O R O R A P E S E E D

THE COMMERCIAL DEVELOPMENT

AND

EVALUATION OF A LOW ERUCIC ACID RAPESEED VARIETY

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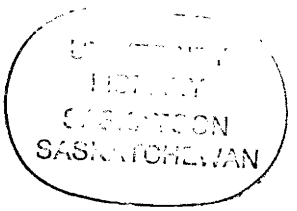

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1. INTRODUCTION

1.1 Problem.

Erucic acid in rapeseed oil became a problem to the Canadian vegetable oil industry with a telephone call received by Mr. J. R. Reynolds at his home at 7:00 a.m. (Saskatoon time), Monday, July 23, 1956. In this call, Dr. L. I. Pugsley, Assistant Director, Scientific Services, Food and Drug Directorate, Department of National Health and Welfare, Ottawa, issued a directive to the Saskatchewan Wheat Pool "to cease and desist immediately, all shipments and production of edible rapeseed oil for the Canadian consumer." In his capacity as Quality Control Officer for the Industrial Division, Saskatchewan Wheat Pool, Mr. Reynolds was advised that he would be held responsible to account for and identify the position of all stocks of previously manufactured products which were shipped prior to this date. The Food and Drug Directorate also required an assurance that, within eight hours of the telephone conversation, all stocks of the rejected material were removed from all consumer store shelves, and that these and all bulk stocks in storage were being held for future disposal at the direction of the Food and Drug Directorate officers.

Full compliance with the directive were mandatory; the Company and its Quality Control Officer were responsible for carrying out the orders within the required time limit.

Deviations from full compliance would be taken as contravention of the Food and Drug Act and legal action would be implemented immediately. The telephone message was confirmed by telegram and, later, a letter was received in which the established procedures for serving the directive were provided in detail.

Representations to the Department of National Health and Welfare were made by Mr. J. Gordon Ross of J. Gordon Ross Syndicate, Moose Jaw, Saskatchewan, which questioned the basis for the cease and desist order. The Food and Drug Directorate then partially eased their restrictions on the use of rapeseed oil as an edible oil pending a submission showing that the oil was a safe ingredient in the diet of man. At the request of Mr. Ross, Dr. H. R. Sallans and Dr. B. M. Craig of the Prairie Regional Laboratory, National Research Council, Saskatoon, Saskatchewan prepared a review of published information on the nutritional properties of rapeseed oil. The review was presented for discussion at the annual meeting of the Canadian Committee on Fats and Oils in October of 1956. The Committee concluded that there was no evidence to indicate that rapeseed oil in its current limited use represented a hazard to human health but further information on its nutritional properties was urgently needed. Three research objectives were set out by the Committee: to obtain more nutritional data on rapeseed oil and its relationship to fatty acid composition, to

determine the feasibility of reducing the erucic acid content of rapeseed oil through plant breeding, and to review the health records and autopsy reports from Germany during the second World War when rapeseed oil was virtually the only edible seed oil available for human consumption. The latter information was considered to be of only limited value because physiological stresses and nutritional deficiencies during the war may have biased the results.

Nutritional studies were initiated immediately by Dr. J. A. Campbell and Dr. Joyce L. Beare of the Food and Drug Directorate in addition to the continued investigations by Dr. K. K. Carroll of the University of Western Ontario, London. Samples of oils from known seed sources, fractions of the oils, synthetic oils and analytical data on these oils and on fat deposits in test animals were supplied by the Prairie Regional Laboratory. Results of these investigations and the survey of data from Germany during the war years are documented in the literature review.

As a result of these studies, Dr. C. A. Morrell, Director of the Food and Drug Directorate provided the following statement to the Edible Oil Institute in 1958 to clarify the status of rapeseed oil in Canada.

" While rapeseed oil has been employed in Europe as a constituent of margarine and in other foods, it has been shown

to have certain undesirable characteristics which have been related largely to its erucic acid content. It may also be noted that no detailed information has been available regarding its possible effect on humans. As a result of this situation a comprehensive program was undertaken eighteen months ago by the Food and Drug Directorate to investigate the status of rapeseed oil with albino rats. These experiments have now indicated no harmful effects of rapeseed oil from a nutritional standpoint when fed at levels which would ordinarily be consumed by humans. We would, therefore, have no objection at this time to the use of rapeseed oil in moderate amounts in food in Canada."

1.2 Objectives.

About 1957, the rapeseed breeders at the Plant Science Department of the University of Manitoba, Winnipeg and of the Canada Agriculture Research Station, Saskatoon acquired gas liquid chromatographs for intensive plant breeding on fatty acid composition. The world's first strain of rapeseed with oil low in erucic acid was isolated by Dr. B. R. Stefansson and Dr. R. K. Downey in B. napus in 1960, and a Polish rape (B. campestris) strain with the same characteristic was isolated in 1963 by Dr. R. K. Downey.

In the fall of 1964, Dr. R. K. Downey and Mr. J. R. Reynolds discussed the feasibility of a market development program for low erucic acid strains of rapeseed. A joint presentation was made to the Board of Directors of the Saskatchewan Wheat Pool to proceed with commercial field testing, oilseed crushing, crude oil refining, and oil utilization studies in domestic and foreign markets at the processor level. The Board gave its enthusiastic support to the project and instructed the Industrial Division to proceed with the joint development program.

Dr. R. K. Downey concentrated on strain evaluation and licensing of low erucic acid rapeseed while Mr. J. R. Reynolds undertook the commercial development of this new type of vegetable oil. Due to the lack of pilot plant facilities, it was necessary to utilize commercial facilities for the extraction, refining, hydrogenation of the oil and manufacture of margarine and shortening. Therefore a relatively large scale seed increase program was undertaken to provide sufficient seed for processing in the Saskatchewan Wheat Pool oil extraction plant, which had a 100 ton per day crushing capacity, and tank carlots of refined oil for shipment to the domestic vegetable oil manufacturing industry.

The objectives of this thesis are to describe the problems and procedures followed to contract the crop, segregate the seed and products, and evaluate the oil characteristics of low erucic acid rapeseed. In addition to maintaining seed purity during field production, it was also necessary to develop "in plant" procedures for oil extraction and refining. Special techniques were devised for grading the seed with respect to erucic acid levels and green seed content. Collaborative studies with several domestic oil processors were carried through to final product evaluation but market development work with consumers was not initiated.

The adverse nutritional data on high erucic acid oils which was presented at the International Conference at St. Adele in 1970 indicated the need for an immediate reduction of erucic acid levels in food products. The availability of low erucic acid seed in commercial quantities, and the processing and utilization experiences with the seed and oil, permitted an immediate and complete switch-over to low erucic acid varieties in Canada. This gave Canadian plant breeders a lead time of several years over those in other countries to develop high yielding and more adapted varieties of this new genotype. Canada became the first country to offer low erucic acid seed and oil in world markets. It will take years for other countries

to develop and convert to low erucic acid varieties and offer competitive quantities in the world trade. In addition, the Canadian experiment gave other countries confidence that their plant breeders could develop similar varieties and only limited legislative action was instituted against the use of high erucic acid oils until local genotypes with the desired nutritional properties were brought into production.

2. LITERATURE REVIEW

2.1 World Production of Rapeseed.

In nearly all countries of Europe and Asia the rape plant can be cultivated (Table 2.1).Large quantities of rapeseed and rapeseed oil are produced in India, China and in the Indonesia where it is an important domestic oil utilized in curries and other spiced dishes as a cooking oil.

The winter variety of B. napus is commonly grown in France, Belgium and Sweden (Appelqvist,1973).

In Poland the best known brand of margarine had rapeseed oil as its chief ingredient (Czaplicki et al.1955), and a beef tallow - rapeseed oil mixture was shown to be similar to lard for the making of doughnuts (Ruthowski,1954).

2.2 Canadian Production of Rapeseed.

In 1936, a farmer in the Shellbrook area, Mr. Fred Solvoniuk, grew a few plants of spring rapeseed from Poland (White, 1974). Due to its early maturity, the crop was productive in this northern community and continued to be grown on a small scale until wartime requirements indicated a need for commercial quantities of rapeseed. Mr. Solvoniuk distributed seed of Brassica campestris to his neighbors who coined the name Polish rapeseed for this species of turnip rapeseed.

Table 2.1 Rapeseed Production in Major Producing Countries

1967 - 1973

Country	1967	1968	1969	1970	1971	1972	1973
	('000 Metric Tons)						
Canada	560	440	758	1,638	2,155	1,300	1,207
India	1,228	1,568	1,347	1,564	1,975	1,433	1,853
China, P.R.	800	786	688	780	830	996	1,000
Pakistan	270	224	246	265	296	315	324
Poland	651	712	204	566	595	430	645
France	433	457	513	582	668	722	635
W. Germany	125	170	158	185	228	249	222
E. Germany	273	265	164	181	197	234	250
Sweden	246	263	208	191	253	323	350
Czechoslovakia	85	73	48	63	101	101	100
Bangladesh	120	128	126	136	112	108	56
Denmark	39	30	21	22	51	45	90
Sub Total:	4,830	5,116	4,481	6,173	7,461	6,256	6,732
World Total	5,127	5,391	4,751	6,467	7,849	6,643	7,068

Prior to the second World War, experimental plantings provided growth data on the summer types of rapeseed on Canadian experimental farms (White , 1974). During the wartime blockade of European and Asian sources of rapeseed oil, Canadian production of Brassica napus was initiated by Dr. T. M. Stevenson to meet the needs for lubricants in marine engines. The first major seedlot was obtained from Argentina and thus the name Argentine rape was used widely to identify this late maturing species. The initial crops were contracted in Western Canada by the Provincial Department of Agriculture and the first crop of 3,200 acres yielded over 2 million pounds (Table 2.2).While Argentine rapeseed predominated in the early years because of higher seed yields, the production gradually switched to the Polish type because of early maturity and shattering resistance. Varieties of the Polish type or B. campestris have occupied between 70 and 80% of the rapeseed acreage over the past decade or more.

As shown in Table 2.2, acreage sown to rapeseed almost doubled in each year from 1943 to 1948 but production almost disappeared by 1950 because government price supports were discontinued in 1948. The principal crusher of rapeseed in Canada, Prairie Vegetable Oils, Moose Jaw, closed its plant

Table 2.2 Acreage, Yield, and Production of Rapeseed 1943 to 1973.[1]

Year	Seed Acreage ('000 omitted)				Ave. Yield Bus. Per Acre	Total Prod. in Bushels ('000 omitted)
	Man.	Sask.	Alta.	Total		
1943	1.5	1.7	-	3.2	13.8	44.0
1944	6.0	4.8	-	10.8	11.3	122.4
1945	4.0	8.5	-	12.5	13.4	168.0
1946	2.5	21.0	-	23.5	11.0	259.4
1947	-	58.3	-	58.3	7.5	438.0
1948	-	80.0	-	80.0	16.0	1,280.0
1949	-	20.0	-	20.0	17.0	340.0
1950	-	0.4	-	0.4	5.0	2.0
1951	-	6.5	-	6.5	18.5	120.2
1952	6.5	12.0	-	18.5	15.0	278.0
1953	4.5	25.0	-	29.5	16.6	491.0
1954	9.0	31.0	-	40.0	14.4	578.0
1955	7.0	123.0	8.0	138.0	11.3	1,559.0
1956	29.1	297.0	25.8	352.0	17.0	5,996.0
1957	27.5	520.0	70.0	617.5	14.0	8,661.7
1958	21.0	535.0	70.0	626.0	12.4	7,762.0
1959	12.0	165.0	36.5	213.5	16.7	3,560.0
1960	33.0	550.0	180.0	763.0	14.6	11,120.0
1961	29.3	374.0	307.0	710.3	15.8	11,220.0
1962	32.2	167.0	172.0	371.2	15.8	5,860.0
1963	45.0	210.0	223.0	478.0	17.5	8,360.0
1964	84.0	303.0	404.0	791.0	16.7	13,230.0
1965	145.0	555.0	735.0	1,435.0	15.7	22,600.0
1966	170.0	731.0	624.0	1,525.0	16.9	25,800.0
1967	145.0	600.0	875.0	1,620.0	15.2	24,700.0
1968	91.0	511.0	450.0	1,052.0	18.4	19,400.0
1969	196.0	1,000.0	816.0	2,012.0	16.6	33,400.0
1970	400.0	2,200.0	1,450.0	4,050.0	17.8	72,200.0
1971	581.0	2,737.0	1,988.0	5,306.0	17.9	95,000.0
1972	470.0	1,500.0	1,300.0	3,270.0	17.5	57,300.0
1973	400.0	1,450.0	1,300.0	3,150.0	16.9	53,200.0
1974	500.0	1,500.0	1,200.0	3,200.0	16.2	52,000.0

[1] Source of Data - Agriculture Division, Statistics Canada, Ottawa.

in 1951 but the ownership was reorganized as J. Gordon Ross Syndicate. This organization became the sole marketing agency for rapeseed in Canada during the next three years. Their contracts stimulated production and utilization of rapeseed and the oil. Crushing was done on a custom basis by the Saskatchewan Wheat Pool Vegetable Oil Plant which was originally designed as a flax processing plant. Co-Operative Vegetable Oils, Limited, Altona, Manitoba also undertook rapeseed crushing in 1953 along with sunflower and soybean which were available at this location.

Therefore, rapeseed production expanded progressively until 1958-59 when J. Gordon Ross Syndicate discontinued their contractual arrangements with the Saskatchewan Wheat Pool. The latter organization and Western Canadian Seed Processors Limited of Lethbridge, Alberta undertook direct contracts with rapeseed growers after 1959 and production again expanded for a few years (Table 2.2).Production was further stimulated by the construction of a fourth crushing plant, Agra Vegetable Oil Products at Nipawin, Saskatchewan in 1963. Peak production was achieved in 1971 when 95 million bushels were produced on over 5 million acres in Western Canada. Production over the past three years has stabilized at just over half that level because of high prices for wheat and other cereal grains. A significant factor was the effect of the government L.I.F.T. program the previous year.

Proportions of the rapeseed crop that was crushed in Canada, exported as seed or utilized otherwise for seeding, dockage, bird seed, feed, industrial uses, etc. are shown in Table 2.3. The quantity of rapeseed crushed in Canada has increased progressively since 1958-59 when data was first published by Statistics Canada. Approximately 20% has been crushed domestically with the major portion being exported as seed.

Table 2.3 Rapeseed Supply and Disappearance in Bushels by Years from 1958-59 to 1974-75. [1]

	SUPPLY ('000 omitted)			DISAPPEARANCE ('000 omitted)		
Crop Year	Stocks At August 1	Production	Total Supply	Exports	Domestic Disappear.	Crushed in Canada
1958-59	279	7,762	8,041	5,720	2,073	761
1959-60	248	3,560	3,808	2,880	798	226
1960-61	131	11,120	11,251	8,089	2,681	960
1961-62	480	11,220	11,700	6,919	2,623	1,314
1962-63	2,158	5,860	8,018	5,710	1,808	1,616
1963-64	501	8,360	8,861	5,308	2,672	1,574
1964-65	880	13,230	14,110	9,276	3,516	2,156
1965-66	1,318	22,600	23,918	13,632	7,001	3,746
1966-67	3,284	25,800	29,084	13,818	9,308	4,963
1967-68	5,958	24,700	30,658	12,309	8,660	5,159
1968-69	9,689	19,400	29,089	14,311	9,509	6,934
1969-70	5,269	33,400	38,669	22,213	12,773	7,768
1970-71	3,683	72,200	75,833	46,811	18,043	8,575
1971-72	11,029	95,000	106,029	42,603	20,287	12,050
1972-73	43,139	57,300	100,439	54,059	25,702	15,572
1973-74	20,110	53,200	73,310	39,100 *	15,500 *	-
1974-75	12,215	52,000	64,215	-	-	-

* Preliminary Estimates.

[1] Source of Data - Agriculture Division, Statistics Canada, Ottawa. Canadian Grain Commission, Winnipeg.

2.3 Utilization of Rapeseed Oil.

Rapeseed oil was extracted and utilized as an illuminant during the Middle Ages and only gradually developed as an edible food product in Europe (Wijsman ,1970). Rapeseed production in Canada arose during the second world war when a critical shortage of marine lubricants occurred. Rapeseed oil is superior to mineral oils in its ability to adhere to metal surfaces, especially when in contact with steam or water (Youngs, 1974). Ship and railway engines powered by steam were lubricated with formulations containing rapeseed oil because of its desired viscosity, adhesiveness and solubility in mineral oil fractions. When diesel engines replaced steam, this market for rapeseed oil largely disappeared. However, other industrial uses for rapeseed oil such as in the cold rolling of steel and in plastics manufacture have provided a small market for rapeseed oil (Molnar, 1973).

