COMPARATIVE EFFECTS OF LOW ERUCIC ACID RAPESEED OIL AND SOYBEAN OIL ON WHOLE BLOOD HEMATOLOGY AND SERUM LIPIDS IN YOUNG MEN

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ABSTRACT

The effects of low erucic acid rapeseed oil (Brassica napus cv. Tower) and soybean oil on serum lipid patterns and whole blood hematology were investigated with eight healthy male subjects. The diet was composed of conventional low fat foods and added fat, in which soy protein was substituted for meat. Fat contributed 40% of total calories in a 3000 kcal. daily diet. Approximately 93% of the total fat was added fat. The 31 day study was divided into four periods: (1) An eight-day pre-experimental stabilization period during which the added fat was a mixture of fats formulated to simulate the composition of fat in the average North American diet; (2) An eight-day experimental period during which half the subjects were fed rapeseed oil and the other half soybean oil as the added fat; (3) A second eight-day experimental period during which the subjects received the alternate oil (crossover design); and (4) A seven-day post-experimental period during which the diet containing mixed fat again was fed to all subjects. Fasting blood samples were drawn on days 2, 9, 17, 25 and 32. Serum cholesterol and serum lipid phosphorus levels decreased during the pre-experimental mixed fat period, and were lower when vegetable oil was fed as the fat source than when mixed fat was fed; but there was no statistical difference between the two oils, rapeseed and

soybean, in their effect on serum lipids. Changes in serum phospholipid fatty acid patterns reflected changes in dietary fatty acid patterns. Red blood cell count, reticulocyte count, platelet count, hemoglobin levels and hematocrit levels did not change in response to changes in fat source. Leucocyte counts when the test diet was fed (days 9, 17, 25 and 32) were lower than initial counts (day 2). Leucocyte counts were lower when vegetable oils were fed than when mixed fat was fed, and were lower when rapeseed oil was fed than when soybean oil was fed. Nevertheless, all values observed during this study for six hematological parameters, including leucocyte counts, remained within levels considered normal in the human. Therefore inclusion of a high level of low erucic acid rapeseed oil in the diets of healthy young men appears to have no detrimental effect on serum lipid patterns and whole blood hematology.

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INTRODUCTION

Until 1971, soybean oil was the main edible oil used in Canada. In 1971, the use of rapeseed oil (Brassica napus and Brassica campestris) surpassed that of soybean oil for the first time. In 1973 there was 1.37 times as much rapeseed oil as soybean oil used in Canada (Teasdale, 1975). Although soybean oil regained the lead in 1974, the combined usage of these two oils continues to increase. Together they accounted for 78% of the total domestic oil consumption in 1973 and 83% in 1974 (Statistics Canada, 1974).

Since 1971, all rapeseed oil for edible use in Canada has been of the low erucic acid type (less than 5% erucic acid). Erucic acid, a monounsaturated 22 carbon fatty acid, occurs in traditional rapeseed oil at levels of 22-45% of the total fatty acids, (Teasdale, 1975) but may rise to as much as 65% in special high-erucic varieties developed for industrial applications (Downey et al., 1975). Breeding of varieties with low erucic acid content was undertaken because of observations that very long chain monoenoic fatty acids, such as erucic and cetoleic acids, produced cardiopathological changes and detrimental changes in skeletal tissues (Abdellatif and Vles, 1973; Rocquelin et al., 1973; Beare-Rogers et al., 1974). The erucic acid

in traditional rapeseed oil is replaced by its 18 carbon progenitor oleic acid in the low erucic acid varieties. Traditional rapeseed oil and low erucic acid rapeseed oil resemble soybean oil in their linolenic acid content (considered undesirably high in all three oils because linolenic acid deteriorates readily during storage). High and low erucic acid rapeseed oils are both characterized by relatively low levels of linoleic acid compared to soybean oil, and relatively low levels of the saturated fatty acids, palmitic and stearic acids (Downey et al., 1975).

