

EFFECTS OF HARDENED PALM OIL ON RAPESEED OIL-INDUCED
CHANGES IN DUCKLINGS AND GUINEA PIGS

By R.O. Vles and A.M. Abdellatif,
Unilever Research,
Vlaardingen, The Netherlands.

INTRODUCTION

This paper deals with the effects of dietary hardened palm oil on the pathology of ducklings and guinea pigs, fed rapeseed oil. As reported earlier^{1,2}, growth retardation, histopathological changes in the myocardium, liver and spleen and hematological anomalies have been observed in ducklings and guinea pigs fed rapeseed oil. In these experiments, the animals were fed different dietary levels of European rapeseed oil, which contained about 45% erucic acid.

CHANGES INDUCED BY FEEDING RAPESEED OIL

IN DUCKLINGS

The nature and the frequency of the changes observed in groups of ducklings fed increasing amounts of rapeseed oil are presented in Table I.

TABLE I

FREQUENCY OF HISTOPATHOLOGICAL CHANGES IN GROUPS OF 9
DUCKLINGS FED INCREASING AMOUNTS OF RAPESEED OIL FOR 3 WEEKS

C h a n g e s	CAL% RAPESEED OIL		
	30	35	40*
<u>Heart</u>			
Hydropericardium	1	6	8
Vacuolation of myocardium	1	5	8
<u>Skeletal Muscles</u>			
Vacuolation	2	6	9
<u>Liver</u>			
Degenerative/Regenerative Changes	2	2	7

* - Seven animals died during the experiment.

Table I shows that feeding 30 cal% rapeseed oil (RSO) or more induces considerable changes in the heart, skeletal muscles and liver. Lower percentages (10, 20 and 25 cal% respectively) caused no changes. Figures I, II and III illustrate the major pathological findings. On autopsy (Fig. I), the pericardial sac is distended with transudate. The heart itself is pale. The skeletal muscles are also very pale and the liver is cirrhotic. Fig. II is a photomicrograph of the heart muscle showing the main lesion-vacuolation or fatty deposition. The vacuoles in this section of the heart are fat droplets, which were washed out when the section was processed. Examination of frozen sections of the same tissue confirmed the lipid nature of these vacuoles. Skeletal muscles are also fat-infiltrated as is shown in Fig. III: note the Sudan-stained fat droplets in the frozen section of a striated muscle.



FIGURE I
HYDROPERICARDIUM IN A DUCKLING, FED RSO

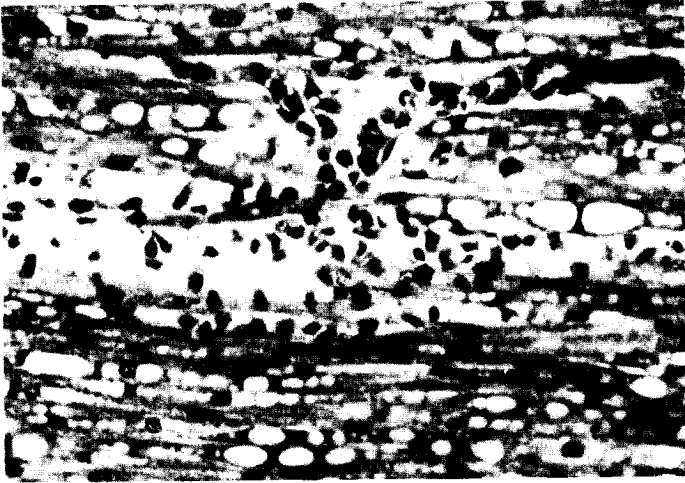


FIGURE II

VACUOLATION IN THE MYOCARDIUM OF DUCKLINGS, FED RSO



FIGURE III

FATTY DEPOSITION IN SKELETAL MUSCLE OF DUCKLINGS,
FED RSO

IN GUINEA PIGS

The gross changes in guinea pigs observed after feeding increasing amounts (0, 12.5, 25 and 50 cal%) of RSO for 6 weeks are given in Table II.

TABLE II

NATURE OF POST MORTEM-FINDINGS AND THEIR FREQUENCY IN GROUPS OF 9 GUINEA PIGS FED INCREASING AMOUNTS OF RSO FOR 6 WEEKS

C r i t e r i o n	CAL% RAPESEED OIL	
	25	50 ^a
Slight jaundice	-	5
Hypertrophic spleen	9	9
Hydropericardium-pale myocardium	4	9

^a - Two animals died during the experiment.

