Erucic Acid Levels in Western Canadian Canola and Rapeseed[1]

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Canadian exports of canola seed and oil are shown to meet the Generally Recognized as Safe (GRAS) standard of 2% erucic acid. Canadian seed exports averaged less than 2% erucic acid since 1980 and individual cargoes, with one exception, contained less than 2% erucic acid since 1982. Most Western Canadian crushing plants have produced oil with less than 2% erucic acid since 1981, and all since 1984. Areas where *B. campestris* varieties of canola predominate may still have difficulty in meeting a 2% erucic acid standard without screening incoming seed. Further reductions in the erucic acid level of *B. campestris* canola varieties are desired.

Canada has been a world leader in the use of low erucic acid rapeseed and canola. The first low erucic acid lines of rapeseed (LEAR) were isolated in Canada in 1961 (1); the first commercial LEAR variety, *B. napus* cv. Oro, was released in 1968. Antinutritional effects of erucic acid were given widespread publicity at the International Rapeseed Congress at St. Adèle in 1970 (2). Canadian farmers responded to these reports by quickly adopting a voluntary policy of growing only LEAR varieties. The average level of erucic acid in Canadian rapeseed dropped quickly from about 30% of the total fatty acids in 1970 to less than 5% in 1974 (3).

The Canadian oil industry voluntarily restricted the erucic acid content in rapeseed oil to less than 5% in 1974 and has guaranteed less than 2% for many export shipments since 1981. In 1975, the Canadian Health Protection Branch adopted a maximum level of 5% erucic acid in Canadian fats and oils (4). This maximum level for safe use eventually was matched by Codex Alimentarius (5) and ISO Standards (6) and EEC Regulations (7). In January of 1985, the Federal Register of the United States added LEEAR oil to the GRAS (Generally REcognized as Safe) list of foods (8). In this listing, the maximum level of erucic acid was set at 2%, rather than 5%, "because of the erucic acid content of the rapeseed oils that are presently available and...to ensure safety" (8). Canada's new CGSB Standard for Canola (LEAR) oil will include a level of 2% erucic acid. This report summarizes the erucic acid contents of Canadian rapeseed and canola over the period 1979 to 1985.

MATERIALS AND METHODS

Samples from the Grain Research Laboratory's new crop surveys were obtained from grain companies and canola crushing plants as described in Crop Bulletins (9-14). Samples of oil were obtained from Western Canadian crusing plants throughout the period of study as part of a project to evaluate the chlorophyll levels in seed and oil. Participation in this project was voluntary, but three crushing plants supplied samples regularly throughout the period of study. Samples of rapeseed shipped from Canada were obtained from the Canadian Grain Commission's Inspection Division as a part of the Grain Research Laboratory's regular export cargo survey (15). These samples were subsamples of the official loading samples obtained through continuous sampling of the seed as it was being loaded on vessels. All seed exported from Canada, graded No. 3 Canada Rapeseed or better, was included in this survey.

Erucic acid was determined, as total C22:1 fatty acids, by gas liquid chromatography (GLC) (16). In 1984, the chromatography was modified to use open tubular fused silica columns (15 m × 0.32 mm i.d.) coated with Supelcowax 10 (0.25 μM). Operated at 240 C with a helium flow of 25 cm/sec, these columns gave better separation than the mixed phase packed columns (16) in about one-third of the analysis time.

RESULTS AND DISCUSSION

Export Cargoes. Since 1979, the average level of erucic acid in Canadian rapeseed and canola exports exceeded 2% only once, in January of 1980 (Fig. 1a). The maximum level of erucic acid in a cargo shipment (Fig. 1b) has exceeded 2% only once since 1982. In this instance, in August of 1984, a small shipment of seed accidentally was contaminated with high erucic acid