Most of the industrial uses for rapeseed oil are associated with the long chain fatty acids, erucic and eicosinoic acids, which are characteristic of rapeseed triglycerides (Molnar, 1973). B. napus cultivars contained more erucic acid than B. campestris (Table 2.4) and cultivars of the former were favored as sources of oil for industrial purposes in Canada.

Table 2.4 Fatty Acid Composition of Rapeseed Species and Cultivars. [1]

Species and Cultivars	Fatty Acid Composition of Triglycerides, %						
	Palmitic	Stearic	Oleic	Linoleic	Linolenic	Eicosenoic	Erucic
Brassica campestris							
Polish	2.7	1.6	32.9	17.5	9.0	11.5	24.2
Arlo	2.7	1.4	27.3	17.2	9.0	11.5	30.2
Echo	2.7	1.4	27.3	17.2	9.0	11.5	30.2
Brassica napus							
Argentine	3.6	1.5	19.7	14.3	8.9	12.2	39.3
Golden	3.4	1.6	17.9	14.1	8.7	11.7	41.8
Nugget	3.8	1.5	16.9	13.7	8.7	12.4	42.4

[1] Craig and Wetter, 1959.

While Canada is changing over to the production of the new low erucic acid cultivars during 1970-1975, provision will be made to ensure adequate production and crushing capacity for the high erucic acid oils for industrial purposes (Downey, 1975).

In northern Europe, rapeseed and mustard are the only oil-bearing crops grown on a wide scale and production has been subsidized by most countries. Imports of soybean, palm, coconut, peanut, whale and other marine oils constituted the major source of food oils and fats throughout most of Europe prior to the second World War (Appelqvist, 1973). During the 1939-45 war, Germany was quickly cut off from imported sources of vegetable oil, and rapeseed became the chief source of vegetable oil and fat in the diet. By 1941, the consumption of rapeseed oil in Germany was estimated to be 250,000 tons per year (Allied Invest. 274,297; 1945).

During this period in Germany, rapeseed oil, derived entirely from home-grown seeds, was extracted and refined in equipment previously designed to handle imported vegetable and marine oils. Most of these converted oilseed mills and refineries were located around the major seaport of Hamburg (Allied Invest.19, 86,92,182,213,297,364,407; 1945).

One of the largest plants crushed 600-700 tons of rapeseed per day and was designed to extract essentially all of

the oil. Seeds were subjected to low pressure expellers; the first, second and third pressings left residues with oil contents of 28, 22, 15-18%, respectively. Cage presses reduced the oil content to approximately 6.5% after which the presscake was further extracted with solvent using batch-type units. Although some oil was utilized without processing, the usual treatments were neutralization of the oil with aqueous NaOH at 80° C., removal of the soaps, bleaching the neutral oil in vacuum kettles with activated earth and then deodorization at 160° C. Since rapeseed oil had tendencies toward flavor reversion, great precaution was taken during the operations of bleaching and deodorizing (Allied Invest. 297; 1945).

Lecithin was recovered from the oil during refining but it was dark in color and was poor in emulsifying properties (Allied Invest. 92; 1945). Uses for the by-product were limited.

Germany made extensive use of rapeseed oil in margarines and compound cooking fats. Rapeseed oil was difficult to hydrogenate but it was accomplished with electrolytic hydrogen gas using a non-selective nickel-formate catalyst. (Allied Invest. 19; 1945). This catalyst was reused 10 to 50 times, depending on the degree of hydrogenation desired. Melting points of the hydrogenated product varied between 42° - 30° C. After hydrogenation, the fat was filtered at 100° C, neutralized to a

free fatty acid content of $\geq$0.03% and deodorized with super-heated steam and high vacuum at 250° C.

During the war there was also a serious shortage of edible fats and oils in Canada, and a portion of rapeseed oil was diverted to edible use (Youngs 1974). Some crude oil was refined for inclusion in blended shortening but the high proportions of immature seeds resulted in green oils that were difficult to bleach and deodorize. When cottonseed, peanut and soybean oils became available, the use of rapeseed oil in edible products in Canada was discontinued. Research at the Prairie Regional Laboratory and Division of Applied Biology of the National Research Council demonstrated that careful refining, bleaching, hydrogenation and deodorization of oil from mature rapeseed could replace soybean oil in most edible products. During 1951 to 1955, the Co-Op Vegetable Oil plant in Altona produced small quanitites of salad and cooking oil for marketing by Gattuso Corporation in Montreal. In 1956 the Saskatchewan Wheat Pool installed equipment for deodorization and the improved product brought large quantities of salad oil to the Montreal market until the Food and Drug Directorate action. By 1957 Canada Packers, Montreal, were also producing salad oil from rapeseed on a continuous basis from oil supplied by the Saskatchewan Wheat Pool plant in Saskatoon.

Research by Dr. K. K. Carroll, University of Western Ontario demonstrated that rapeseed oil and erucic acid in rat diets resulted in reduced weight gains, increased cholesterol content and weights of adrenal glands (Carroll, 1951; Carroll and Noble,1952; Carroll,1953). During 1956 there was a ban on the use of rapeseed oil in food products but the objections were partially withdrawn in late 1956 after a thorough review of available information on the nutritive properties of rapeseed oil.

During 1958, Canada Packers began using significant quantities of rapeseed oil in shortening and salad oil (Youngs,1974). By 1970, the utilization of rapeseed oil equalled that of soybean oil in the principal food uses for vegetable oils in Canada. However, rapeseed oil still represented only 40% of the deodorized oils utilized in Canada and a high proportion of vegetable oils are still imported from the United States and the subtropics (Table 2.5).

Table 2.5
Utilization of deodorized vegetable oils in food products in Canada 1972 in ,000 pounds. [1]

	Margarine Oil	Shortening Oil	Salad Oil	Total Utilization
Rapeseed	68,578	73,968	69,482	212,027
Soybean	41,767	72,365	30,788	144,921
Palm	9,444	35,887	7	45,337
Coconut	1,666	36,304	57	38,026
Corn	8,350	-	-	28,812
Sunflower	112	4,673	17,453	22,238
Cottonseed	15	11,726	1,961	13,702
Peanut	-	-	-	13,546
Palm Kernel	118	10,185	-	10,373
Other	-	81	88	169
Totals:	130,120	252,504	146,979	529,152

[1] Adapted from Rapeseed Association of Canada (1973) (Vol 7(4):4).

2.4 Nutritive Value of High Erucic Rapeseed Oil.

Rapeseed oil was not used in large quantities by German industry during the war but it constituted a significant portion of fat calories during these years of scarcity (Allied Invest. 14; 1945). Initially, the German people were rationed to 270 grams of fats and oils per week and this was reduced to 50 grams by the end of the war (Allied Invest. 213, 1945). The ration was commonly half butter and half rapeseed margarine. In a typical margarine containing 80% fat the average consumption of hydrogenated rapeseed fat would be only 20 grams per week during the final period. Therefore it was not surprising that autopsy reports did not show adverse effects of high rapeseed oil ingestion on health or body organs.

Among a series of vegetable oils, Deuel et al., (1940) reported that rapeseed oil had the slowest rate of absorption in the gastrointestinal tracts of rats. Three hours after the administration of the oil, the absorption was 36.5% and six hours after consumption it was 43.3%. The digestibility of olive oil was 56.4 % and 58.7 %, respectively, for the two periods. As compared to rats Deuel et al.,(1948b) showed that rapeseed oil was more digestible by humans, being 77% of the crude oil and 82% for bleached and alkali refined oil. However,

poor digestibility of rapeseed appeared due to the presence of erucic acid in the triglycerides, since free erucic acid was excreted in the feces as soap. Carroll and Noble (1957) demonstrated that the digestibility coefficient for erucic acid in the rat was 52% while those of its methyl and ethyl esters were 55% and 59% respectively. In a later study, erucic acid digestibility varied from 37% to 61%, the average being 53% (Carroll, 1958).

Deuel et al., (1948a) also found that rapeseed oil, when fed as 60% of the diet to 29 day old rats of both sexes, caused appreciable reductions in weight gains as compared to olive. On the other hand, rapeseed oil fed as 15% of the diet to adult female rats (160-175 grams) had no adverse effects on weight gain. The results with growing rats were confirmed by Thomasson (1955) who found that the average body weights decreased as the level of rapeseed oil was increased in the diets in a six week feeding trial. At the highest rapeseed oil level of 73 Cal %, all rats died after being on the diet an average of 17 days. Thomasson (1955a) showed that erucic acid with 22 carbon atoms caused the decreased weight gain of rapeseed oil-fed rats and advanced the theory that fatty acids with 20 or more carbon atoms were

responsible for the adverse growth effects.

Thomasson (1956) also found that rapeseed oil affected the longevity of rats. While rats consumed less rapeseed oil-based diet and gained less weight, they lived 20-25% longer than those receiving comparable amounts of butter. Of the eighteen oils tested, rapeseed was the most slowly absorbed oil at the end of three hours and fourth slowest at the end of six hours. While 50% of the rapeseed oil was absorbed in 8-9 hours, the same level of absorption was achieved in six hours for other common vegetable oils. Only kepokseed oil showed slower growth rates than rapeseed oil. A slight liver degeneration was noted in rapeseed oil-fed rats but butter-fed rats showed more serious pathological changes in body organs.

Carroll (1951) associated the growth retarding effect of rapeseed oil with cholesterol metabolism. Rapeseed oil fed to rats at the 25% level for four weeks produced pale and slightly larger adrenals with increased amounts of adrenal cholesterol. Other fats and oils fed at this level also caused an elevation of adrenal cholesterol over that of a low fat (3-6%) control. However, the total cholesterol was 5.1 mg for rapeseed oil but only 1.8 mg with corn oil. In a second paper Carroll and Noble (1952) determined that the increased adrenal cholesterol did not markedly affect the

responsible for the adverse growth effects.

Thomasson (1956) also found that rapeseed oil affected the longevity of rats. While rats consumed less rapeseed oil-based diet and gained less weight, they lived 20-25% longer than those receiving comparable amounts of butter. Of the eighteen oils tested, rapeseed was the most slowly absorbed oil at the end of three hours and fourth slowest at the end of six hours. While 50% of the rapeseed oil was absorbed in 8-9 hours, the same level of absorption was achieved in six hours for other common vegetable oils. Only kepokseed oil showed slower growth rates than rapeseed oil. A slight liver degeneration was noted in rapeseed oil-fed rats but butter-fed rats showed more serious pathological changes in body organs.

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function of the endocrine glands but the animals showed less tolerance to stresses such as cold and confinement treatments. Erucic acid was demonstrated to be the factor in rapeseed oil which altered adrenal cholesterol, and this activity was destroyed by hydrogenation of the oil.

The effects of feeding rapeseed oil were investigated by Food and Drug in their laboratories. Corn and rapeseed oils and mixtures of the two oils were fed to rats (Beare et al.,1963a). Body weight gains showed a linear response with decreasing amounts of rapeseed oil, but the adverse effects of rapeseed oil diminished as the experiment continued. In a second series of feeding studies (Beare et al.,1961) unhydrogenated rapeseed oil was found to be inferior to hydrogenated rapeseed oil, and both of them were inferior to mixtures of either unhydrogenated or hydrogenated soybean oil in producing significant weight gains during two weeks of rat growth.

2.5 Fatty Acid Analysis.

Prior to the development of gas liquid chromatography, differences in chemical composition among the various oils and fats used for human food were difficult to determine and lacked precision and specificity. In 1951, Youngs et al., (1951) demonstrated by special techniques that oils for Argentine and Polish rapeseed, and mustard species, contained different levels of erucic acid. However, each analysis required at least

two weeks of work and a pound of oil (Craig , 1975).

In the mid-1950's Martin (1952) adapted a method of quantitative and chemical analysis called gas liquid chromatography to the analysis of petroleum oils. Gas liquid chromatography (GLC) units were purchased in 1956 by the Prairie Regional Laboratory and the Saskatchewan Wheat Pool and later in 1958 by the University of Winnipeg. The Prairie Regional Laboratory developed procedures for the separation of fatty acids in rapeseed oil on the basis of carbon chain length in minutes rather than days. The GLC technique was used to measure the variation in fatty acid composition of seven varieties grown at seven locations (Craig and Wetter , 1959) and six varieties grown at 22 stations. This research demonstrated that there was a wide variation in erucic acid content among varieties of rapeseed and a recommendation was made to Canadian Plant breeders to reduce the erucic acid level in rapeseed oil. Dr. Downey of Canada Agriculture and Dr. Stefansson at the University of Winnipeg were the first plant breeders to use GLC units in plant breeding and selection. The world's first strain of rapeseed with oil low in erucic acid was isolated from the forage rapeseed Liho in 1960 by Stefansson et al., 1961.

The first Polish rape strain with the same characteristic was isolated in 1964 by Dr. Downey's group at Saskatoon (Dorrell and Downey, 1964).

During the same period, the Prairie Regional Laboratory further modified the GLC technique by means of polyester columns (Craig and Murty, 1959; Craig, 1960). These columns permitted the segregation of fatty acids by degree of unsaturation as well as chain length. Disc and electronic integrators brought the accuracy of duplication determinations to within the range of $\pm$ 0.1% for each fatty acid. Coupled with the small quanitity of oil required for hydrolysis and esterification for each analysis, the GLC technique became a powerful tool for rapeseed breeding, nutritional evaluations, oil processing, hydrogenation and manufacture of finished food products.

2.6 Inheritance of Erucic Acid Content.

During the 1950's, plant breeding consisted primarily of selection for agronomic characters with some attention being given to oil content of the seed. The Prairie Regional Laboratory provided facilities for selection of low erucic acid strains until 1957-58 when GLC units and staff were acquired by plant breeders at Winnipeg and later at Saskatoon. Methods for measuring oil content by the Swedish method and the very efficient Nuclear Magnetic Resonance Analyzer also improved the efficiency of plant breeding for quality.

With techniques available to determine the oil quantity and quality of single seeds, and even half-seeds, genetic studies and biochemical pathways were soon under investigation. The inheritance of chain length in fatty acids was permitted by the isolation of erucic-acid free plants from the German forage variety Liho by Stefansson et al. (1961). Genetic studies were enhanced by the discovery that the erucic acid content of the seed oil was not controlled by the maternal plant but by the developing embryo (Downey and Harvey, 1964). Thus each seed on a F_1 plant may differ in its fatty acid composition. Therefore, the "half seed" technique described by Downey and Harvey (1963) had immense value in the study of fatty acid composition of segregating populations by GLC analysis. Crosses between zero erucic acid strains and the high erucic acid genotypes of B. napus demonstrated that the genetic control was a two gene system with two alleles acting in an additive manner giving five levels of erucic acid (Craig and Harvey, 1964) (Table 2.6).While the level of erucic acid was mainly governed by two genes in the allotetraploid B. napus, only one gene controlled the presence of this long chain fatty acid in the diploid B. campestris (Dorrell and Downey, 1964). Two alleles acting in an additive manner resulted in three levels of erucic acid.

The absence of erucic acid was reported not to influence the oil content (2.6), but subsequently has been found to effect the levels (Downey, 1975b).

Table 2.6 Oil content and fatty acid composition of self-pollinated seeds from rape plant genetically capable of producing five levels of erucic acid. [1]

Plant Genotype	Seed Oil %	Fatty Acid composition in percentage of total fatty acids								
		C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:1
++++	39.0	3.8	0.4	0.8	18.4	15.8	9.8	0.8	11.0	39.2
-+++	45.5	3.8	0.5	1.3	24.3	15.7	9.1	1.0	13.9	30.4
--++	38.9	4.1	0.4	1.4	34.2	16.3	7.9	0.7	14.1	20.9
---+	39.4	4.8	0.7	0.8	41.8	18.7	7.3	1.0	12.1	12.8
----	43.4	4.8	0.9	1.2	63.1	20.0	8.2	0.8	1.0	0.0

[1] Downey and Craig, 1964.

By 1964, the genes for low erucic acid had been transferred to the oilseed varieties and evaluated in yield plot experiments (Kondra and Stefansson, 1964). Small quantities of seed were defatted by the Prairie Regional Laboratory, and evaluated by Canada Packers' Toronto Laboratory (Teasdale, 1966). The low erucic acid oils did not have any advantage in margarines or shortening products but appeared to yield an excellent salad oil.