Changes in spleen and heart are the main findings: the minimum effective dose is 25 cal% RSO. The most peculiar autopsy finding is splenomegaly (Fig. IV).



FIGURE IV

ENLARGEMENT OF THE SPLEEN OF GUINEA PIGS BY FEEDING RSO

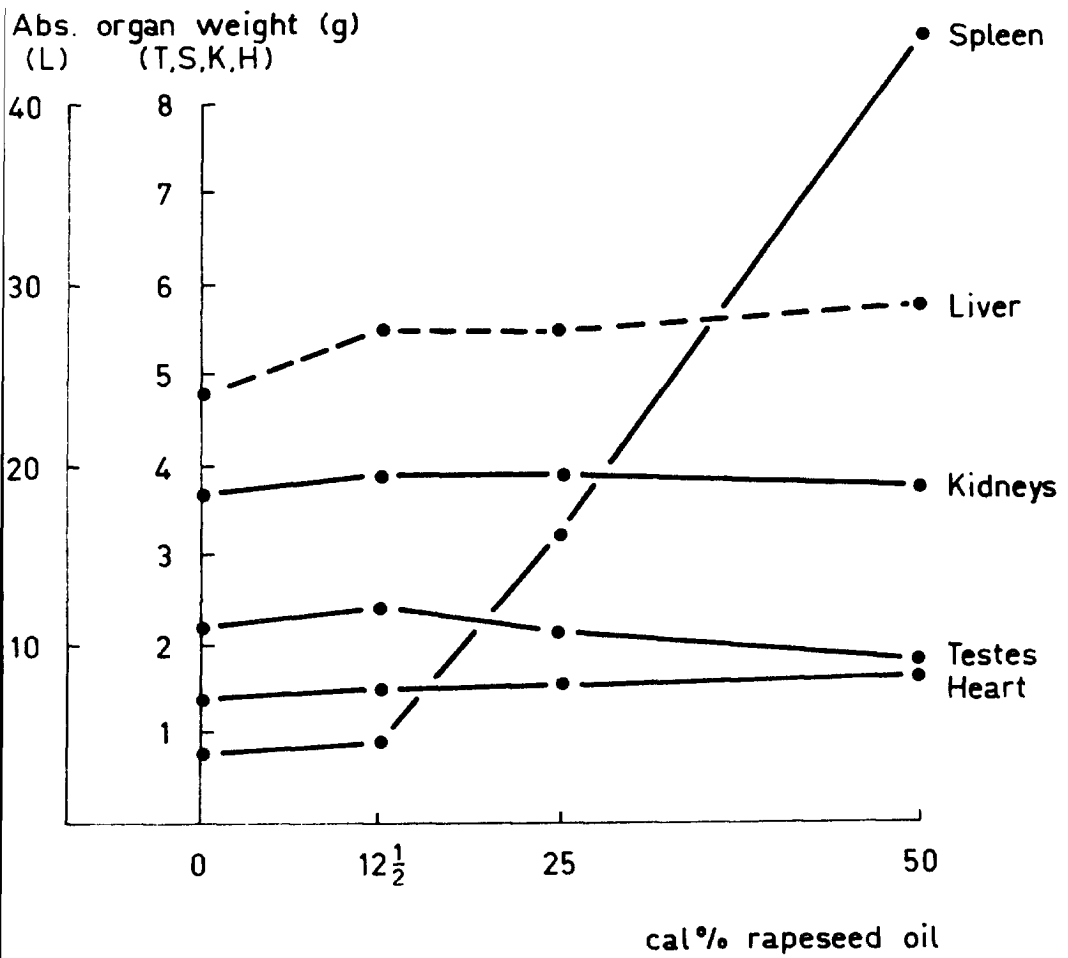


FIGURE V

INFLUENCE OF THE PERCENTAGE OF RSO IN THE DIET ON
THE ORGAN WEIGHTS OF GUINEA PIGS

In Fig. V the organ weight is plotted versus cal% RSO in the diet. There is a considerable increase in spleen weight with increasing percentage of RSO in the diet. This enlargement of the spleen reflects the increased destruction and increased production of red blood cells (erythropoiesis).