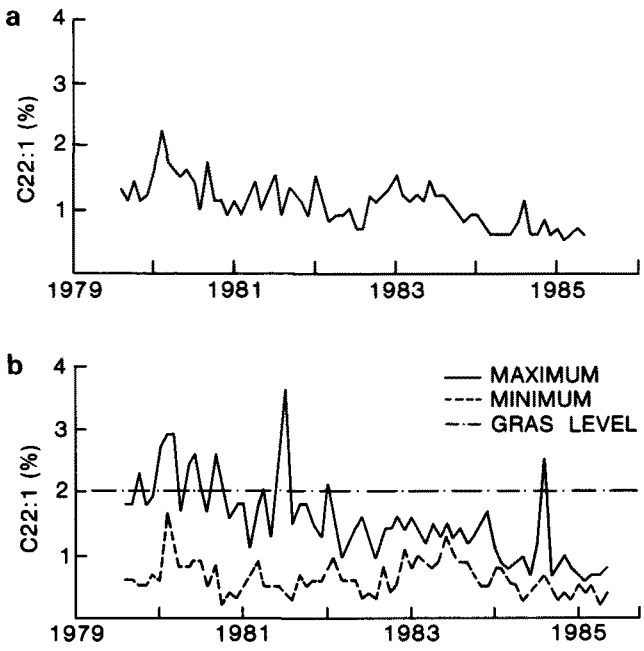

FIG. 1. (a) Monthly averages for erucic acid in canola and rapeseed exported from Canada. (b) Monthly extremes for erucic acid in canola and rapeseed exported from Canada.

[1]This is paper No. 573 of the Grain Research Laboratory.

seed being processed through the same terminal. Because shipments of high erucic acid seed are rare, the one in question being the first since the early 1970's, it is unlikely that this situation could occur again. Table 1 shows the number of export cargo samples tested in each crop year since 1979, along with the number of samples with more than 2% erucic acid.

Export shipments contain seed drawn from throughout the canola growing area in Western Canada, although seed exported through Thunder Bay has been drawn mainly from the Eastern Prairies. This means that seed from areas with higher levels of erucic acid has been blended with seed from areas with lower levels of erucic acid to give cargoes made up with seed averaging less than 2% erucic acid.

Crushing plants. The situation with crushing plants, however, is different. Crushing plants draw most of their seed from their immediate surrounding area, and there is less chance to blend. Figure 2a shows the erucic acid level in oils from crushing plants which are located at the three extreme corners of the rapeseed growing triangle in Western Canada.

Plant A is situated in an area where farmers have been slower to adopt new varieties and have used less certified seed. The high level of erucic acid in oils from Plant A in the years 1979 to 1982 was likely due to a combination of:

(i) The predominant use of the *B. campestris* canola variety Candle, in which up to 2.0% erucic acid has been allowed in certified seed (17).

(ii) The presence in the ground of old, high erucic acid seed, some of which has been shown to germinate (volunteer) up to 10 yr after planting.

(iii) Growing old uncertified seed which had outcrossed to higher levels of erucic acid.

Since 1984, Plant A consistently has produced oil with less than 2% erucic acid. This improvement has been due to a combination of improved management practices by growers and the replacement of Candle with the lower erucic acid variety Tobin (Table 2); the introduction of the very low erucic acid *B. napus* canola types into the growing area, and a reduction in the amount of volunteer high erucic acid seed. In order to ensure its ability to produce oil with less than 2% erucic acid, Plant A routinely analyzes incoming seed for erucic acid.

The higher level of erucic acid in varieties of *B. campestris* (Table 2) is illustrated by comparing the erucic acid levels in oils from Plants B and C (Fig. 2). Plant B is situated in an area which grows a mixture of *B. napus* and *B. campestris* varieties, while Plant C is located in an area in which *B. napus* varieties are grown almost exclusively. The levels of erucic acid allowed in certified *B. campestris* varieties, especially Candle, have made it more difficult to produce canola oil within the GRAS specification without admixing with oil or seed from *B. napus* varieties.

Crushing plants D to H are located in areas where a mixture of *B. napus* and *B. campestris* varieties are grown, as illustrated by the erucic acid level in their oils (Fig. 2). These plants, along with plants B and C, have produced oils with less than 2% erucic acid since 1981.

TABLE 1

Number of Cargoes of Canola and Rapeseed With More Than 2% Erucic Acid

Crop Year	Samples Tested	Samples with 2% Erucic Acid
1984/85[a]	73	1
1983/84	92	0
1982/83[b]	79	0
1981/82[b]	101	1
1980/81[b]	135	12
1979/80[b]	150	18

[a]Up to May 1985.

[b]Included some partial loading samples.

TABLE 2

Erucic Acid Standards (1984/85) for Pedigreed Canola Seed (17)

Variety	Maximum Erucic Acid (%) Allowed In	
	Foundation	Certified
Brassica napus		
Altex	0.6	N.A.
Andor	0.6	N.A.
OAC Triton	0.6	N.A.
Regent	0.5	N.A.
Tower	0.6	N.A.
Westar	0.5	N.A.
Brassica campestris		
Candle	1.8	2.0
Tobin	1.0	1.8

N.A. = Not Applicable.