However, it was not known if these strains could be grown commercially without contamination with pollen from high erucic acid varieties and seed admixtures. Could the genotype be mainatined at a zero erucic acid level within the agricultural areas where regular rapeseed has been grown for years? It was also an economic and practical problem for the oil processor if both types of rapeseed oil were to be extracted and marketed without contamination within the plant. Would it be necessary to pay a premium for low erucic acid seed and could the cost be recovered from the refiners and manufacturers? It was these questions that led to the initiation of the present research and development program for low erucic acid rapeseed.

2.7 Nutritional Studies on Low Erucic Acid Oils.

2.7.1 Growth Studies.

The GLC technique permitted the nutritionists to evaluate the effects of individual fatty acids. Associated with

the large quantities of long chain fatty acids in rapeseed oil was a relatively low level of palmitic acid. Beare et al., (1963a) demonstrated that the imbalance of these two fatty acids was responsible for some of the adverse nutritional effects of rapeseed oil. It appeared that increasing the level of saturated palmitic acid in food fats and oils or the consumption of mixed sources of vegetable oils would overcome any health hazards represented by the use of rapeseed oil in Canada.

Except for the physiological studies of Carroll and associates, most of the early research was concerned with the growth effects of the various long-chain fatty acids in young female and male rats (Aaes-Jorgensen, 1972). Generally it was found that rat growth retardation occurred when rapeseed oil equalled or exceeded 5% by weight of the feed or 30% of the total dietary calories (Vles and Abdellatif, 1970). Approximately similar effects were reported for mice and pigs (Rocquelin and Cluzan, 1968), and for turkeys and chicks (Salmon, 1970). Generally the growth retardation was associated with appetite depression especially when rapeseed oil constituted over 40% of the dietary calories.

Acceptability of the diets was improved by decreasing the erucic acid level and the proposition of long-chain fatty acids by the addition of palm oil to rapeseed oil-based diets (Aaes-Jorgensen, 1972). It was concluded that the

effect of rapeseed oil in experimental diets was due to its low content of saturated fatty acids and its high content of erucic acid.

When canbra oil became available in 1967, Rocquelin and Cluzan (1968) compared the effects of rapeseed oil with 45% erucic acid, canbra oil and peanut oil. These oils were fed as 15% of the diet to young male and female rats for six months. The ordinary rapeseed oil caused growth retardation in both sexes but canbra and peanut oil supported excellent growth rates in all animals. Craig and Beare (1968) fed weanling rats for 24 days on 20% oil-based diets and found that food intake and gain in body weight of canbra and olive oil were equal and significantly higher than that of regular rapeseed oil.

2.7.2. Pathological effects of dietary rapeseed oil.

Roine *et al.*,(1960) reported heart damage (myocarditis) among rats and pigs fed large amounts of rapeseed oil high in erucic acid (Rocquelin and Martin,1970). Heart lesions were also found to be present in mice, gerbils, hamsters, guinea pigs, pigs, rabbits, ducklings, chickens and squirrel monkeys when rapeseed oil was fed at 35 calorie % (Thomasson,1967). These results were confirmed by Rocquelin and Cluzan (1967) using lower fat percentages in the diet over a longer period of time. These lesions were non-reversible and persisted in rats fed either ordinary rapeseed oil

or canbra oil. Erucic acid did not appear to be the sole causative factor since the same type but less frequent and severe lesions occurred among rats fed canbra oil.

Abdellatif and Vles (1970a)also studied the pathological effects of dietary rapeseed and canbra oils, using sunflower oil as the control. Rapeseed oil produced fatty deposits in the heart and skeletal muscle fibers after the first day of feeding the weanling rats; the deposition was so massive by 3-6 days that the heart showed a creamy yellow color. After this period the fatty changes regressed and the skeletal muscles regained their normal histology after 16 weeks. In the heart muscle, the decrease of fatty accumulation was associated with necrosis and fibrosis which also appeared in the kidney after 16 weeks. The heart and kidney weights of rats fed rapeseed oil were also heavier than those on sunflower oil diets. Contrary to rapeseed oil, these investigators found that canbra oil in the diet did not produce growth retardation, pathological changes in the heart or skeletal muscle or organ weights after feeding for up to 24 weeks.

Vles and Abdellatif (1970) reported that ducklings and guinea pigs showed similar pathological symptoms as weanling rats to diets high in erucic acid. Hardened palm oil, when incorporated in the rapeseed oil diets, did not correct all of the effects of the high erucic acid oil. While growth was

improved by the blend, the histological changes in the heart and skeletal muscles were the same.

Beare-Rogers (1970) showed that rapeseed oil, hydrogenated rapeseed oil and hydrogenated herring oil increased total cardiac fat levels of rats, mini-pigs and squirrels. The proportions of erucic and docosenoic oils deposited in the cardiac tissues of rats was highest after one week of feeding and dropped rapidly during the second week. After long term feeding, the necrotic lesions were evident in rapeseed oil and herring oil diets but not in rats maintained on canbra oil. In general, hydrogenated oils were intermediate in their effect on heart lipidosis and necrosis but canbra oils fed at up to 20% of the diet were similar to the control oils in their lack of pathological effects.

Abdellatif and Vles (1971, 1973) demonstrated that the duckling, which was highly susceptible to the adverse effects of erucic acid, (Thomasson, 1967) could be fed large quantities of canbra oil for long periods without the development of heart lesions. Vles (1974) has emphasized that the physiological effects of the lesions developed in rats which have been fed rapeseed oil has not been determined. However, most investigators agree that the development of rapeseed varieties which contain only 1-3% of erucic acid represents a major step toward the improvement of nutitional quality in rapeseed oil.

3. Commercial Development of the Crop.

3.1 Involvement of the Saskatchewan Wheat Pool

By 1959, Saskatchewan Wheat Pool began contracting rapeseed directly with farmers for processing into oil and meal or for export as whole seed. Because of its status as a non-quota cash crop, rapeseed production and utilization became a major activity for this farmer co-operative organization.

The joint announcement by the University of Manitoba and the Canada Department of Agriculture, Saskatoon, that a low erucic acid rapeseed genotype had been selected was fully appreciated by the technical and management staff as being of substantial significance to rapeseed development in Western Canada. In the fall of 1964, Dr. R. K. Downey and Mr. J. R. Reynolds proposed that the Saskatchewan Wheat Pool become involved in the commercial development of the low erucic acid type of rapeseed and the market evaluation of the oil. The proposal was based on the available information that the Food and Drug Directorate would have no objections to the widespread use of this oil in food products. The low erucic acid oil could develop new uses for the oil domestically and expand the export of seed.

The Board of Directors gave their approval and enthusiastic support to the project and directed the Industrial Division to proceed with the commercial development and study of the market potential for low erucic acid rapeseed. The objective

was to offer the refined oil processors an assured supply of low erucic acid oil in tank car lots for process and product evaluation. The project was designed to develop procedures for rapid seed increase and commercial crushing which could be of value in future new developments by plant breeders. At the same time, it was realized that several problems had to be solved for even partial completion of the program and that substantial funding would be necessary over several years to evaluate this nutritionally preferred rapeseed oil.

3.2 1965 - Field Production.

The two strains, SZ62-11 and S-7054 had been field tested for two years and 650 pounds of bulked seed of each strain was available for increase. The Saskatchewan Wheat Pool arranged for contract production, isolation and inspection of the fields to meet Canadian Seed Growers Association requirements for Foundation seed, for land purity and four hundred yard isolation. This was to ensure pure seed for commercial processing.

A field of each strain was contracted in the north-east portion of the rapeseed production area near Tisdale and another set in the north-west area beyond North Battleford (Appendix A). The selected fields had been previously summer-fallowed and had not produced rapeseed for the previous three years. The closest field of B. napus was one-half mile or more, indicating that isolation would be relatively good. Each field

was 80 acres in size and seeding rates were restricted to four pounds per acre. The crop was inspected by Canada Department of Agriculture and Plant Products Divisions staff throughout the growing season. Seed samples were taken to assess the degree of cross pollination with high erucic acid rapeseed.

Three fields matured in 103-107 days but one field was delayed in maturity because of the application of 90 pounds of nitrogen per acre. This field was harvested in a green and immature condition and the seed was graded as No. 2 Canada Rapeseed. The other fields were harvested and the seed was of good quality.

Samples taken before harvest indicated that contamination with foreign pollen transmitted by honey bees was high on the margins but declined rapidly towards the center of the fields. The highest erucic acid content of rapeseed at a depth of twenty feet within the field was 6% (Downey, 1965). Therefore a sixteen foot swath was taken from the outside of each field for separate threshing and use in the preliminary "wash-out" of the crushing plant. A thirty-two foot swath was segregated from the one field which was located only a half-mile from a field of high erucic acid rapeseed. The average erucic acid of this bulk seed lot from the outside swath of rejected seed was 0.7%. The original seed sown was 0.2%. Field performance and plot studies indicated SZ62-11 performed better and was retained as the seed for futher field and commercial evaluation.

Total seed delivered to the processing plant was 8200 bushels indicating an average yield of 25.6 bushels per acre. The contract incentive price was $ 3.75 per bushel to a maximum of 18 bushels per acre. Production in excess of this level was purchased at the commercial price of $ 2.075 on the completion date for the contract.

The financial outlay to the growers from the Saskatchewan Wheat Pool was:

18.0 bushels/acre @ $ 3.75 = $ 67.50

\+ 7.6 bushels/acre @ $2.075 = $ 15.77

This price was $ 30.00 per acre above the commercial value for high erucic acid rapeseed and represented an additional financial outlay of $ 10,000.00 by the Company.

3.2 1966 - 1967 Field Production.

Based on their experience with the first crush, the domestic oil users requested at least double the quantities shipped in the first year.

The strain SZ62-11 gave the best field performance in 1965 and 80 bushels from the 1965 production were utilized for a larger increase in the second year. An attempt was made to obtain 720 acres under contract and adequate land and growers were found for planting 660 acres. A list of the seven seed growers, their location, acreages and seed yields is presented in Appendix A.

Foundation seed production requirements were followed for this seed increase and Plant Products Division issued certificates of field inspections for all fields. As in the first trials, 16 foot swaths were cut around the outside of each field and this portion of the crop was segregated during harvesting and delivery to the processing plant. This contaminated seed was again used for preliminary processing ahead of the low erucic acid rapeseed. Over 20,000 bushels of seed was received at the crushing plant and the average erucic acid content was 0.9%. The incentive premium offered to the growers was $ 2.90 per bushel for the first 18 bushels per acre and the remainder was purchased at the commercial rate of $ 2.25 per bushel. The extra cost to the Company was $ 10.00 per acre or nearly $ 6,000.00 in total.

3.3 1967 Field Production.

At the Canada Committee on Fats and Oils meeting in October, 1966, the Saskatchewan Wheat Pool requested that each food processor make a firm commitment for their low erucic acid oil requirements on the basis that 10,000 acres could be grown in 1967. To cover the cost of the farmer incentive program, a premium of 15 cents per 100 pounds of oil was requested. While the total acreage was required by food processors, the incentive was not collected because of the depressed oil price situation in 1968 when large quantities of sunflower oil were being sold on the

world market by Russia.

The Farm Service Division of the Saskatchewan Wheat Pool undertook the commercial production of SZ62-11, offering a contract incentive of 15 cents per bushel. The growers were required to pay for the seed, which had not been the case in previous years. A separate foundation seed program was administered by Dr. Downey and Mr. Reynolds to ensure the availability of pure seed for future production. Plant Products Division provided field inspection for the pedigree seed fields and many of the commercial fields.

The climatic conditions during 1967 were cool and wet which delayed seeding and exposed the immature crop to early frosts, snow and rain. Some fields were not harvested and yields were significantly reduced in others. The quality of the seed was also generally poor.

The production statistics for the commercial crop of SZ62-11 were as follows:

Total acres contracted	10,300
Total acres harvested	8,300
Number of growers on contract	115
Number of fields harvested	97
Number of bushels anticipated	336,000
Number of bushels harvested	263,000

Number of bushels dry/dried	195,000
Number of bushels tough	53,000
Number of bushels damp	20,000

In Canada, most rapeseed oil used for food purposes is extracted from No. 1 Canada Rapeseed. Because of its late maturity, the strain of B. napus was harvested in particularly poor condition. In addition to high moisture content, much of the seed was immature and green. Therefore, the major portion of the crop was graded as No. 2 Canada Rapeseed or lower.

Grades:	No. 1 Canada Rapeseed	12 %
	No. 2 Canada Rapeseed	65 %
	No. 3 Canada Rapeseed	15 %
	Sample Rapeseed	8 %

Much of the extracted oil was greenish in color and the costs associated with refining the low erucic acid oil was relatively high.

The cost of premiums to the growers which produced No. 1, No. 2 or No. 3 Canada Rapeseed and handling charges by the Farm Service Division amounted to $ 50,000. The estimated handling costs at the processing plant and refining of off-standard oil raised the total costs to $ 1.25 per 100 pounds of oil shipped to the edible oil industry.

However, the poor condition of the seed had little adverse effects on the erucic acid level.

The original seed at planting contained 0.2% erucic acid and field contamination increased the levels to between 0.4 and 2.0% with a mean of 1% (Figure 3.1).

3.4 1968 Field Production.

The Subcommittee on Oilseed, Associate Committee on Grain Research, National Research Council, at their annual meeting on February 21, 1968, recommended that the strain SZ62-11 be licensed for production in Canada. A short time later, the first variety of low erucic acid rapeseed was licensed under the name Oro by the Plant Products Division.

In the spring of 1968, the bulk of the pedigree seed was in the hands of the Saskatchewan Wheat Pool with both Foundation and Commercial seed available for wide distribution. Seed distribution was controlled by the Canada Department of Agriculture after licensing the new variety.

The Saskatchewan Wheat Pool, Industrial Division, contracted 10,000 acres of Oro for domestic crush and seed export. The Farm Service Division undertook the Pedigree seed increase program through contract production.

The erucic acid content of the 1968 production varied from 0.0 to 2.4% with a few samples showing levels up to 4.2% (Figure 3.2).

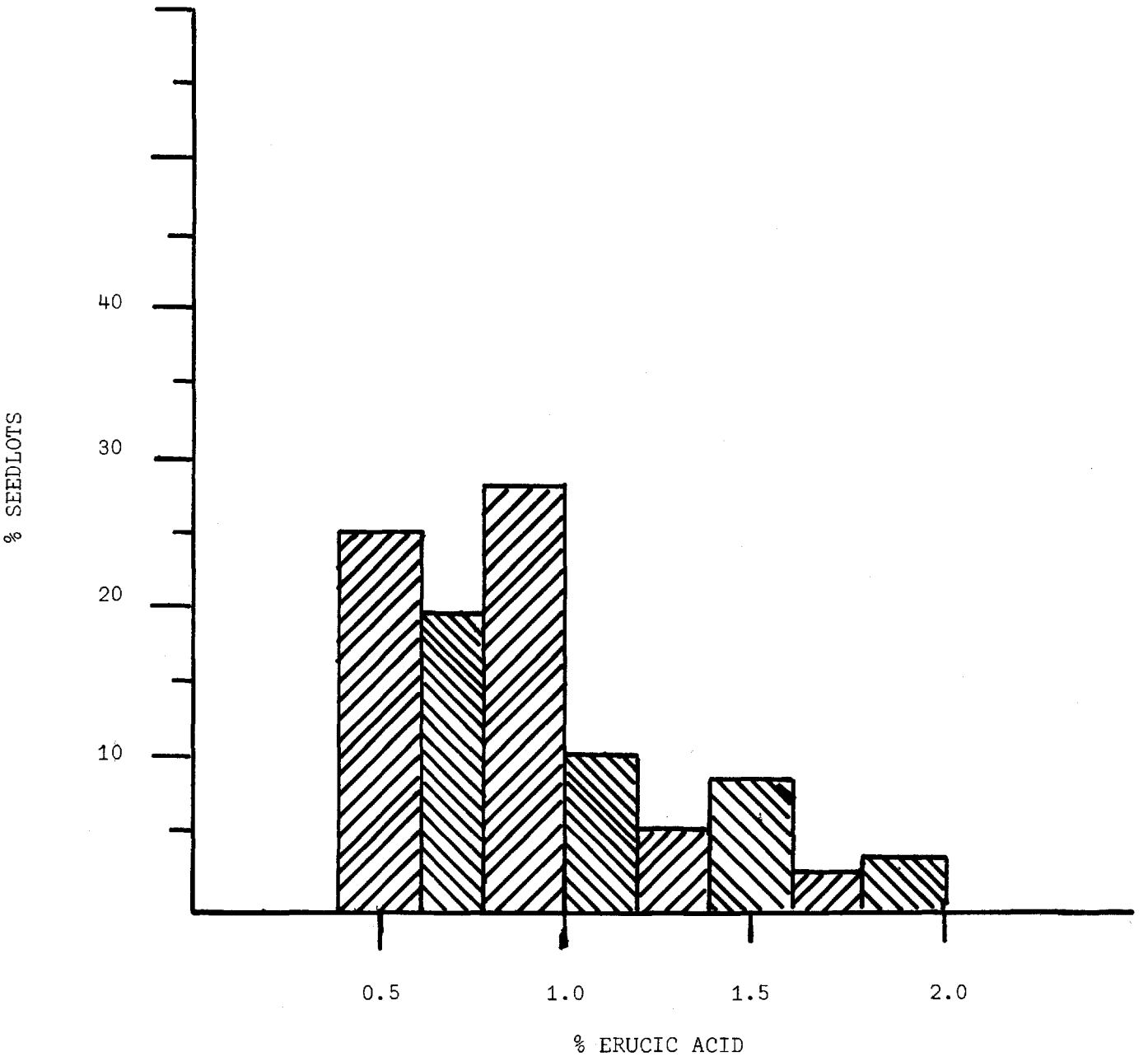

Figure 3.1 Erucic acid distribution found in representative field samples from contract growers in 1967.