The liver of RSO-fed guinea pigs also shows foci of erythropoiesis. Fig. VI shows the foci of normoblasts, erythroblasts and reticulocytes, and deposits of hemosiderin pigment due to the increased destruction of erythrocytes.

The hematological data are presented in Fig. VII. Increasing the level of RSO in the diet induces a considerable increase in the number of immature red blood cells (reticulocytes) and a decrease of hemoglobin content F(Hb), packed cell volume (PCV) and red blood cell count (RBC).

From these histopathological and hematological findings it can be concluded that RSO induces hemolytic anemia in guinea pigs.

EFFECTS OF HARDENED PALM OIL

In 1963, Beare et al.³ demonstrated that supplementation of RSO by palm oil (rich in palmitic acid) improves the nutritional qualities of RSO. Therefore, the effect of hardened palm oil - containing 56% palmitic acid - on the pathogenicity of RSO has been investigated in ducklings and guinea pigs; this was achieved by feeding isocaloric fat mixtures containing equal amounts of erucic acid but increasing levels of palmitic acid; the erucic acid was supplied either by rapeseed oil or by glyceryl trierucate.

IN DUCKLINGS

The diet for ducklings contained 23 cal% casein, 60 cal% fat mixture, 17 cal% corn starch, vitamins, minerals and pebbles. The caloric percentages of erucic and palmitic acid are given in Table III.

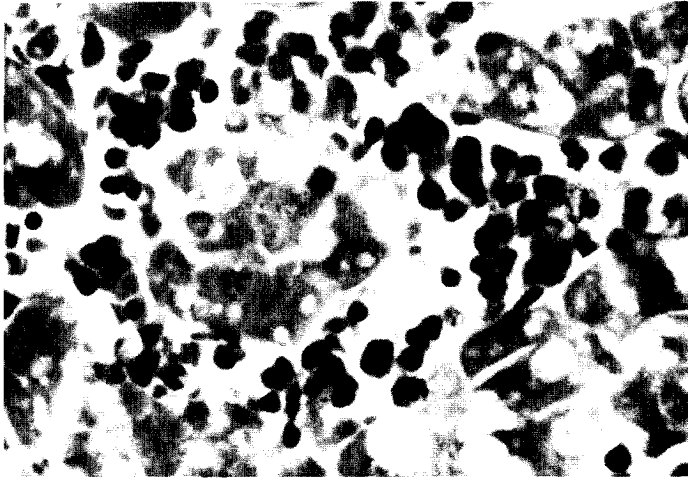


FIGURE VI

SECTION OF LIVER IN A RSO-FED GUINEA PIG

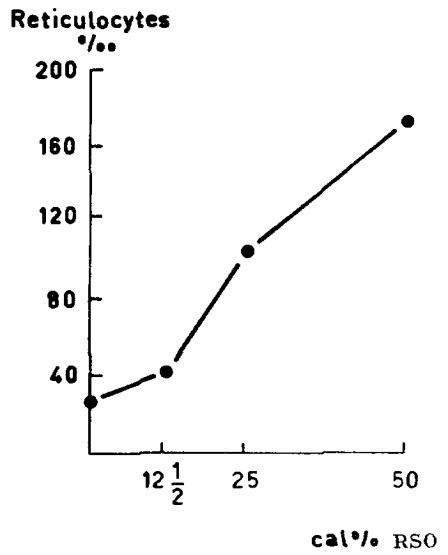
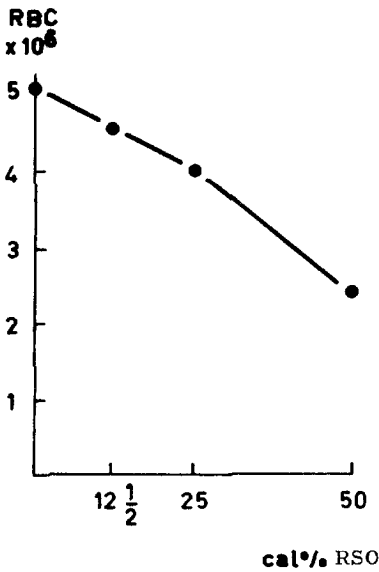
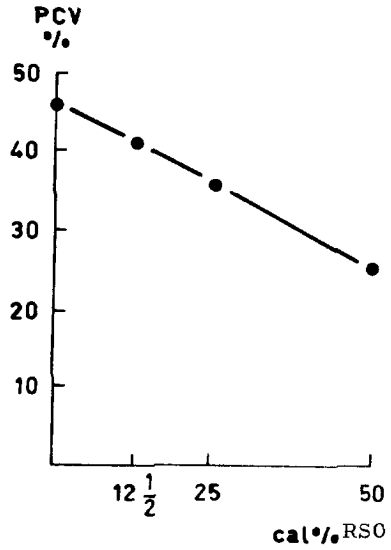
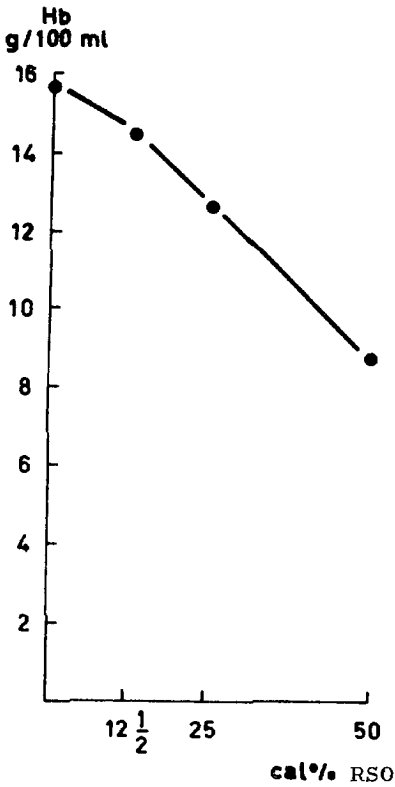


