FACTORS INFLUENCING MYOCARDIAL LESIONS IN ANIMALS FED DIETS CONTAINING LOW ERUCIC ACID RAPESEED OILS

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Pathological changes have been extensively investigated in the hearts of animals fed diets containing 20% by weight low erucic acid rapeseed (LEAR) oils for prolonged periods. When Tower rapeseed oil (RSO) and soybean oil were fed up to 24 weeks to cynomolgus monkeys (Table 1), no significant difference in heart lesion incidence was observed (1). Six large studies with pigs (2-7) demonstrated no significant differences in the incidence of heart lesions between basal fat free diets and diets containing control oils, LEAR oils and RSOs high in erucic acid. No sex difference was observed in pigs. The results suggested that heart lesions specific to the ingestion of LEAR oils is not a general phenomenon in different animal species.

In contrast, reported studies indicated that the rat, especially the young growing male rat, is very susceptible to the development of heart lesions. A significantly higher incidence of heart lesions occurs in males than in females (Table 2). The reduction in the incidence of myocardial lesions in the castrated males and not in the castrated females (Table 2), suggests the involvement of androgen in the pathogenesis. Furthermore, the incidence of heart lesions in male rats was directly related to the fat content in the diet, e.g., lesion incidence of 5% corn oil < 20% corn oil (Tables 2 and 3). The inconsistent strain differences in lesion response between albino male rats (Table 3), merely pointed out the variations observed between experiments (10). However, the Chester Beatty hooded rat showed a resistance to the formation of myocardial lesions (Table 3). In a repeat study, the difference in the lesion response between the albino (Sprague-Dawley) and the hooded (Chester Beatty) male rat was confirmed (Table 4). It is known that the hooded rat absorbs fat mainly as free fatty acids bound to albumin via the portal circulation, while the albino rat absorbs long-chain fatty acids mainly as triglycerides via the thoracic duct lymph (12). Despite the difference in fat absorption and the difference in lesion response between the strains of rats, cardiac and hepatic lipid changes were similar between the two strains at 1, 4, and 16 weeks of feeding the test oils (11).

Although it has been suggested that RSOs might contain specific cardiotoxic contaminants (13, 14), we have failed to remove or concentrate such compound(s) from Span RSO by exhaustive molecular distillation or absorption chromatography (15, 16). The fractionation was repeated using Tower RSO which contained only 0.2% 22:1. Molecular distillation and absorption chromatography were used in series to fractionate Tower RSO, i.e., the pure triglyceride fraction from molecular distillation (Tower MD7) was further purified by adsorption chromatography. The brassicasterol content of the sterol esters was used as an indicator of purity of the RSO triglycerides. Soybean oil was used as the control oil and a similar molecular distillate (Soybean MD7) was prepared for comparison. The pathological results (Table 5) confirm our previous findings that a toxic contaminant(s) could not be removed from LEAR oil triglycerides; all Tower RSO fractions tested had a high incidence of heart lesions using growing albino male rats. Therefore, we conclude that there is no evidence for cardiotoxic contaminant(s) in LEAR oils.

Table 1. Myocardial lesions in cynomolgus monkeys fed soybean oil or Tower RSO for up to 24 weeks (1).

Diet	Sex	Affected/Examined
Soybean oil	Male	2/7
	Female	0/7
Tower RSO	Male	0/14
	Female	0/12

Table 2. Myocardial lesions in entire and castrated male and female rats fed experimental diets for 16 weeks (8).

Diets	5% Corn oil	20% Corn oil	20% Zephyr RSO
Group	Heart lesions: Affected/Examined		
Entire male	3/26	7/26	16/25
Castrated male	1/26	1/26	9/27
Entire female	0/26	4/26	3/26
Castrated female	0/26	1/26	4/26

Table 3. Myocardial lesions in male rats of selected strains and different sources fed experimental diets for 16 weeks (9).

Diets		5% Corn oil	20% Corn oil	20% Zephyr RSO
Strain	Source	Heart lesions: Affected/Examined		
Wistar	A	3/26	4/24	16/25
Sherman	A	0/26	9/25	17/24
Sprague-Dawley	A	1/23	4/24	10/22
Sprague-Dawley	B	2/26	6/26	22/25
Chester Beatty	B	0/10	2/10	0/8

A = Hemlock Hollow Farm, Blackoak Road, N.J.
B = Bio-Breeding Laboratories, Ottawa, Ontario.

We suggest that the observed myocardial lesions in rats fed LEAR oils may be related to the fact that the fatty acids of LEAR oils fail to meet the specific fatty acid requirements of the fast growing albino male rat. To demonstrate this, we pooled data from 20 experiments conducted in three independent laboratories. The results of a step-wise multiple regression analysis (11) applied to the aggregate data of observed myocardial lesions in rats and dietary fatty acids showed the following: differences between experiments accounts for 29.3% of the variation, 16:0 for 40.1%, 18:3 for 5.8%, and the remaining dietary fatty acids for 1.4%, for a total of 76.6%. The fact that the first step-wise multiple regression failed to reflect a relationship between incidence of heart lesions and 18:0 can be attributed to the high correlation (r = 0.75) between 16:0 and 18:0.

A plot (Figure 1) of observed incidence of heart lesions in male rats vs. incidence of heart lesions predicted by the regression equation incorporating levels from all dietary fatty acids shows a remarkably linear relationship. The relationship holds satisfactorily over the entire range, the results of all three laboratories show a similar distribution around the regression line, and lastly, Brassica oils, non-Brassica oils and mixtures thereof form a continuum of points about the regression line. These results clearly show that myocardial lesions in male albino rats are closely associated with dietary levels of saturates, to a lesser extent with 18:3 and not at all to 22:1.

It is concluded that the assay, incidence of heart lesions in albino male rats, used to test the oils is really a measure of the saturated fatty acid imbalance and not the toxicity of oil contaminants.

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Table 4. Myocardial lesions in male albino (Sprague-Dawley) and hooded (Chester Beatty) rats fed experimental diets for 16 weeks (11).

Diet	Corn oil	Zephyr RSO	RSO (23% 22:1)
Strain	Heart lesions: Affected/Examined		
Sprague-Dawley	8/24	20/24	24/24
Chester Beatty	4/24	6/24	4/23

Table 5. Myocardial lesions in Sprague-Dawley male rats fed diets which contained soybean oil, Tower RSO or its fractions for 16 weeks (11).

Diets	% 22:1	Brassicasterol (µg/g of oil)	Incidence
Soybean	0	(1000)[a]	12/26
Soybean-MD7	0	(100)	13/26
Tower RSO	0.2	520.2	22/26
Tower RSO-MD7	0.2	17.2	18/26
Tower RSO-AC (1)	0.2	1.0	11/26
Tower RSO-AC (2)	0.2	9.0	20/26

[a] Number in brackets refer to total sterol content.

Figure 1. Myocardial lesions incidence observed vs. lesion incidence predicted by the regression equation obtained from the step-wise multiple regression analysis of aggregate data pooled from Agriculture Canada (■), Health and Welfare Canada (Δ) and Unilever Research, Vlaardingen (o).