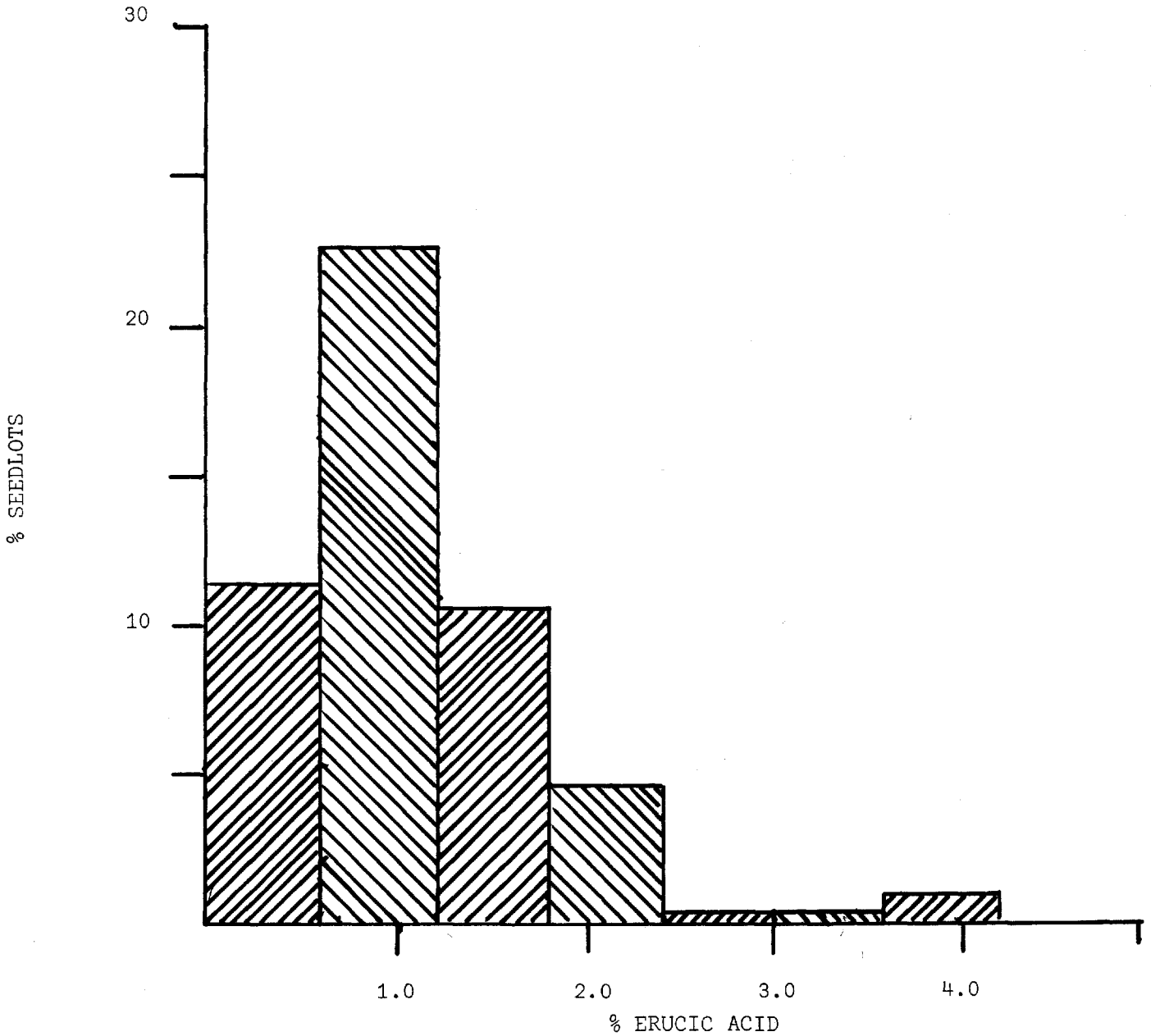

Figure 3.2 Erucic acid distribution found in representative field samples from contract growers in 1968.

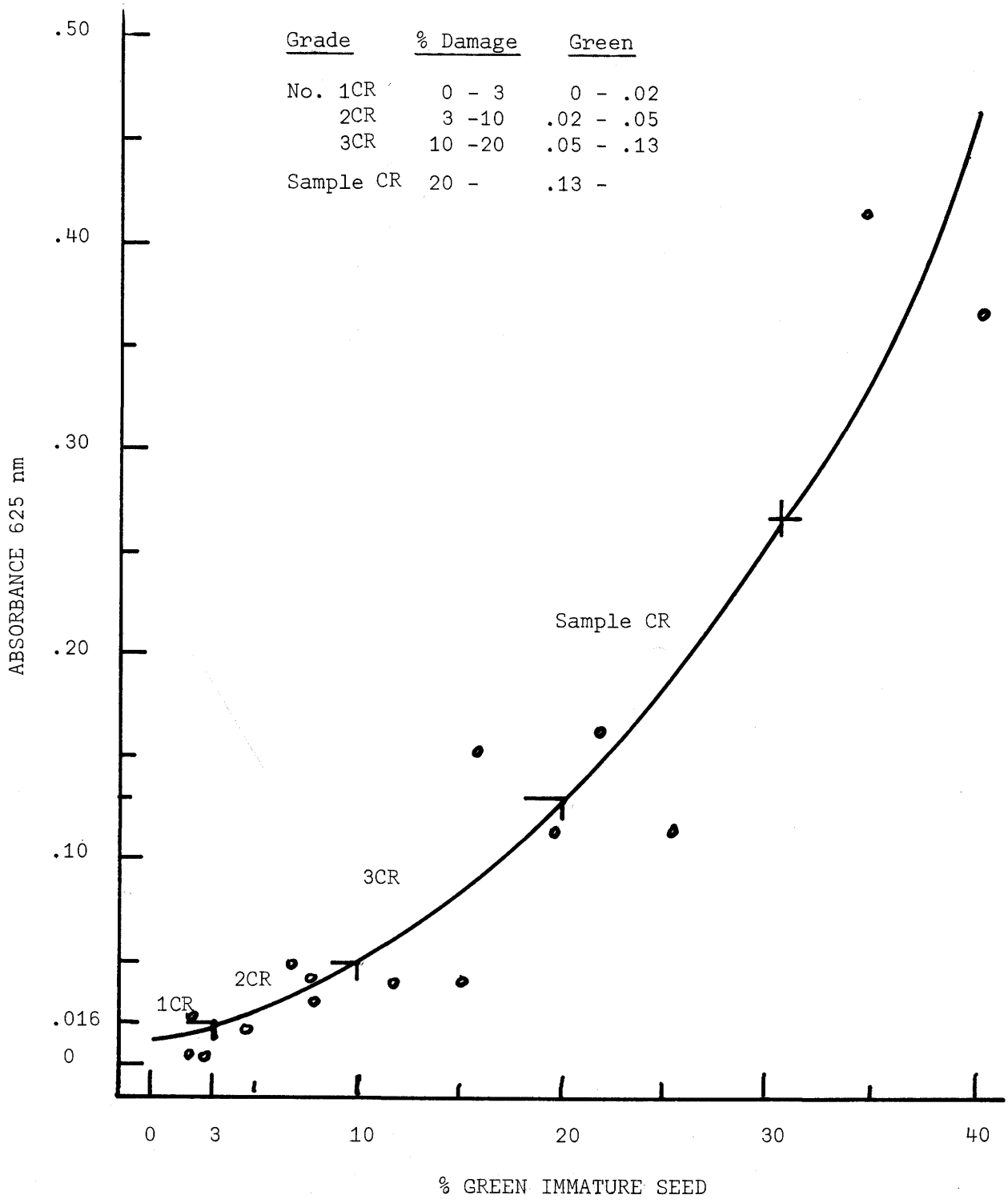

Figure 4.1 1965 Rapeseed grades based on % green immature seed and absorbance at 625 nm.

(Abstracted from Sallans 1965).

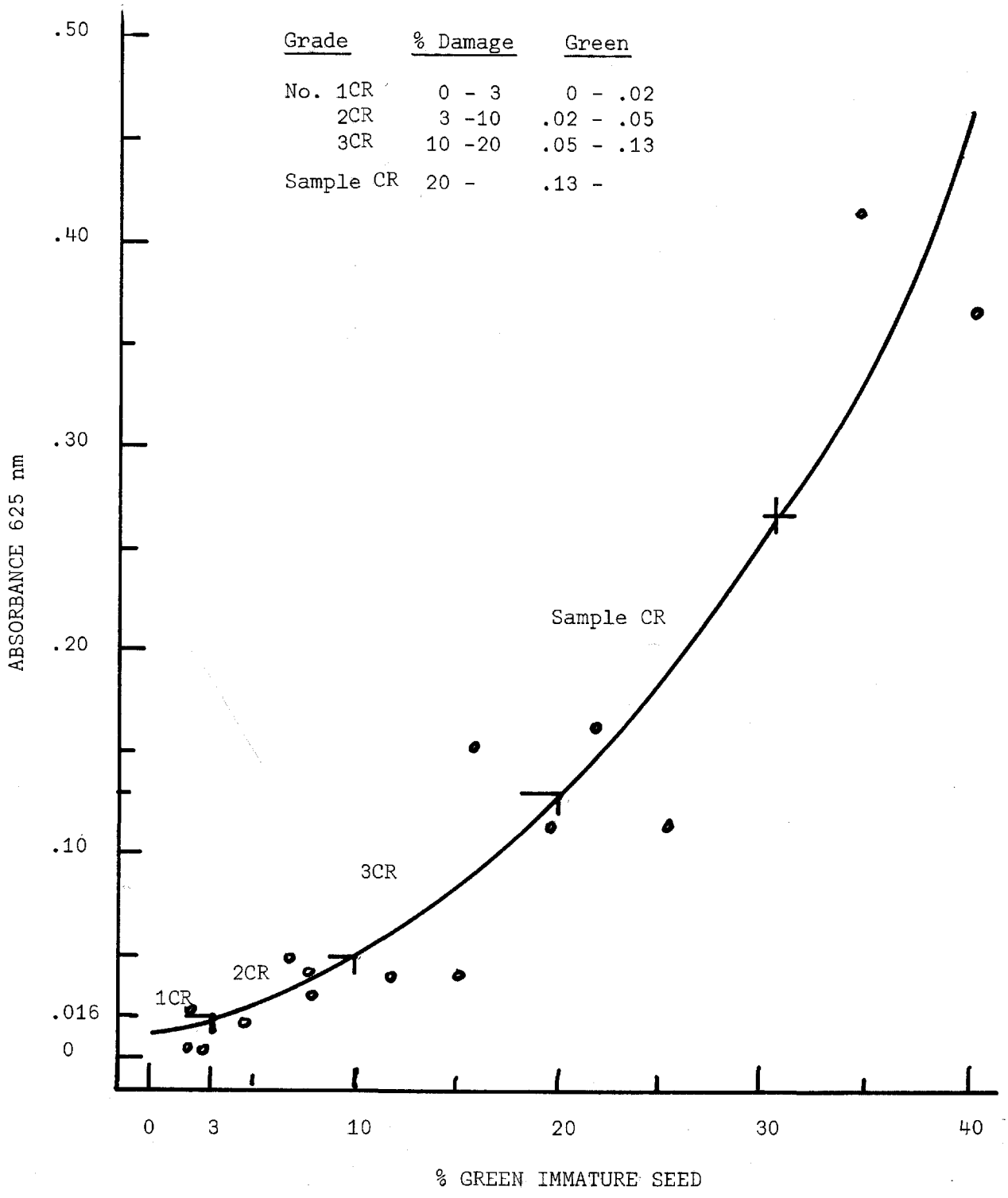

Figure 4.1 1965 Rapeseed grades based on % green immature seed and absorbance at 625 nm.

(Abstracted from Sallans 1965).

In addition, six grower's samples were rejected for very high erucic acid levels (6 - 14%) for lack of proper isolation and field contamination with mustard.

The 1969 production represented the conclusion of a seed increase and product evaluation program to assess the utility of a potential new crop. Due to the lack of pilot plant facilities at the crushing and product manufacture level, it was necessary to undertake field production and processing under strictly controlled conditions to avoid contamination with high erucic acid seed and oil. The successful conclusion of this seed development program was to place the Canadian rapeseed industry in an excellent position to adjust to adverse publicity given to high erucic acid oils during 1970.

4. Oil Quality Standards.

The finished products formulated from vegetable oils have specific color requirements. The natural colors of vegetable oils determine in part, whether the oils are utilized more readily in salad oils, cooking oils, margarine or shortening. For widespread utility a vegetable oil with adverse color characteristics may have to be extensively bleached and deodorized, which adds considerably to the refining costs.

Animal fats, corn oil and peanut oil rarely show color problems but greeness in the crude oil is more common in soybean,

sunflower and especially rapeseed. Green colors are particularly undesirable in margarine and shortening blends and usually arise from improper harvesting of the crop and immaturity of the seed. The wide distribution of the soybean growing area in the United States and the magnitude of the crop can generally allow the blending-off of low quality, immature seeds with the remainder of the crop. The majority of sunflower oil find its end use in table and cooking oils and only the better quality samples are utilized in margarine blends.

Rapeseed presents a more difficult problem as green cotyledons occur in the seed until maturity is attained. The green color is due to the presence of chlorophyll which is soluble in oil solvents. When adverse weather conditions such as cold springs and early frosts occur, it usually affects a major portion of the crop because the area of production is concentrated to a limited portion of Western Canada. As the rapeseed acreage was being expanded, inexperienced farmers tended to plant the crop too late or swathed the crop too early. In addition, the initial introduction of the B. napus varieties to the northern production area was only gradually corrected by the development of B. campestris varieties which matured much earlier. Early swathing to prevent shattering losses can cause green color in the seed by frost until the seed is mature.

Due to limitations in bleaching and decolorizing equipment, the rapeseed crushers and exporters avoided the purchase of green rapeseed. During this critical period, it becam increasingly essential to establish a grading system based on the color of the seed

or crude oil. Representatives of the rapeseed crushers and refiners met with members of the Department of Industry, Trade and Commerce in late 1963 to establish a national trade standard for crude rapeseed oil. The specifications which were established for crude, degummed rapeseed oil (Appendix B) included a provisional standard for the maximum amount of green pigment in the oil after standardized refining and bleaching. The measurement of green pigment employed a colorometric procedure using a Corney No. 625 red glass and a 9% nickel sulfate solution as a comparative standard for maximum green color in the oil.

To meet the provisional oil standards, the vegetable oil industry specified that the oil should be extracted from No. 1 Canada Rapeseed. However, there were no official standards for green seed in the Statutory Grades that were sufficiently critical to ensure that No. 1 Canada Rapeseed would produce crude degummed oil of acceptable quality color level.