FIGURE VII

INFLUENCE OF THE PERCENTAGE OF RSO ON BLOOD VALUES OF GUINEA PIGS

TABLE III

CALORIC PERCENTAGE OF ERUCIC AND PALMITIC ACID
IN THE DIET OF DUCKLINGS

C 22:1	C 16:0
-	22.2
17.6*	3.6
17.6	4.4
17.6	8.8
17.6*	11.1
17.6	13.2
17.6	17.6

* - Supplied by rapeseed oil, otherwise by glyceryl trierucate.

The total dietary fat was made isocaloric for the different groups by adding soyabean oil up to 60 cal%. This experiment lasted 3 weeks.

The effects of increasing the palmitic acid content of the diet on growth and mortality are shown in Table IV

TABLE IV

EFFECTS OF HARDENED PALM OIL ON GROWTH AND MORTALITY
OF 10 DUCKLINGS FED ERUCIC ACID

CAL% IN DIET		Growth (g) After 3 Weeks	Mortality
C 22:1	C 16:0		
-	22.2	633	1
17.6	3.6	473	5
	4.4	485	0
	8.8	580	0
	11.1	595	0
	13.2	620	1
	17.6	655	0

Hardened palm oil decreases the mortality and improves the growth: the improvement in growth is clearly demonstrated in Fig. VIII. A linear relationship was found between the ratio palmitic/erucic acid in the diet and the gain in body weight.

Table V shows the effects of hardened palm oil on the pathology of ducklings fed erucic acid.

TABLE V

EFFECTS OF HARDENED PALM OIL (C 16:0) ON THE PATHOLOGY OF 10 DUCKLINGS FED ERUCIC ACID

CAL% IN DIET		INCIDENCE OF		VACUOLATION SCORE (0-4)	
C 22:1	C 16:0	Hydro-Pericardium	Liver Cirrhosis	Myocardium	Skeletal Muscle
-	22.2	0	0	0	0
17.6	3.6	5	10	2.1	3
	4.4	6	9	1.8	2.3
	8.8	0	7	2.0	2.4
	11.1	2	3	2.7	3.1
	13.2	3	6	2.4	3.0
	17.6	2	2	2.8	2.5

Increasing the palmitic acid content of the diet decreased the incidence and severity of hydropericardium and liver cirrhosis but increased the severity of fatty accumulation in the heart muscle. The optimal effect of palmitic acid was achieved when the ducklings were given a high protein diet (Table VI).

IN GUINEA PIGS

In guinea pigs, the effect of hardened palm oil on the pathogenicity of RSO was studied using a diet consisting of 23 cal% casein, 50 cal% fat mixture, 27 cal% corn starch, vitamins and minerals. The composition of the fat mixture is given in Table VII. The results of this 8 weeks' feeding experiment are detailed in Tables VIII and IX.