Rape is raised not only for its oil but for the high-protein residue that remains after oil extraction. Traditional rapeseed meal has been used as a supplement for animal feeding even though it contains high levels of glucosinolates, which have growth-depressing and goitrogenic effects. Plant geneticists therefore have been working toward the elimination of these compounds. This goal was achieved in 1974 with the licensing of the Brassica napus cultivar Tower, the first Canadian low glucosinolate, low erucic acid cultivar. Tower is the result of backcrosses of Liho, a low erucic acid variety, and Brownowski, a low glucosinolate variety, to Turret. Plant breeders are now attempting to increase the linoleic acid content to 40% and decrease the linolenic acid content to 3% (Downey et al.,

1975).

The pathogenic effects of traditional rapeseed oil have been attributed to the high level of erucic acid and the low level (4 to 6%) of saturated fatty acids. Erucic acid alone cannot be the entire answer, since Rocquelin and Cluzan (1968) reported pathological changes in rats fed low erucic acid rapeseed oil, a finding that was confirmed by Rocquelin et al (1970) and has been observed repeatedly by other researchers (Kramer et al., 1973; Beare-Rogers et al., 1974).

Although animal studies of rapeseed oil are quite numerous, little work has been done on the metabolism of rapeseed oil in man. Rapeseed and soybean oil, as mentioned previously, are the major edible oils used in Canada. Therefore it was thought meaningful to compare the effect of low erucic acid rapeseed oil from the new cultivar Tower with the effect of soybean oil on whole blood hematology and lipid patterns in the human.

REVIEW OF LITERATURE

A. HISTORY OF RAPESEED OIL IN CANADA

Rapeseed oil became a product of Canadian agriculture in 1942 when it was introduced as a lubricant for reciprocating steam engines. Later rapeseed oil was sold on the domestic market as a replacement for some of the imported edible oils.

Rapeseed oil is extracted from the seeds of two traditional species; Brassica napus or Argentine rape, a high-yielding long-season variety, and Brassica campestris or Polish rape, a somewhat lower-yielding, earlier-maturing variety.

Traditional rapeseed oil is characterized by a high content of the long chain monounsaturated fatty acids erucic acid (C22:1n9) and eicosenoic acid (C20:1n9), members of the oleic acid series. The oil from the two species are similar, although the oil from the traditional B. napus varieties contains more erucic acid than that from the traditional B. campestris varieties. Seventy-five to eighty percent of the commercial crop over the last ten years has been of the B. campestris type, due to the short growing season on the Canadian prairies (Craig et al., 1973).

In 1961, Stefansson and coworkers in Canada succeeded in isolating a true-breeding low erucic acid strain of rapeseed (Stefansson et al., 1961). They used as starting material a variety of Brassica napus called Liho, from Limberger Hof, Germany; a variety which exhibited great variability in the erucic acid content of its seeds. Since then there has been considerable work on genetic selection with rapeseed, and low erucic acid variants of both B. napus and B. campestris have been isolated. These new low erucic acid varieties lack the enzymes necessary for the elongation of the C18 monoenoic fatty acid oleic acid to produce eicosenoic and erucic acids. The new oil from these selected strains therefore is characterized by a high content (53-60%) of oleic acid, the C18:1n9 fatty acid. The new oil was initially termed canbra oil, a contraction of Canada Brassica, and this name is encountered in the early literature.

B. A COMPARISON OF SOYBEAN OIL WITH HIGH AND LOW ERUCIC ACID RAPESEED OIL

In 1973, in accordance with a request from National Health and Welfare, Canadian producers switched over to low erucic acid varieties of rapeseed. This decision was based on reports of deleterious effects of erucic acid.