Working in co-operation with Dr. C. G. Youngs (Sallans , 1965) and the Board of Grain Commissioners (Connacher , 1965), the present investigator established that 3% of green immature seeds in admixtures with fully mature seed would produce oil which barely passed the established quality standard (Figure 4.1).

The author designed a simple procedure for measuring the percentage of green kernels in a sample of rapeseed. A sample stick, one inch x eight inches, was made from a sheet of one-eighth inch plexiglass. Round depressions, large enough to hold only a single seed (3/32 inches x 3/32 inches), were drilled in five rows across and forty rows in length to hold 200 seeds.

The procedure involved passing the sample stick through a representative sample of rapeseed in a manner that filled each depression with seed. The excess seeds were rolled and brushed off the stick. A strip of masking tape was then laid over the seeds and pressed down firmly by finger pressure. By careful peeling away of the masking tape all the seeds were adhered to the tape in the same position as on the sample stick (Figure4.2). The tape was placed, seeds upward, on a table and a smooth roller passed over them to crush the seed and expose the cotyledons. A count could then be made of the number of green and immature kernels (Figure 4.3).

The new procedure was very simple, rapid and required no specialized equipment or technical skills. The technique was adopted by all elevator agents in the Saskatchewan Wheat Pool system to segregate seed that would not meet the trading standards with specific reference to green color in the oil.

The Board of Grain Commissioners became aware of the procedures and after correlation studies in their laboratory with

Figure 4.2 STRIP TEST EQUIPMENT:

A. Government designed stick adapted from B

B. Original test stick

C. Seed container with rapeseed sample for testing

D. Masking tape 1" wide to cover a stick sample of seed

E. Hand roller to flatten seed sample for grading factors

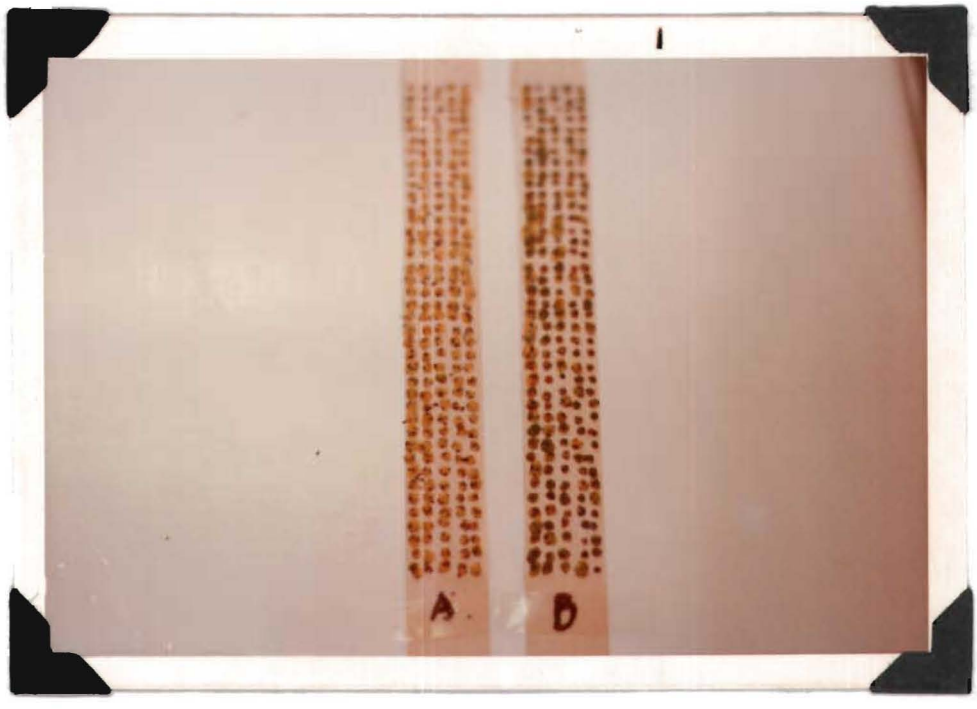

Figure 4.3 Strip test showing clearly the Sample A meets NO. 1 C.R. grade. Strip B displays numerous immature and damaged seed as degrading factors.

oil color measurements, adopted the stick sampling technique as an official grade procedure in 1966. The levels of greeness permitted in the various grades were those developed by the author for use by the elevator agents (Appendix B).

The development of the stick sampling technique greatly aided in the handling of Tanka rapeseed which was first licensed in 1963 as a high oil strain of B. napus. At that time, Japan had become a large importer of Canadian rapeseed but their discounts for seed with less than 40% oil content was relatively severe. Exporters began to encourage the production of Tanka for the purpose of blending with B. campestris varieties in the grain terminals in order to meet the minimum requirements for the Japanese market. It was then discovered that a high proportion of all samples of Tanka gave high green seed counts by the stick sampling procedure. Subsequent investigations demonstrated the presence of a cell layer under the seed coat which remained green long after the seed appeared mature. The 1966 regulations adopted by the Board of Grain Commissions for green seed content permitted the downgrading of Tanka on this basis and production of the variety declined rapidly.

The stick sampling technique also permitted the immediate identification of heat damaged kernels which appeared as dark brown or black cotyledons in the test. Driers are commonly used to reduce the moisture content of freshly harvested rapeseed since the safe

storage level is only 10.5%. Excessive temperatures during drying will reduce the oil content of the seed by breaking down the triglycerides, shorten the storage life of the oil by raising the free fatty acid levels and increasing the yield of soap during the alkali refining stage. The heated musty odor of the seed appears in the meal to reduce its palatability to livestock and there may be heat destruction of essential amino acid such as lysine. Heat damage in rapeseed was hard to detect at the elevator under cold temperature conditions or if the damaged seed was blended off with sound seed.

While the stick sampling technique is very efficient in exposing the color of the cotyledons, there are still problems with the visual assay of the sample. At the present time, green seed is defined as only those which show a brilliant green color and those with a greenish caste are not counted for grading purposes (Figure 4.3). However, a sample containing a high proportion of greenish kernels would provide as green an oil as a sample with only a few brilliant green kernels. It would be advisable to further refine the test by counting the greenish seeds and considering them as equivalent to a certain number of brilliant green seeds in order to improve the quality of the higher Statutory Grades.

5. Extraction Plant Operation.

5.1 Extraction Operation 1965.

The initial plant run of 8200 bushels of low erucic acid presented a unique problem to the operation and technical staff of the crushing plant since such an experimental run had not been previously undertaken. Although it was not desirable to shut down the plant entirely, the author decided that this should be done for the first run. During the 48 hour shut-down period, the storage bins, conveyors, elevator legs, and pipes were brushed down and cleaned of high erucic acid seed. The 100 ton per day crushing plant was flushed through with fresh hexane to minimize the residual erucic acid oil in the system. The cooking and desolventizing equipment for seed and meal were cooled and opened for sweeping out of all adhering material in the system. The loss to the Company for the shut-down period was about $ 2,000 per day.

The shut-down began on December 13 and the first batch of seed from the outer swaths of each field was introduced into the seed cookers on December 15. The green and immature seed from one farm was also used. The initial level of this bulked seed was 2.1% and there was sufficient seed to operate the plant for 8 hours. Erucic acid levels were monitored on the desolventized crude oil in the extraction plant and after degumming in the oil refinery. The erucic acid level of the crude oil dropped rapidly during the first

8 hours from over 28% to 6%, and by the time the wash-out seed and oil had passed through the extraction plant (Figure5.1) the erucic acid level was down to 3%. The color of the wash-out oil was dark green and the refined green oil was blended off in commercial high erucic acid oil during the following several weeks.

Field seed was introduced into the mill rolls immediately after the wash-out seed and the extracted oil began to appear after 16 hours of processing (Figure5.1). The erucic acid level varied between 1 and 2%. During the last portion of the run, all samples taken contained about 1% of this long chain fatty acid in the crude oil. Commercial rapeseed was introduced into the mill on the morning of the second day and the late afternoon sample showed over 5.0% erucic acid in the oil.

The erucic acid content of the oil after degumming was essentially the same as the crude oil (Figure5.2) and it was possible to supply 140,000 pounds of degummed rapeseed oil containing 1.0 to 2.0% of erucic acid to the oil users. A small portion of the transitional oil obtained between the wash-out and low erucic acid run was passed through the refinery operations of alkali treatment, bleaching and deodorizing. This oil was retained by the Saskatchewan Wheat Pool for evaluation of flavor, taste, color and keeping quality of the oil for salad and cooking oil purposes.

The low erucic acid oil tended to foam excessively throughout the extraction and refining, especially when vacuum was applied. The problem persisted through the degumming, alkali refining, bleaching and deodorizing of the oil. Later experiments showed that this phenomena was due to hexane retention by the oil. None of the oil refiners encountered the same problem, and it did not occur in the following years. Therefore, the exact cause of the phenomena is unknown but it was of some concern at the time.

The 140,000 pounds of low erucic acid oil was shipped to Lever Brothers in Toronto, Canada Packers in Toronto and to Proctor and Gamble in Hamilton and Pointe Claire for evaluation. Small quantities were provided to several Universities and to Food and Drug Directorate, Ottawa, for nutritional studies. Samples were also supplied to Rocquelin and Thomasson.

5.2 Extraction Operation 1966.

Based on the experience of the first year and the availability of 20,000 bushels of seed it was decided to process the seed without a preliminary shut-down and clean-out of the plant. On December 15, the plant was operated for 3 hours to clean-out the commercial oil and meal before adding the wash-out seed from the outside swaths into the cookers. This time, the monitoring system showed that at least 20 hours were required to reduce the erucic acid level to below 3% (Figure 5.2). Otherwise,

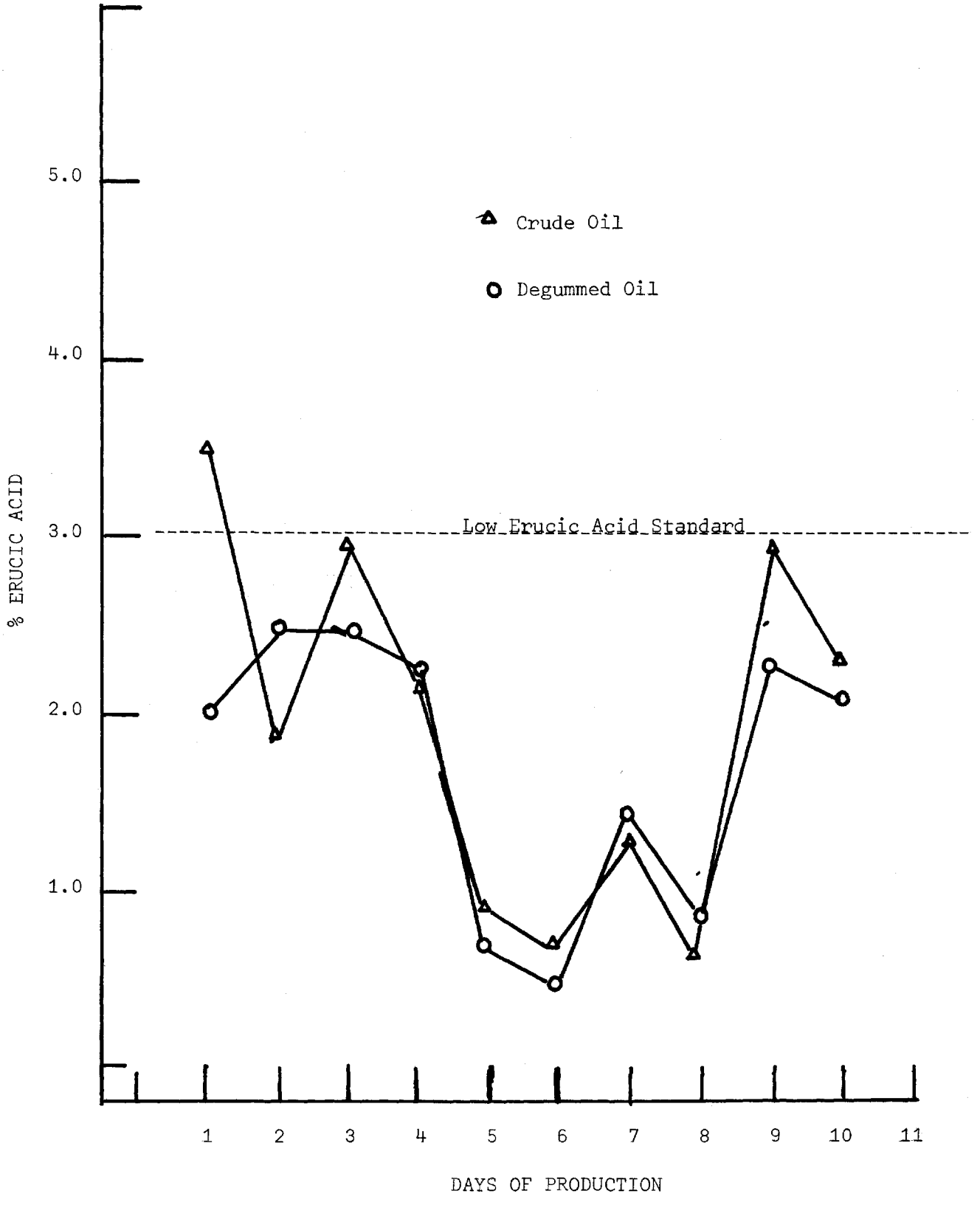

Figure 5.3 Erucic acid levels of daily composite samples of crude desolventized and degummed oil production in 1967.

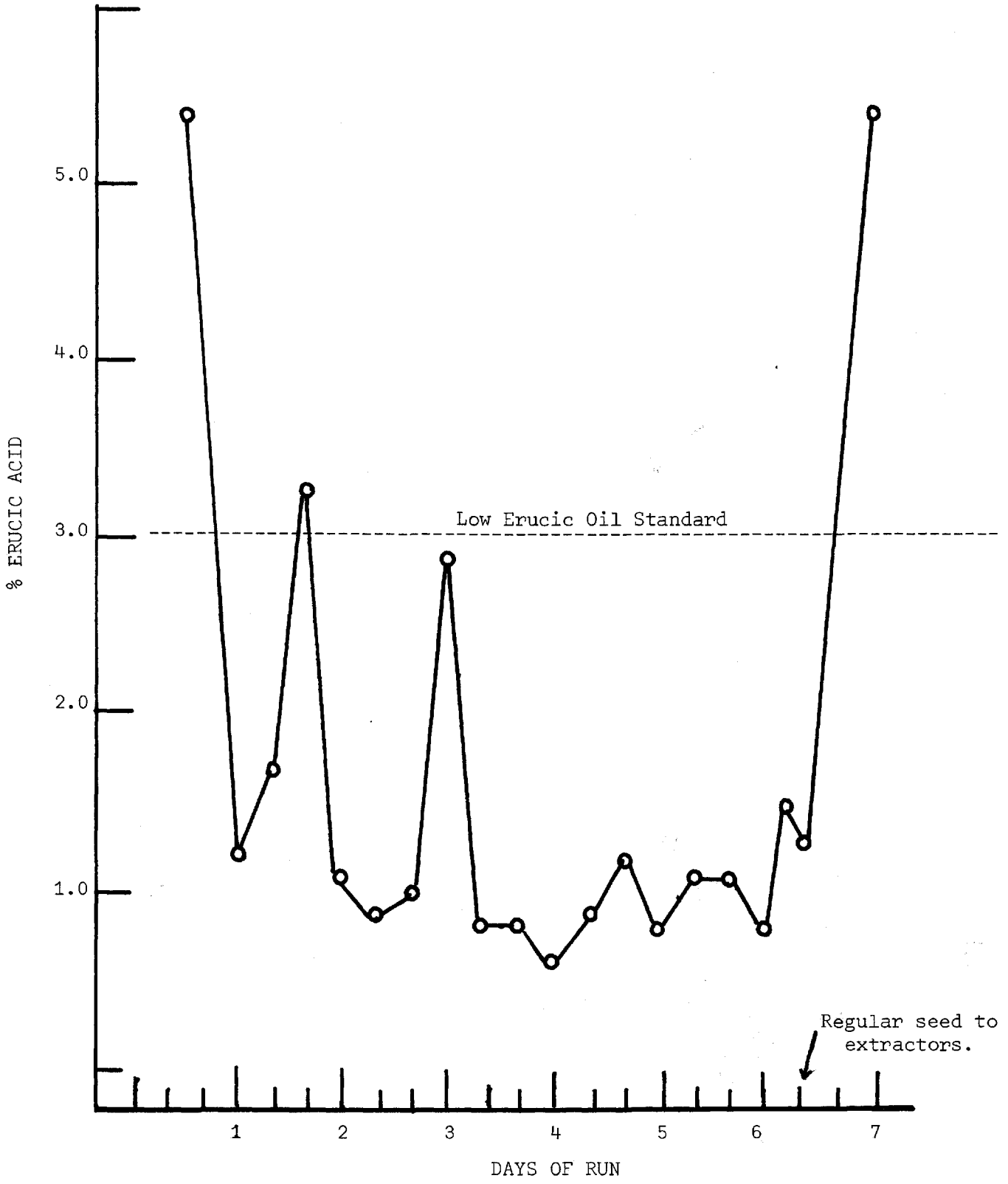

Figure 5.4 Erucic acid levels in crude desolventized oils obtained during a complete extraction period for low erucic acid seed in 1967.

