temperature. Under the extreme conditions of eight days' accelerated storage, the low-linolenic acid oils showed greater flavor stability than the unhydrogenated soybean oil. Room odor evaluation of the oils during use at 190°C showed that the low-linolenic acid oils performed better than the unhydrogenated soybean oil and lacked the objectionable fishy odor even after five hours of heating. Significantly, low-linolenic acid oils performed better than hydrogenated oil in that they did not generate the hydrogenated odor.

In a subsequent evaluation (11), A5 (3.3% 18:3) and A6 (20% 18:0) were compared with oils from two commercial soybean varieties—Hardin (6.9% 18:3) and BSR-101 (8.1% 18:3). Bread cubes were fried for one minute at 185°C ± 5°C. Two 30 g batches were fried in fresh oil; one batch was stored at 60°C for 14 days and the second batch was frozen at −10°C until sensory evaluation. After 40 hours of heating, 30 g of bread cubes were fried one minute and frozen as before. The flavor scores of the bread cubes fried in the A5 oil at 0 hour and 40 hours of heating were generally higher than those of the cubes fried in other oils. The flavor scores of the cubes fried in all oils after 40 hours were lower than those fried in the fresh oils. The stored cubes fried in A5 and A6 oils were significantly blander ($P < 0.05$) than those fried in commercial oils.

The results of these performance tests showed that the oils from the new varieties produced by induced mutation breeding generally performed better at high temperature than commercial soybean oils or hydrogenated soybean cooking oils.

Lipoxygenase has been considered to be important to the formation of objectionable flavors in soybean products and to the oxidation of oil during cracking and flaking operations in preparation for extraction of soybeans. Commercial practice is to inactivate lipoxygenase with a heat treatment; however, this decreases protein solubility and lowers oil yield. Therefore, elimination of lipoxygenase by mutation breeding or genetic engineering could be advantageous.

Researchers at the University of Illinois found a soybean genotype lacking one of the three lipoxygenase isozymes in soybean, L-1 (12). Frankel and colleagues (13) evaluated the flavor quality of oil and meal obtained by extraction of samples of this genotype in comparison with normal beans. Heat-tempered beans were compared to untempered beans, both normal and null L-1. Flavor scores of all the defatted flours were improved by heat tempering. This result suggests that L-1 is not the lipoxygenase enzyme responsible for development of off-flavor in defatted flours. Oils were evaluated for flavor and peroxide development at each processing step and after deodorization. These evaluations showed there was no significant difference in either the flavor or oxidative stabilities of the oils from normal and from null L-1 soybeans. The genotype evaluated in these tests contained significant L-2 and L-3 activities.

Recently, evaluation of soybean lines lacking the L-2 and L-3 isozymes of lipoxygenase has been reported (14). Century seeds grown at the same time as the experimental lines were used as a control in sensory evaluations of soy flours and soymilks. Samples were rated by six individuals experienced in flavor profiling in three test periods conducted during the mornings of three consecutive days (one test period per day).

There was a large difference between the scores of the null L-2 line and those of the other lines concerning aroma and flavor of soymilk samples. Although the difference in flavor scores of soy flours was less dramatic than that for the soymilk, the beany flavor of the flour from Century was significantly less in the null L-2 line flour. The results of these tests indicated that both off-flavors and lipid oxidation were lower in sample preparations from the null L-2 lines. Considerable industrial interest has been generated by these results.

These and future developments in the genetic modification of soybeans to facilitate end uses will have a major impact on the marketing system for soybeans. As breeders and genetic engineers achieve the goal of tailoring the soybean, segregating the crop on the basis of specific characteristics will be important. Processors may develop contracts with farmers to plant the specific variety to provide the desired end-use properties.

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