Rapeseed oil and soybean oil are the most widely used edible oils in Canada. The disappearance data for the leading vegetable oils is presented in Table 1. Prior to 1971, soybean oil was used most widely in Canada. From 1971

Table 1

Domestic Disappearance Statistics for Edible Oils in Canada[1]

	Millions of Pounds			
	Margarine Oil	Shortening Oil	Salad Oil	Total Oils
1973				
Rapeseed oil	75.8	89.3	72.6	237.7
Soybean oil	59.2	84.6	29.5	173.3
Palm oil	8.8	35.5	0.3	44.3
Coconut oil	0.8	38.8	1.5	41.0
Sunflower seed oil	0.1	3.3	23.0	26.5
1974				
Soybean oil	90.4	120.0	49.7	260.0
Rapeseed oil	63.4	65.3	72.3	201.1
Palm oil	8.9	20.0	0.3	29.2
Coconut oil	0.6	23.2	-	23.8
Sunflower seed oil	0.1	4.1	16.3	20.6

[1]Data from Statistics Canada Fats and Oils.

to 1973, rapeseed oil usage was greater than that of soybean oil, but in 1974, soybean oil again assumed the lead in Canada.

Soybean oil differs in composition from rapeseed oil in that soybean oil contains more of the polyunsaturated fatty acid linoleic and of the saturated fatty acids palmitic and stearic acids (Table 2). Low erucic acid rapeseed oil differs from traditional rapeseed oil in that oleic acid largely replaces eicosenoic and erucic acids (Table 2).

There are also differences between rapeseed oil and soybean oil in positional conformation of the triglyceride. The linoleic acid in soybean oil seems to be randomly distributed among the three positions of the glycerol moiety of the triglycerides (Figure 1) whereas linoleic acid appears to be located primarily in the two position in rapeseed oil (Figure 2). Erucic acid in rapeseed oil is located almost exclusively in the one and three position of the triglyceride and is found only in trace amounts in the two position (Appelqvist, 1971; Grynberg and Szczepanska, 1966; Jacquot et al., 1969). It is not known whether these positional differences affect the metabolism of these oils by the body. However, free erucic acid, when ingested in conjunction with oleic acid, is incorporated into the one and three positions rather than the two position of lymph triglycerides in the rat, indicating a similar positional

Table 2

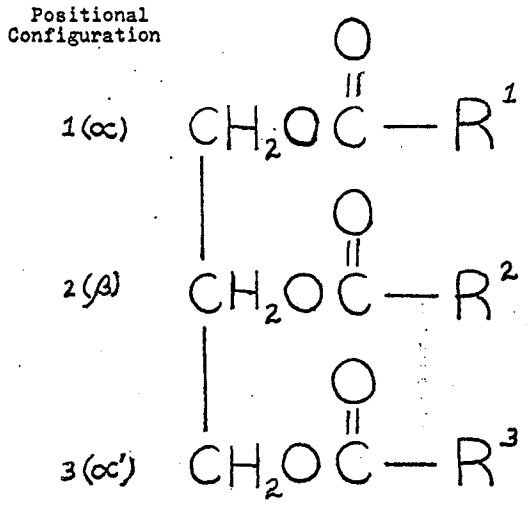
Fatty Acid Compositions of Soybean and Rapeseed Oils[1]