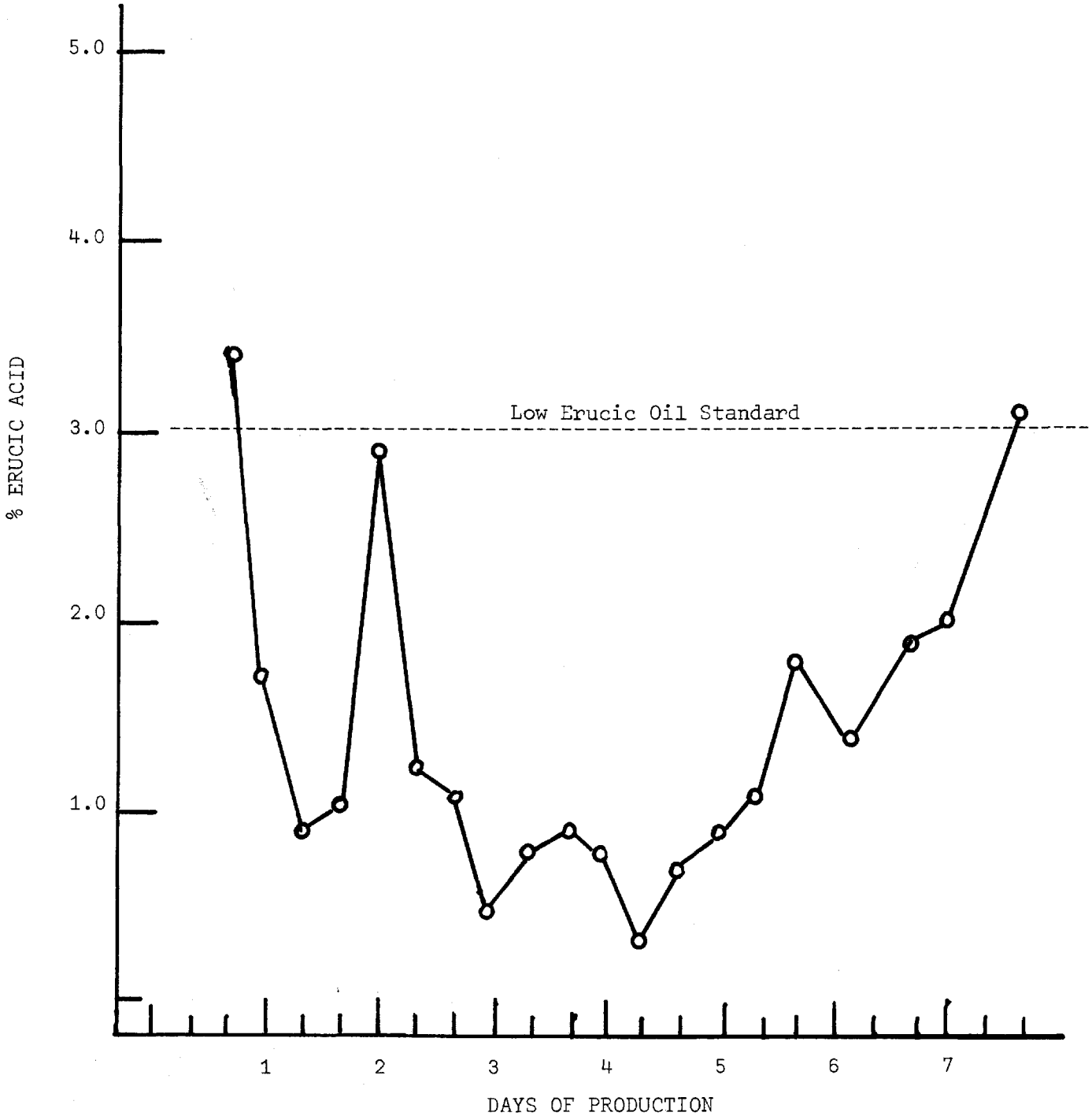

Figure 5.5 Erucic acid levels of daily composite samples of a degummed oil during a complete refining period for low erucic acid in 1967.

no problems were encountered during the experimental run with the remainder of the low erucic acid seed. The extraction was completed in six days and a high yield of oil was obtained (38%). Approximately 320,000 pounds of degummed rapeseed oil containing 1.2% of erucic acid was made available to oil processors which now included Swift Canadian Company. Oil met Canbra standards (Appendix C).

There was no foaming problem with this rapeseed oil.

It was concluded that the preliminary wash-out of the crushing plant with 3,000 bushels of waste seed was adequate to clean out the crushing and refining equipment without interrupting the operation of the plant. (Figures 5.4 and 5.5).

5.3 Extraction Operation 1967.

The high moisture content and immature condition of the crop posed new problems for the low erucic acid program. Little information was available on the proper drying conditions for rapeseed. A paper by Appelqvist (1965) on the optimum temperature-moisture relationships for drying rapeseed was of immense value in handling the 1967 seed lots obtained from the 97 seed growers.

In 1967, a much larger crop was crushed and 150,000 bushels were processed during 40 days extraction at intervals throughout the year. Erucic acid levels were well below the maximum level designated for low erucic acid oil. Degummed oil tended to be lower in the long chain fatty acids than the crude oil. This (Figure 5.3)

reflected the modified degumming procedure adapted to remove the green color from the oil. Charcoal was added to the oil and agitation with heating promoted a more efficient pigment absorption than activated clay. The charcoal was separated by filtration through a plate filter press.

The 2,500,000 pounds of degummed oil containing 2.8% of erucic acid was shipped to all refiners in Eastern Canada with a significant quantity going to Kraft Foods.

5.4 Extraction Operation 1968.

The 1968 crop was the first year of production of the now licensed seed Oro. The Saskatchewan Wheat Pool and all other commercial crushers were involved with establishing growers and market procedures for the Canbra oil.

The Saskatchewan Wheat Pool essentially contracted for the same production as the previous year with a small contract incentive for seed produced over regular rapeseed production. The markets remained small in comparison to regular rapeseed outlets, however, it was consistent and showed signs of increasing as companies such as Kraft and Standard Brands began to utilize the products.

First experimental shipments were made to both Germany and Japan of small quantities for testing the commercial handling system for purity and segregation of seed. The program was successful with the erucic acid identified at the receiving

ports below 3.5% from initial inputs to carloads on the prairies at 2.7%. This assured all parties concerned that segregation of seed was possible in the system and later confirmed by Craig et al. (1973) after the crop had reached levels of production to enter the export markets.

The extraction of the crop proceeded along the lines previously established with minimum conversion times from the regular rapeseed production to the Canbra oil production. Minor adjustments continued to be made in extraction procedures to minimize the hydrolysis effects on the hydrogenation of the oil. These were basically mechanical adjustments only.

In 1971 a program to monitor the low erucic acid content of desolventized crude oil and degummed oil through the first twenty four hours were again carried out. Figures 5.6 and 5.7 confirm the previous findings when similar conditions existed in the plant schedule. The decision to use a fixed time period when converting the extraction unit from one type of seed to another was arrived at as eighteen hours for the solvent extraction processing unit as a safe decision for quality.

These results are only accurate for this one type of extraction unit and cannot apply to any other process.

Filtrex extraction carried out by the Saskatchewan Wheat Pool is unique in the fact that no oil is recycled as a coolant which takes place in pre-press units.

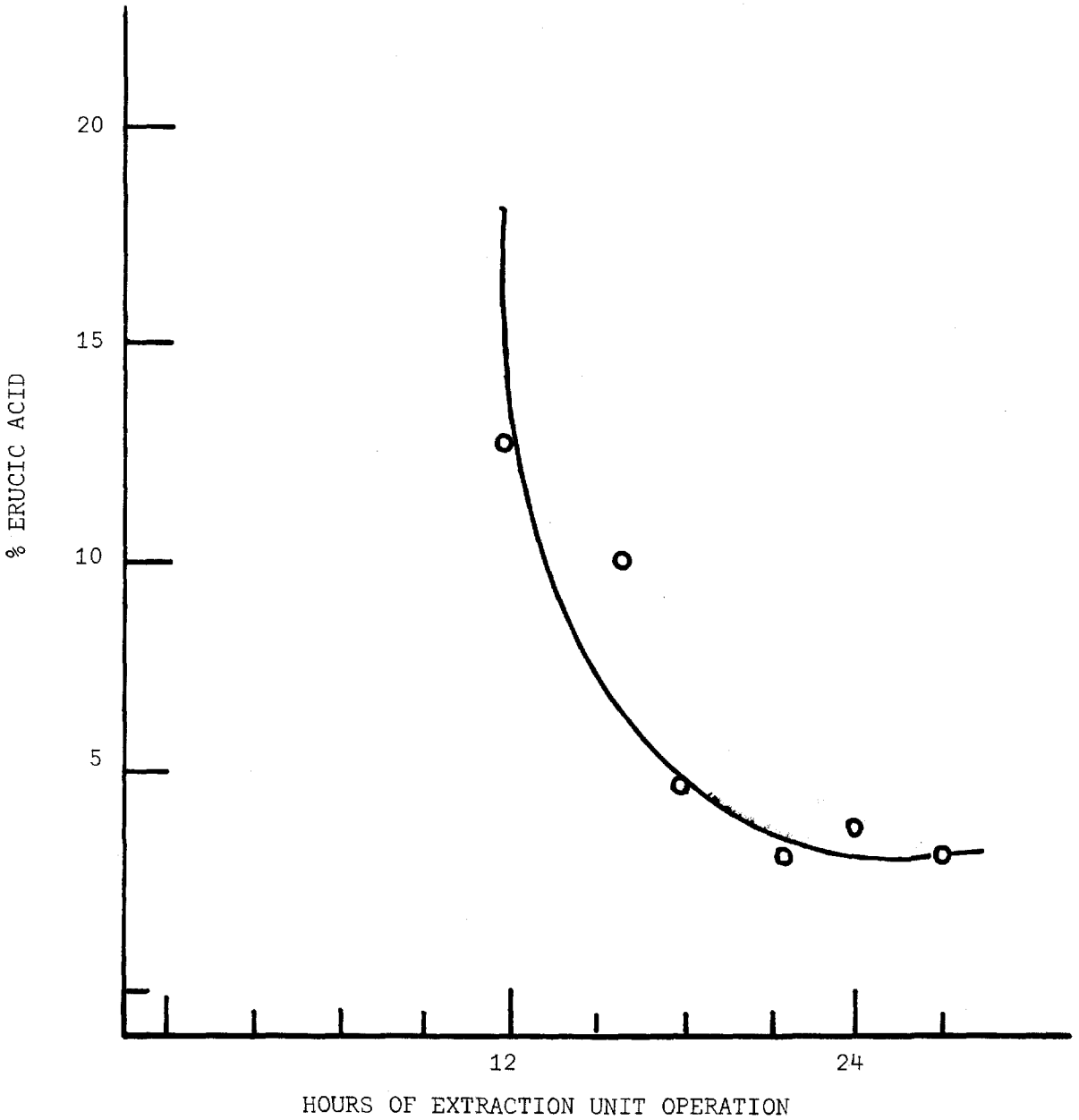

Figure 5.6 Erucic acid levels found in crude desolventized oils during the extraction of low erucic seed in 1971.

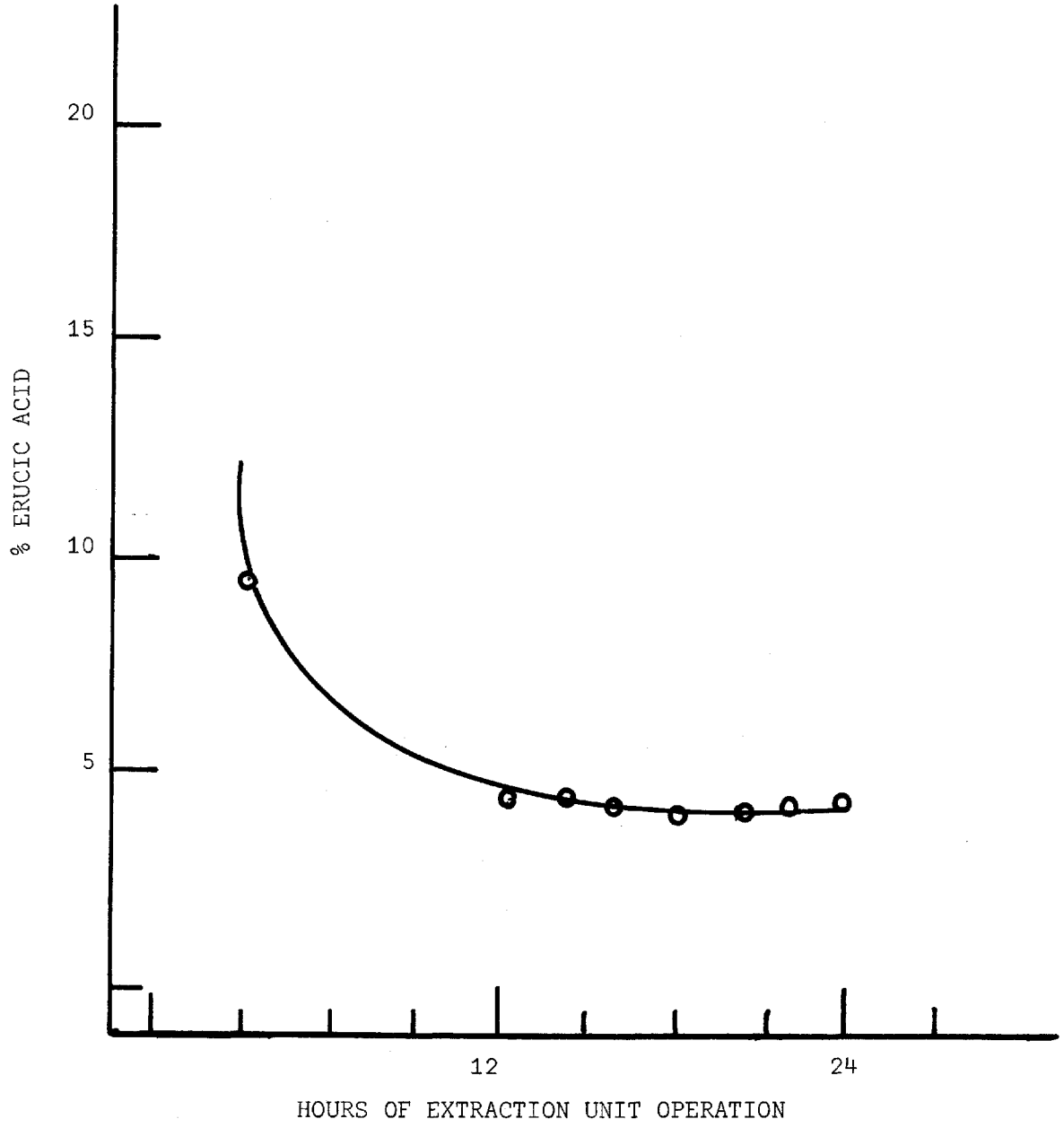

Figure 5.7 Erucic acid levels found in degummed oil during a low erucic seed run in 1971.

6. Oil Utilization.

6.1 1965 Production.

Prior to the present research and development program, a small quantity of low erucic acid rapeseed from the Research Station, Saskatoon, was extracted at the Prairie Regional Laboratory and the oil sent to Canada Packers, Toronto, for evaluation. They reported that the low erucic acid oil did not have any advantage over soybean oil in margarine and shortening manufacture. However, excellent yields of stabilized salad oil was obtained after light hydrogenation and winterization of the oil. Canadian Patent No. 726,140 was issued to Canada Packers for the selective hydrogenation of low erucic acid rapeseed oil in the manufacture of table and salad oils.