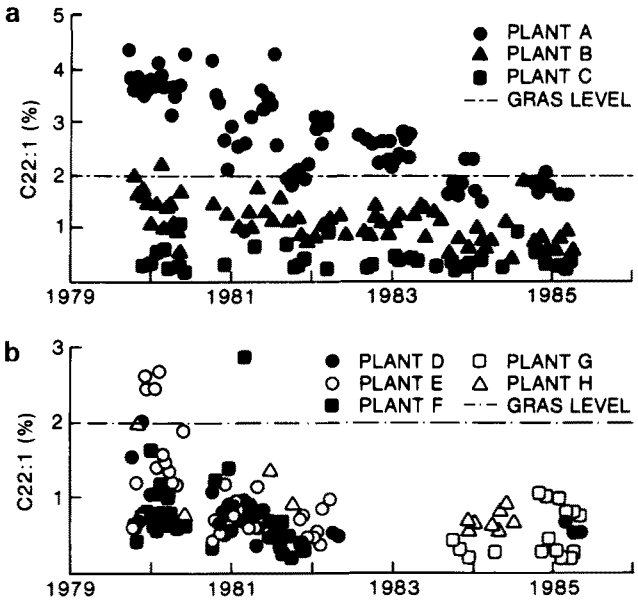

FIG. 2. (a and b) Erucic acid in oils from Western Canadian crushing plants (1979–1985).

New Crop Survey. The regional variation in erucic acid levels of Western Canadian canola seed can be demonstrated using data collected in the Grain Research Laboratory's annual new crop surveys (9-14). Table 3 shows that the average level of erucic acid has decreased in all three Western Canadian provinces since 1979. The level of erucic acid was higher in the west part of the growing region (Saskatchewan and Alberta) than in the east, reflecting the larger use of *B. campestris* types in the Western growing area.

Seed from the Province of Alberta consistently had the highest levels of erucic acid in Western Canada. Examination of the levels of erucic acid in seed from different areas within Alberta (Table 4) showed that seed from the northern growing area had the highest levels of erucic acid. The average level of erucic acid in seed from northern Alberta dropped below 2% only in 1984.

Examination of the erucic acid level in individual samples of seed from Southern, Central and Northern Alberta (1984 New Crop Survey) showed that the samples form a distribution which is heavily skewed to low levels of erucic acid (Fig. 3). Many more samples with more than 2% erucic acid were obtained from Northern Alberta than from Central or Southern Alberta. Most of the samples with erucic acid levels greater than 3% were found to be unlicensed varieties such as *B. campestris* cv. Torch.

A comparison of samples collected from Northern Alberta in 1983 with those collected in 1984 showed there was no significant difference in the average level between the two years (Fig. 4). A logarithmic transformation removed the skewness from the data and a t-test on the transformed data confirmed lack of difference. In order to ensure that seed grown in Northern Alberta continues to produce oil with less than 2% erucic acid, it would be useful if plant breeders further reduced the level of erucic acid in *B. campestris* canola varieties and developed *B. napus* varieties which are sufficiently early maturing to be grown successfully in Northern Alberta.

TABLE 3

Erucic Acid Levels in Canola and Rapeseed Grown in Western Canada

Year	Manitoba	Saskatchewan	Alberta	Western Canada
1984	0.3	0.4	0.9	0.6
1983	0.3	0.6	1.1	0.8
1982	0.5	0.7	2.0	1.0
1981	0.5	0.8	1.6	1.0
1980	0.3	0.7	1.6	1.1
1979	0.7	1.0	2.1	1.3

TABLE 4

Erucic Acid Levels in Canola and Rapesed Grown in Alberta

Year	South[a]	Central[a]	North[a]	Overall
1984	0.4	0.9	1.9	0.9
1983	0.6	0.9	2.5	1.1
1982	1.6	2.0	2.4	2.0
1981	1.3	1.3	2.5	1.6
1980	1.1	1.5	2.7	1.6

[a]Provincial crop districts: 1, 2, 3, South; 4, 5, 6, Central; 7, North.

ACKNOWLEDGMENTS

New crop survey samples were collected and documented by W. Podolak and B.A.S. Misener. Samples of oil processed by Western Canadian crushing plants were supplied by the quality control supervisors at the respective plants and were documented by K. M. Clear. Erucic acid determinations were made by P. B. Mazur.

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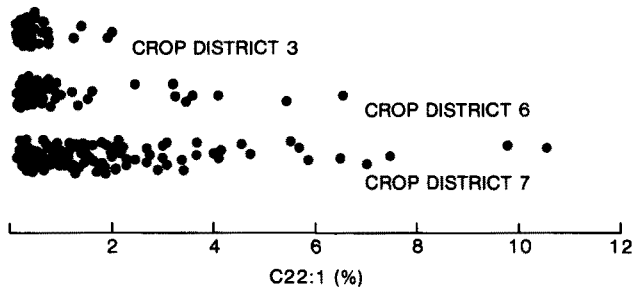

FIG. 3. Erucic acid in canola and rapeseed seed from three crop districts in Alberta (1984 New Crop). Data points have been jittered on the non-dimensional Y-axis to reduce overlap.