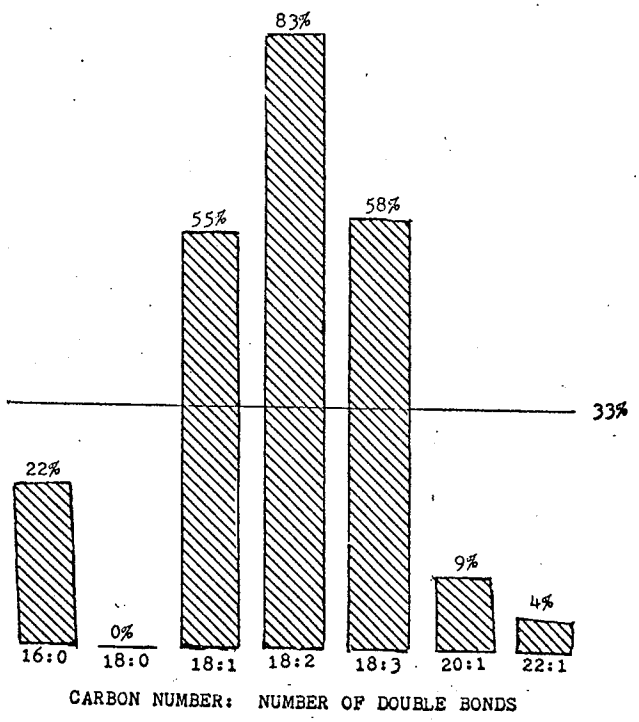
	Rapeseed Oil		Soybean Oil
	Low Erucic Acid	High Erucic Acid	
C16:0 Palmitic	1.5-5.0	2.4	10-11
C16:1 Palmitoleic	0.3-0.9	<0.5	tr
C18:0 Stearic	0.9-2.0	1.2	4
C18:1 Oleic	53-60	13-36	23-26
C18:2 Linoleic	19-25	12-23	50-54
C18:3 Linolenic	8-12	7-11	7-9
C20:0 Arichidic	0.5-1.0	0.5-1.5	tr
C20:1 Eicosenoic	1.5-2.5	8-15	-
C22:0 Behenic	<1.0	tr	-
C22:1 Erucic	tr -5.0	22-45	-

[1]Teasdale, 1975.

Figure 1

Structure of a Typical Triglyceride





[1]Jacquot et al., 1969.

Figure 2

Proportion of Various Fatty Acids in the 2 Position in Triglycerides of High Erucic Acid Rapeseed Oil[1]

incorporation as in the rape plant (Savary and Constantin, 1966).

C. RAPESEED OIL AND CARDIOPATHOLOGY

Concern about the content of erucic acid in rapeseed oil stemmed from reports of pathological changes associated with the feeding of high levels of rapeseed oil. A major concern with traditional high erucic acid rapeseed oil was the high incidence of cardiac lesions in experimental animals fed the oil. All ten animal species studied to date have exhibited cardiac changes in response to a diet containing erucic acid, either as a component of rapeseed oil or as ethyl erucate or glyceryl trierucate (Beare-Rogers et al., 1972 a, b; Beare-Rogers and Nera, 1972; Beare-Rogers, et al., 1971; Houtsmuller, 1972).

The development of cardiopathology in response to rapeseed oil has been reviewed by LeBlanc (1973), King (1974) and Lake (1975). However, a few additional comments deserve mention.

Development of cardiopathology in the rat follows a characteristic pattern. Triglycerides rich in erucic acid accumulate in the heart muscle within 24 hours of ingestion of a diet containing erucic acid. Erucic acid concentration reaches a peak in three to six days after the introduction of erucic acid, and then tapers off gradually

(Abdellatif and Vles, 1973; Abdellatif and Vles, 1970a; Lall et al., 1972).

The reason for this lipid accumulation has not been established. However, two biochemical changes have been reported in response to feeding of erucic acid. Houtsmuller et al (1970) reported a decrease in the rate of ATP synthesis by isolated rat heart mitochondria, although Kramer et al. (1973) disputed this finding and attributed the decrease in ATP production to improper isolation of the mitochondria. Feeding of erucic acid has also been reported to cause a decrease in the rate of β-oxidation in isolated rat heart mitochondria, which may account for the fat accumulation in the heart muscle (Swarttouw, 1974). There appears to be an improvement over time in the ability of heart tissue to metabolize erucic acid to oleic acid through β-oxidation, as evidenced by an increase in the oleic acid in the heart (Christopherson and Bremer, 1972; Houtsmuller et al., 1972; Craig et al., 1963a; Craig and Beare, 1967). This improved β-oxidation may account for the gradual clearing of fat deposits in the heart (Jaillard et al., 1973).

Necrosis and fibrosis of cardiac tissue has been observed in several species fed diets containing erucic acid over an extended period. However there is question as to whether erucic acid alone is responsible for all cardiac lesions observed. Low erucic acid rapeseed oil also produces