Initially, the issuance of the above patent had a dampening effect on interest in low erucic acid oil among other oil processors. However several competing companies did not wish to be left out of the evaluation program and requested quantities of the new oil for pilot plant evaluation. The results of their tests were not reported back to the present investigator. However, each collaborator confirmed that the oil had unique characteristics with commercial potential. Each company requested additional quantities when further supplies were available.

The Saskatchewan Wheat Pool carried out a limited evaluation of the low erucic acid oil as a deodorized product and found it to be quite acceptable with a shelf life approximately 10% longer without antioxidant addition than regular rapeseed oils. Taste panels were employed to establish deep frying potentials and no significant differences were found between the two products although the initial oil tested appeared to withstand heating for a longer period than the regular oils. These were visual observations reported from commercial trials carried out in the Saskatoon commercial food outlets in the area.

Canada Packers received 60,000 of the 140,000 pounds available for evaluation for confirmation of their patented process and investigate the oil utilization in various food products. The results were received on a confidential basis but can be released at this time and are reported verbatum below:

" The following is the data on Car C.G.T.X. 8611 of Canbra oil processed through our plant last month.

1). Crude Oil Analysis:

F.F.A.	0.4 %
Chromo Loss	1.13 % A.O.C.S. Method
Lecithin	1.14 % (Calculated from P. analysis)

F.A. Analysis by G.L.C.

C_{16} [1]	C_{16}=	C_{18}	C_{18}=	C_{18}^2=	C_{18}^3=	C_{20}	C_{20}=	C_{22}=	
3.9	0.3	1.8	60.6	19.4	8.8	0.7	1.8	2.7	%

2). Refining:

The oil refined satisfactorily through our continuous caustic plant. There was no foaming problem.

F.F.A. 0.02% on refined oil.

Lecithin trace

Plant Refining Loss - 3.4% approximately. (With one car it is not possible to be certain of the loss.)

Bleaching of the oil prior to hydrogenation (1% Special Filtrol), did not improve the color substantially. The oil was gray-brown and the color could not be matched on the Lovibond scale.

3). Hydrogenation:

Temperature	320 to 340° F.				
H_2 Press	5 psig.				
Catalyst	0.2% Rufert (0.05% Ni)				
Time	50 minutes				
I.V.	93.2				
Solids	50°	70°	80°	92°	104° F
	2.1	1.1	0.8	0.7	0.6

---

[1] C_{16} palmitic; C_{16}= palmitoleic; C_{18} stearic; C_{18}= oleic; C_{18}^2= linoleic; C_{18}^3= linolenic; C_{20} arachidic; C_{20}= eicosanoic; C_{22}= erucic.

C_{16}	C_{18}	C_{18}=	C_{18}^2=	C_{18}^3=	C_{20}	C_{20}=	C_{22}	C_{22}=
4.0	4.4	70.5	13.9	1.0	1.3	2.1	0.4	2.4

Trans - 24.4 % (of total double bonds)

Bleaching of Hydrogenated Oil (2% S.F.) gave 2.1R with slight greenish tinge.

4). Winterizing at 48° F:

Yield 85 to 88% (here again weighing is a problem with a small amount). The yield was somewhat lower than was obtained in the lab with previous samples. This may be connected with the higher trans content. This could probably be improved by lower hydrogenation temperature.

Deodorized Oil:

Color less than 1.0R (Slightly green).

A.O.M. 55 hours (70 P.V.) no antioxidant.

Comments:

We were well pleased with the performance of the oil. You are to be congratulated on the fine job that you did!"

B. F. Teasdale,
General Superintendent's
Office.

6.2 1966 Utilization.

The quantity of oil available to the vegetable oil refiners amounted to 310,000 pounds. Tank car shipments were made

available to all refiners and limited data on their findings were relayed back to the present investigator.

The report of Canada Packers generally confirmed previous findings with better recoveries of the selectively hydrogenated oil for table use.

Lever Brothers Limited submitted a comprehensive report on their findings in utilization of low erucic acid oil in shortening and margarine preparation.

6.2.1 Shortening Tests.

In their testing program they utilized essentially a regular formulation for shortening products with three trial runs. The three trial batches were formulated using low erucic acid oil, regular rapeseed oil and soyabean oil as the vegetable oil base. Comparisons were made in both analytical (Table 6.1) and comparative bake (Table 6.2) test evaluations relative to a standard product.

Table 6.1 COMPARATIVE ANALYTICAL RESULTS ON LOW ERUCIC, RAPESEED OIL AND SOYABEAN OIL VS. COMMERCIAL PRODUCT.

	Standard	Low Erucic	Rapeseed Oil	Soyabean Oil
Stability (minimum hours)	less than 100° F.	100+	100+	100+
Smoke Point	less than 400° F.	460° F	420° F	420° F
Iodine Value (hydrogenated)		70.1	71.8	71.5
Texture (Penetration)	140 - 180	166	159	179

Examination of Table indicated that the low erucic acid oil had a higher capacity for heating prior to breakdown as shown by smoke point figures. The shelf life or stability was found equal to the other oils included in the test which in all cases were better than the standard employed. The plasticity range was well within trade requirements for a hydrogenated product.[1]

Table 6.2 BAKE EXAMINATION OF THREE EXPERIMENTAL SHORTENINGS VS. COMMERCIAL STANDARD PRODUCT.

	Highest Score			Lowest Score
Bake Test				
Shortening Character	commercial standard	low erucic	soya	regular rapeseed
Total Score	commercial standard	low erucic	soya	regular rapeseed
Cake Volume	commercial standard	soya	regular rapeseed	low erucic
Heating Test				
Highest Smoke Point	commercial standard	low erucic	regular rapeseed	soya
Smoke Point Stability	commercial standard	low erucic	regular rapeseed	soya
Color Stability	regular rapeseed	commercial standard	low erucic	soya
Odour Stability	commercial standard	regular rapeseed	soya	low erucic
Trying Test				
Doughnuts	commercial standard	low erucic	soya	regular rapeseed

[1] Subsequent tests show that there is not a significant advantage with hydrogenated low erucic acid oils over regular rapeseed oil.

In the first week of storage the regular rapeseed oil product was the most stable product for "oiling out" (free oil noted on the surface) but this was reversed with low erucic acid oil after the initial storage period.

Further, the hydrogenation of low erucic oil was accomplished in one-quarter to one-half of the time required for the regular rapeseed or soya stocks. The product from low erucic also exhibited the most desireable plastic range for product utilization.

The following conclusions were made in their report on shortening:

" As well as the advantage associated with processing high quality oil, hardening time can be substantially reduced. The Canbra (low erucic) oil shortenings had a wider plastic range than the rapeseed oil or the soyabean oil shortening. Baking and frying tests showed that Canbra oil shortening produced results similar to the current regular product and better results than the other two shortenings in the experiment.

It therefore appears that the Canbra oil could be a suitable replacement for soyabean oil and rapeseed oil in our shortenings."

6.2.2 Margarine Tests.

Three batches of margarine were produced for the experimental trial from low erucic acid oil, regular rapeseed oil

and a soyabean-palm oil blend. Stability of the products in their resistance to rancidity were tested after eight weeks of storage in a cold room and were found to be equal in all samples and superior to the regular production standard.

Flavor trials were carried out over a twelve week test period utilizing a trained test panel. The results could be summarized in the following table:

Table 6.3 FLAVOR COMPARISONS OF THREE EXPERIMENTAL MARGARINES PRODUCED AND EVALUATED BY TRAINED TASTE PANEL.

	Low Erucic	Regular Rapeseed	Soyabean/Palm Oil
Initial Production	7.5	7.4	7.5
3 weeks	7.3	7.3	7.5
5 weeks	7.4	7.4	7.4
7 weeks	6.6	6.6	6.6
9 weeks	7.2	7.0 [1]	6.8 [1]
11 weeks	6.8 [1]	6.6 [1]	6.9 [1]
12 weeks	6.5 [1]	6.3 (stale)	6.9 [1]

[1] slightly stale

Scale: 10 - best; 1 - poor.

The report from the refinery confirmed previous findings in the shortening procedure that hydrogenation of the low erucic oil took place considerably faster than the other oils tested.

The reports to management after the experimental trials were:

" The results of the extensive plant trials using zero erucic acid rapeseed all appear to have shown that margarine produced from blends containing this oil will produce satisfactory products. It therefore appears that Canbra oil could be used as a replacement for rapeseed oil in our current vegetable oil formula."

The reports confirmed that no problems in the oil refinery operation were associated with the use of low erucic acid oil. One of the prime objectives of the evaluation program was to demonstrate that this oil could be used interchangeably with other oils. This data was valuable when the application was made to license SZ62-11 as Oro rapeseed. When the license was approved, it was possible to assure the domestic and export trade that low erucic acid oils could be utilized in the same manner as other vegetable oils.

At the International Conference on the Science, Technology and Marketing of Rapeseed and Rapeseed Products, Ste. Adele, Quebec, Dr. Weinberg, Messrs. B. F. Teasdale, B. Costigliola and W. G. Mertens all reported further on the utilization of low erucic acid oil in various parts of the domestic edible oil industry confirming the one received in confidence early in the program giving the project the necessary vitalization to keep it going.

In the area of oil utilization Canbra or low erucic acid rapeseed oil has shown a definite advantage in the process of partial hydrogenation of the linolenic acid specifically to be used as a liquid salad and table oil (Teasdale, 1966). Furthermore, it was able to be handled in the usual refining and bleaching techniques giving acceptable products in the normal shortening markets (Teasdale, 1970). In margarine some problems have had to be overcome but significant quantities of this oil are now used. In deep frying of products Canbra has been shown to be equal to all other oils normally used in the trade (Costigliola,1970).

In conclusion the success of the intent of this project can best be summarized on a successful note and the part it had to play by quoting from the Minister of National Health and Welfare in August of 1970:

"that Canada considered it prudent to recommend a phasing in of the new low erucic acid rapeseed varieties."

7.0 Ste. Adele Conference.

7.1 Background.

The increase in seeded acreage with improved yields that began in the early 1960's began to initiate discussions in the grain trade and the implications of expanding crop disposal. Canadian Wheat Board quotas were low and sales to export were not able to reduce stockpile cash crop.

The exclusive Canadian position with the low erucic acid rapeseed development became a focal point for discussions.

The newly formed Rapeseed Association of Canada in 1967 became the nucleus of discussions with the Canadian Department of Industry and Commerce through their oilseed specialist, Dr. B. Weinberg. The involvement began as a financial source for the utilization of Government of Canada funds to assist needed research in rapeseed utilization.

Following the International Conference in Gdansk, 1967, where erucic acid and its implications with cardiac lesions (Thomasson, 1967), was thoroughly discussed the program for a Canadian conference crystallized.

The prime objective of the program was to focus on the many sided discussions of erucic acid and rapeseed oil in the human diet. A direct result of this would be the opportunity for Canada to evaluate the world market for the low erucic acid oil and perhaps establish outlets for this new crop.

The conference was agreed to and the site decided on was the Ste. Adele area, seventy miles north of the international airport at Montreal.

The original indication of attendance by pre-registration established a probable attendance of two hundred but many international rapeseed marketing countries showed little interest.

The Canadian Health Protection announcement of August 12, 1970, barely a month prior to the Conference, changed all plans. It announced to the domestic industry that the erucic acid levels in vegetable oil products sold to the consumer would not exceed five percent.

Immediately, the whole world trade in vegetable oils began to respond. Over four hundred people descended on the conference as a result of this announcement, causing chaos in accomodation, meal facilities and lecture rooms.

7.2 Program.

The committee had established the program months before the Conference, and it was adhered to in spite of extreme pressures being exerted by the implied "Erucic Acid" Conference. Conversations, meetings, small discussion groups were formed and re-formed to try and establish a firm basis for the erucic acid action.

It was necessary on the first day of the Conference to establish several stock-market and international teletype communications about the main meeting hall to allow the international and domestic traders in attendance to follow the very volatile markets being influenced by the discussions in Ste. Adele.

The program established first, the World Trade of all oilseeds and then, the part played by rapeseed oil in this market. Following this, production, agronomic and Canadian marketing procedures were presented. The emphasis then turned to Rapeseed oil

and erucic acid content, highlighting the Canadian new oilseed with low erucic acid and its commercial production and evaluation in the market place. This all tended to pour oil on an already blazing fire.

The last scheduled afternoon program introduced low erucic acid oil. The various studies by nutritional workers from Holland, France, Sweden, Poland and Canada were presented. The pressure released after the papers were presented. Dr. B. B. Migicovsky, Canada Department of Agriculture, offered an invitation for preliminary discussions to finalize a statement to be released at the conclusion of the conference.

7.3 Erucic Acid Discussions.

The first paper (Walker et al. , 1970) reported work with regular rapeseed and low erucic acid seed oil in rat diets under various stress regimes and reproductive performance. Essentially, they were able to show that erucic acid did show up in cholesterol fractions at the expense of polyunsaturated oils (Carroll , 1962a), but no significant difference could be found in the ability of the rat to produce corticosterone under stress. Similar results were also found in reproduction ability utilizing four diets although they felt the ability to reproduce had been slightly reduced. They did show the rats exhibited a wide variation in their ability to incorporate erucic acid which was reflected by the dietary level of the erucic acid fed. Insignificant incorporation of erucic acid was found when low erucic acid oils were employed.

The following papers by Rocquelin and Martin (1970) and Abdellatif and Vles (1970) showed that due to a high content of erucic acid growth retarding effects were related in rapeseed oil trials. They were able to demonstrate that low erucic acid oils gave similar results to sunflower oils, and that heart lesions were found only in regular rapeseed oils with high levels of erucic.

Another paper by Vles and Abdellatif (1970) evaluated hardened palm oil supplements to regular rapeseed oil in feeding trials with duckling and guinea pigs. They reported it increased growth and body weight gains confirming Beare et al.(1963) results.

Dr. Beare-Rogers (1970) then presented the data of the Canadian Food and Drug Directorate tests on long chain fatty acids. In the presentation the results confirmed that lesions were reduced in number with the addition of partially hardened oils, whereas, in regular rapeseed fed alone, the lesions occurred at high levels. The ingestion of regular rapeseed, over a long period of time, (twenty weeks) was found to be responsible for lesions rather than short term trials supplemented after an initial exposure to rapeseed oils with a diet containing saturated fatty acid addition. Utilizing squirrel monkeys and mini pigs with regular rapeseed oil conclusive results indicated that young rats fed levels of 20% regular rapeseed oil responded differently than the other test animals; thereby indicating a difference of specie response to erucic acid feeding

trials. This was attributed to the young rats inability to metabolize long chain fatty acids which could be modified by the addition of partially hydrogenated oil or the addition of saturated fat.

Following the papers a question period allowed for further explanation and interpretations were obtained, The Canadian Food and Drug confirmed that regular rapeseed oil contain 30% erucic acid. Fed to young rats at 5% by weight of the diet, resulted in accumulation of fat in the heart. The magnitude of the deposits were found to be directly related to the amount of rapeseed oil present in the diet. Low erucic acid oils did not cause the fat accumulation. Therefore, as rapeseed oil was never consumed as a sole source of oil in the human diet, the likelihood of harmful results were extremely small. They felt that this hazard could not be overlooked and that the decision to replace oil containing erucic acid with the low erucic acid oils was prudent and practical.

7.4 Canadian Statement.

August 12, 1970 the Canada Department of National Health and Welfare, Food and Drug Directorate issued the following statement to the Canadian public by the Minister of Health.

"Experiments by scientists in the department's food and drug directorate and in Europe indicated that when fed to experimental animals in substantial amounts, rapeseed oil high in erucic acid caused changes in the heart tissue of some. These changes resulted from feeding at levels far in excess of those in Canadian diets.

No harmful effects on humans has been attributed to consumption of the oil but was considered prudent to accelerate a switch in Canada to new rapeseed varieties yielding a vegetable oil free of erucic acid."

7.5 Canadian Manufacturing Practices.

August 9, 1973, the following guide-lines were issued by Dr. A. B. Morrison, Assistant Deputy Minister of Health Protection to the food manufactureres under the heading, quote:

"Restrictions in Content of C_{22} Monoenoic Fatty Acids in Processed Edible Fats and Oils."

"The Honourable Marc Lalonde, Minister of National Health and Welfare, has announced that in the interest of public health the maximum content of C_{22} monoenoic fatty acids in processed edible fats and oils will be restricted as of December 1, 1973.