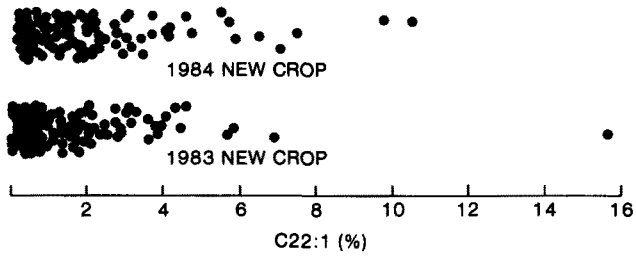

FIG. 4. Erucic acid in canola and rapeseed from Northern Alberta (1983 and 1984 New Crop). Data points have been jittered on the non-dimensional Y-axis to reduce overlap.

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[Received August 23, 1985]

Stability of Lipids and Polyunsaturated Fatty Acids During Smoking of Atlantic Mackerel (*Scomber scombrus* L.)

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Fall Atlantic mackerel (*Scomber scombrus* L.), non-smoked and hot smoked according to the method of Torry (Aberdeen, Scotland) Advisory Note #82, in an AFOS-Torry Mini Kiln, were used to study changes in oxidative rancidity and composition of major lipid classes and fatty acids. After smoking there was an increase in thiobarbituric acid (TBAM) value and peroxide (PO) value, but the values were still indicative of acceptable quality. The percentages of triglycerides (TG) and phospholipid (PL) did not change significantly, and free fatty acids could barely be detected. The overall fatty acid composition remained virtually unchanged after the smoking process. This included the longer chain C_{20} and C_{22} n-3 fatty acids, now regarded as potentially essential fatty acids for humans.

Smoking currently is an important process in Canada for mackerel (1). New developments in the role of fish in cardiovascular-oriented diets, including smoked canned mackerel (2–4), make it important to evaluate the smoking process for effects on the quality and nutritional benefits of the product, particularly in respect to the labile longer-chain (C_{20}, C_{22}) n-3 polyunsaturated fatty acids of the lipids (5,6).

Smoking is a process that combines the effects of brining, heating, drying and, finally, of the smoke itself (7). Not all fish are suitable for smoking purposes (8). Depending on their chemical composition, different fish react to the smoking process in various ways (9). The Atlantic mackerel is being used in considerable quantity for smoking (10), but there are few reports on the effects of smoking on any aspect of this fish. The few data that are available deal only with smoked fish without direct comparison to the unsmoked fish from the same batch, although Deng et al. (10) reported the use of the same batch of Spanish mackerel (a different species and family, *Scomberomorus maculatus*) as a source of both raw and smoked fish.

Not much information is available on the effect of smoke on individual lipids. We have investigated the effect of smoking on the lipids of Atlantic mackerel.

MATERIALS AND METHODS

The fish used for the study were fall Atlantic mackerel (*Scomber scombrus* L.) caught on October 5, 1982. Details about the fish, including their proximate composition and the method of hot smoking in a Torry AFOS Mini-Kiln and pooling of muscle (skinned fillet) samples (usually n = 8) for analysis, were given in a separate part of this study (12). In Nova Scotia fall fish examined in this study, males and females contained equally high TG percentages in their lipids; once the fish were gutted, no distinction by sex was made in further processing. Lipids from the fish fillets were extracted by the Bligh and Dyer procedure (13), and the extracts were stored at −80 C under nitrogen until used. The oxidative condition of the mackerel lipids was assessed by the 2-thiobarbituric acid (TBAM) test (14,15) and by the peroxide value (PO) (16) (AOCS Official Method Cd 8-53).

The major lipid classes of mackerel were quantitatively analyzed by TLC/FID using silica gel Chromarods-SII and an Iatroscan TH-10 Mark III Analyzer (17,18) (Iatron Laboratories Inc., Tokyo, Japan, world distributor Newman-Howells Assoc., Ltd., Winchester, United Kingdom). This was used with a Hitachi Stereo Cassette Tape Deck, Model D-E55, and Spectra-Physics Model 4200 integrating recorder.

Aliquots of fish lipids and standards were applied to Chromarods-SII (Iatron Laboratories, Tokyo, Japan) as dilute solutions in chloroform. 3-Hexadecanone was used as the internal standard which was spotted on each rod,

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