As a guideline to manufacturers, it is pointed out that the C_{22} monoenoic fatty acids should not comprise more than five per cent of the total fatty acids present in the following foods manufactured after November 30, 1973: margarine and margarine-like products, shortenings, salad oils, cooking oils, salad dressings and mayonnaise. This five per cent limit can be met by use of the new low-erucic varieties of rapeseed; however, it may be necessary to reduce the percentage of certain other sources of C_{22} monoenoic fatty acids, such as marine oils, in the named foods. The mandatory declaration of C_{22} monoenoic fatty acids on labels of food products is not proposed at the present time.

It is the wish of the Health Protection Branch that this restriction be met by voluntary action on the part of food manufacturers. The Health Protection Branch will determine the effectiveness of the program by monitoring products leaving the manufacturers premises. If voluntary compliance is not successful, appropriate amendments to the Food and Drug Regulations will be made."

8. Summary.

As a brassica seed, the presence of erucic acid in the oil caused concern with nutritionalists as it was considered a foreign fatty acid to the body.

In Canada, Dr. K. K. Carroll was able to show effects on adrenal cholesterol by erucic acid in rapeseed oils grown in Canada. The results of this and other studies in Europe caused grave concern in the Department of Health and Welfare in 1956 when the Saskatchewan Wheat Pool began producing significant quantities of rapeseed oil for distribution to the Canadian consumer.

In 1961 the announcement by Stefansson et al. (1961) of the isolation of a rapeseed free of erucic acid immediately offered an opportunity to resolve the considered health problems associated with erucic acid oils. It took four years of plant breeding efforts utilizing all the Canadian expertise to accumulate adequate quantities of this seed for a small commercial evaluation of field performance and industrial extraction and processing.

In 1965 the Saskatchewan Wheat Pool and Canada Department of Agriculture, Research Station, Saskatoon entered into this commercial trial. The program was carried out to the licensing of the first low erucic acid rapeseed as "Oro".

The program was paralleled with a pedigree program and it allowed for large scale plantings of a newly released variety to the farmer the same year of licensing.

During the development program the necessity to solve grading proglems of rapeseed with the end use of the extracted oil as the prime criteria necessitated a quick procedure to attain these requirements. A strip test procedure, simple and adaptable to the whole grain trade was developed and found to be acceptable to the Canadian Grain Commission for a grading standard.

The licensing of Oro represented the successful completion of seed increase and the commercial development program.

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APPENDIX A

APPENDIX A:

1965 Contract Growers

Name	Location	% Erucic Acid	Acres	Net Yield	Yield per Acre
Mr. F. Barnsley	Rivercourse	0.2	80	2020 bus.	25.25
Laurel Farm Co-Op	Meskanaw	0.4	95	2228 bus.	23.45
Purdy & Blacklaws [1]	Melfort	0.2	90	2397 bus.	26.63
B. Sommerfeld	Waseca	0.3	68	1740 bus.	25.59
				8385 bus.	

[1] Seed for 1966 Field Production.

1966 Contract Growers

Name	Location	% Erucic Acid	Acres	Net Yield	Yield per Acre
Mr. F. Barnsley	Rivercourse	0.5	120		
Dickie	Melfort	0.6	50		
J. Duncan	Waseca	0.7	70		
Edwards	Melfort	0.5	70		
C. Leask	Melfort	0.6	120		
R. Northcott	Melfort	0.7	50		
B. Sommerfeld	Waseca	0.7	160		
				21021 bus.	32.85 Average

APPENDIX B

BOARD OF GRAIN COMMISSIONERS FOR CANADA
OFFICE OF CHIEF GRAIN INSPECTOR

Inspection Branch Circular No. 2
Crop Year 1965-66

HEATED SEEDS - RAPESEED AND DOMESTIC MUSTARD SEED

The consequence of failure at time of inspection, to detect heated seeds in official or unofficial samples of Rapeseed or Domestic Mustard Seed, can be very serious for one or more of the parties concerned. It is therefore necessary that every sample graded be carefully checked for heat damage.

Use of I.B. Plastic Seed Counter (100 seeds) and Roller

Using this equipment, you must examine not less than five crush strips from each sample inspected. If distinctly heated, or questionable seeds are present, as many additional crush strips as necessary will be examined, to yield a reliable percentage by kernel count to establish proper grade.

e.g. 10 strips x 100 = 1,000 seeds 2 heated seeds = 0.2%

Inspectors will find that examination of crush strips (particularly of Rapeseed) is a useful guide to the general quality of samples. For example, if the crushed seed contains 5% by count of distinctly (grass) green meats, this is an indication that the damage percentage established by weighted separation should be not less than 5%.

N.B. Heated seeds of Rapeseed or Domestic Mustard Seed fall into three distinct categories when crushed.

1. Charcoal Black = Badly binburnt
2. Dark (Chocolate) Brown = Distinctly heated
3. Light Tan = Slightly damaged from oxidation

Limits of heat damaged seeds specified in statutory grades apply to distinctly heated and/or badly binburnt. Samples containing seeds lightly damaged (tan-coloured meats) should be carefully checked for odour; i.e. both bulk of sample and freshly crushed seed strip. If a definitely heated odour is apparent, these seeds will be considered as heated; if no heated odour is detectable, these seeds will not be considered as heated but as otherwise damaged.

WINNIPEG, Manitoba,
May 19, 1966.

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

Provisional Standard
for

RAPESEED OIL: CRUDE, DEGUMMED

1. DEFINITION

1.1 This standard applies to the degummed oil of rapeseed, intended for use in the manufacture of food products.

2. APPLICABLE PUBLICATIONS

2.1 The following publications are applicable to this specification:

2.1.1 Official and Tentative Methods of Test of the American Oil Chemists Society.

2.1.2 Food and Drugs Act.

2.1.3 Western Canada Grain Grades

2.2 Reference to the above publications is to the issues in effect on the date of invitation to tender, unless otherwise specified.

3. REQUIREMENTS

3.1 Raw Material - The rapeseed oil shall be derived from government graded seed, meeting the requirements for "Canada Rapeseed" as described under Western Canada Grades of the Board of Grain Commissioners for Canada. It shall be as free as commercially possible from weed and mustard seeds.

3.2 Refining Loss - The refining loss shall not exceed 8 per cent when determined by AOCS Method Ca 9b-52.

3.3 Color - When the oil is refined by AOCS Method Ca 9a-52 and bleached by AOCS Method Cc 8b-52, the color shall not exceed 3.0 red and 30.0 yellow on the Lovibond scale when determined by AOCS Method Cc 13b-45.

3.4 Free Fatty Acid - The free fatty acid content of the oil, calculated as oleic acid shall not exceed 1.0 per cent when determined by AOCS Method Ca 5a-40.

3.5 Unsaponifiable Matter - The unsaponifiable matter shall not exceed 1.5 per cent when determined by AOCS Method ca 6a-40.

3.6 Flash Point - The flash point of the oil shall not be below 300°F when determined by AOCS Method Cc 9b-55.

3.7 Moisture and Volatile Matter - The moisture and volatile matter of the oil shall not exceed 0.3 per cent when determined by AOCS Method Ca 2d-25.

4. INSPECTION

4.1 Sampling shall be in accordance with AOCS Method C 1-47.

4.2 Test Methods - Test Methods shall be those of the American Oil Chemists Society, as detailed in the individual requirements.

5. NOTES

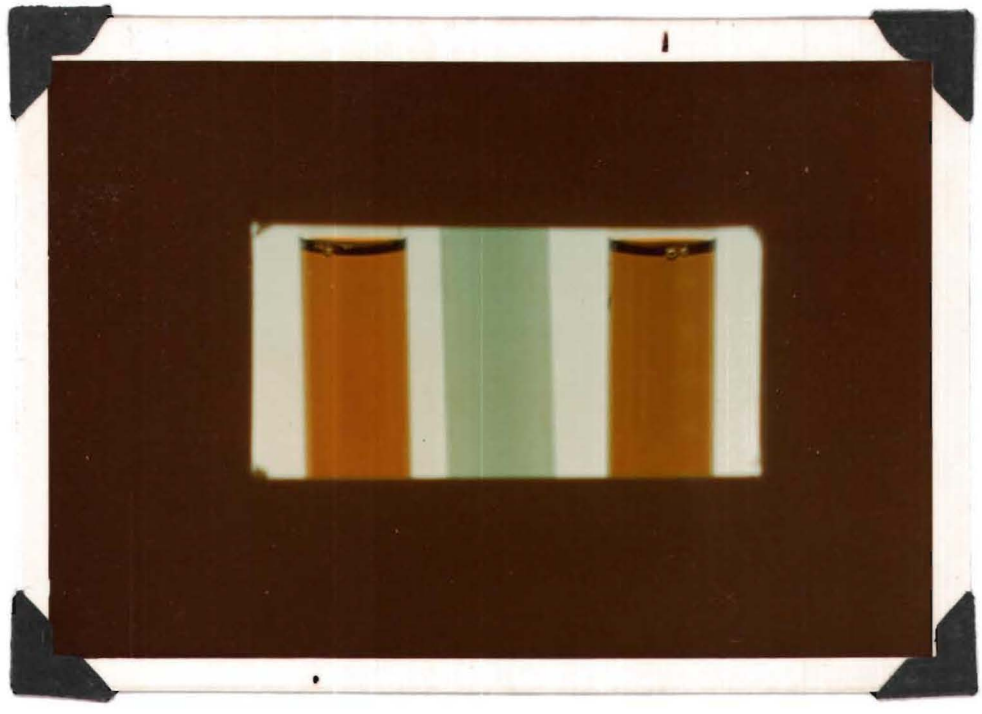
5.1 Publications listed in Section 2 may be obtained as follows:

5.1.1 Official and Tentative Methods of Test of the American Oil Chemists Society, 35 East Wacker Drive, Chicago, Ill., U.S.A.

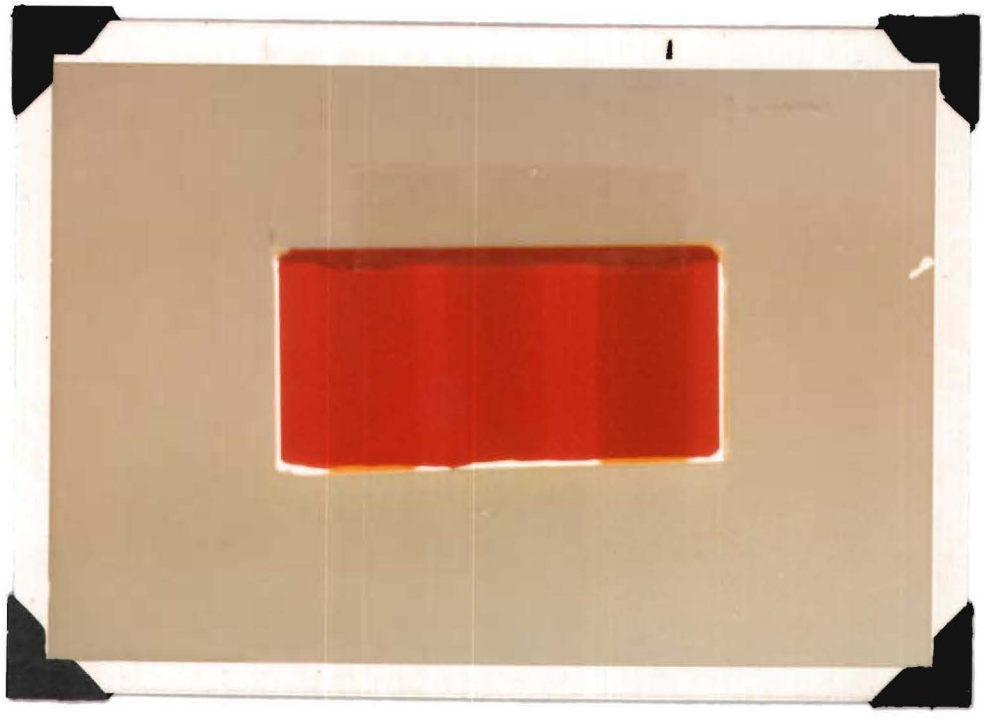
5.1.2 The Food and Drugs Act, The Queen's Printer, Ottawa, Canada.

5.1.3 Western Canada Grain Grades, Board of Grain Commissioners for Canada, 280 Grain Exchange Building, Winnipeg 2, Manitoba.

Correspondence regarding this standard should be addressed to the Secretary, Canadian Government Specifications Board, National Research Council, Ottawa 2, Canada.



Oil samples viewed with Standard "A" in the centre on a white light background illumination.



Same oil samples as on the previous page viewed through a 625 nm. glass. Sample on the left is better than Standard "A", whereas the sample on the right is below Standard "A".

APPENDIX C

DEFINITION OF ZERO ERUCIC ACID RAPESEED OIL AS CANBRA OIL

B. M. Craig

Personnel of the Research and Development Laboratories of Canada Packers Ltd., Toronto, Canada, proposed the name "canbra oil" for rapeseed oil free of erucic acid at the 1965 meeting of the Canadian Committee on Fats and Oils. The word "canbra" was derived from the first three letters of the two words Canadian and Brassica. The intent was that the name be adopted on a national and international basis as the generic term for seed oils free of erucic acid extracted from Brassica crops.

The name "zero erucic acid rapeseed oil" presently in use has several disadvantages:

1. it is too long and cumbersome.
2. it emphasizes the negative rather than the positive aspects and could imply that erucic acid is undersirable in edible oils which is not the case.
3. it relates the new oil type to "normal" rapeseed oil. This is undesirable in that rapeseed oil is discriminated against in many countries due to associations with low quality oils produced during the war year.

In order that the name "canbra" can be retained in the public domain it is proposed that the word "canbra" be registered as a generic name with the Trade Marks Office. A trade mark search has not turned up canbra as a registered trade mark.

To be effective the oil to which canbra refers must be defined in chemical and botanical terms, and the following definition has been proposed:

Canbra oil is that oil extracted from seed produced on plant of the genus Brassica; said oil to contain not more than 6.0 percent of fatty acids with sixteen carbon atoms per molecule, not more than 3.5 percent of fatty acids with twenty carbon atoms per molecule and not more than 3.5 percent of fatty acids with twenty-two carbon atoms per molecule, the percentages to be expressed as weight percent of total fatty acids in the oil.

It has been established that eicosenoic and erucic acid levels can be maintained in the production of breeder and foundation seed at 0.5 percent or less. Three years of commercial production 330, 730 and approximately 9000 acres in 1965, 1966 and 1967 has indicated that the eicosenoic and erucic acid levels of oil extracted from commercial seed can be expected to rise from the 0.5% level to 2.0 and 3.0% due to contamination from cross pollination, admixture and handling. These experiences are the basis for the fatty acid levels set out in the definition outlined above, and serve to point up the fact that the commercial rapeseed oil presently designated as zero erucic rapeseed oil does in fact contain measurable amounts of eicosenoic and erucic acids.

The major advantage found in commercial evaluation of zero erucic rapeseed oil as an edible oil product has been one of an increased

yield of the liquid oil produced by partial hydrogenation and winterization as set out in the patent by Canada Packers Ltd. The advantage in yield over vegetable oils other than rapseed oil is ascribed as due to the low content of saturated acids. Rapeseed oils containing erucic acid cannot be successsully used in production of such derived oils due to filtration problems which are caused by the high content of eicosenoic and erucic acids. The levels of eicosenoic and erucic acids in the definition are slightly higher than those in commercial oil evaluated by the edible oil industry over the past two years, and would not be expected to reduce the yield of liquid product in the processing as outlined.

The fatty acid levels in the definition are given in terms of chain length of fatty acids rather than specific fatty acids for the following reasons:

1. no significant variation has been found in the amounts of palmitoleic, arachidic, eicosadienoic, behenic and docosadienoic acids in the oil extracted from selected strains, pedigree seed or commercial seed. The percentages of these minor acids are 0.5% or less and do not vary markedly from the parent erucic containing rapeseed oils. It is perhaps significant that the zero erucic acid rapeseed oils contain behenic acid to the extent of 0.5% or less.
2. the ease of measurement by gas liquid chromatography using non-polar columns. The measurement of chain length content of the

zero erucic rapeseed oils has been used consistently in the breeding program and in the commercial evaluation of these oils. Naturally, the results of such analyses are confirmed for individual fatty acids using polar polyester liquid phases. Since the minor acids contribute an essentially constant amount to each chain length, the use of non-polar liquid phases for analyses would be adequate for definition.