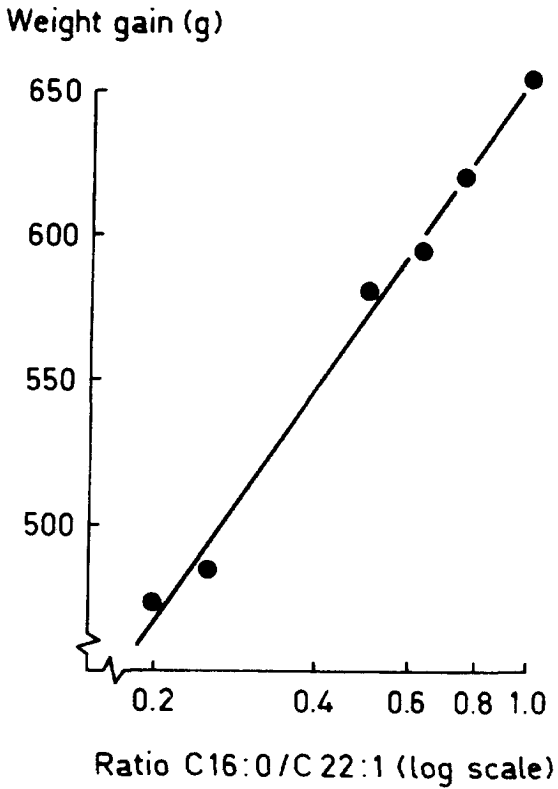


FIGURE VIII

RELATIONSHIP BETWEEN THE RATIO PALMITIC/ERUCIC
ACID IN THE DIET AND THE BODY WEIGHT GAIN OF DUCKLINGS

TABLE VI

EFFECTS OF PROTEIN AND HARDENED PALM OIL ON THE
PATHOLOGY OF 10 DUCKLINGS FED RAPESEED OIL

37 CAL% RAPESEED OIL +		VACUOLATION SCORE (0-4)		LIVER
23 Cal%	Cal% Casein	Myo Cardium	Skeletal Muscle	Cirrhosis Score (0-4)
Soyabean Oil	23	2.1	3.0	1.8
	32	1.2	2.1	1.0
Hardened Palm Oil	23	3.3	2.4	0
	32	1.2	1.8	0

TABLE VII

COMPOSITION OF DIETARY FATS (% OF TOTAL CALORIES)
FOR GUINEA PIGS

DIETARY FAT			FATTY ACID	
Rapeseed Oil	Hardened Palm Oil	Sunflower- Seed Oil	C 22:1	C 16:0
-	25	25	-	16
25	-	25	11	3
25	15	10	11	10
25	25	-	11	15

TABLE VIII

SEVERITY (SCORE 0-4) OF HISTOPATHOLOGICAL CHANGES
IN 9-10 GUINEA PIGS FED ERUCIC ACID

CAL% IN DIET		LIVER		SPLEEN
C 22:1	C 16:0	Fatty Infiltration	Hemo-siderin	Hemo-siderin
-	16	0.1	0.2	1.9
11	3	1.6	1.7	2.8
11	10	1.6	0.9	2.7
11	15	0.9	0.4	2.3

TABLE IX

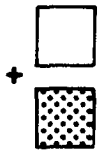
HEMATOLOGICAL FINDINGS IN 9-10 GUINEA PIGS
FED ERUCIC ACID

CAL% IN DIET		Hemo-globin (g/100 ml)	Packed Cell Volume (%)	Mean Cor-puscular Hemoglobin (%)	Reticulocyte Count After 4 Exp. Weeks ($\circ/\circ\circ$)
C 22:1	C 16:0				
-	16	15.0	34	44	19
11	3	12.8	31	42	52
11	10	13.9	34	41	35
11	15	14.5	34	43	24

Higher amounts of hardened palm oil in the RSO diet improved the spleen and liver morphology of guinea pigs as well as the values for hemoglobin content, packed cell volume and reticulocyte count.

The non-electrolyte hemolysis test showed that the erythrocytes of RSO-fed guinea pigs display an increased permeability; this change in permeability was also corrected by hardened palm oil. Moreover, the increase in permeability of the red blood cell in guinea pigs fed RSO may be due to the changes in the fatty acid composition of the erythrocyte membrane (Fig. IX). Feeding RSO, induces a considerable increase in the erucic and nervonic acid contents of the erythrocyte membrane. This fatty acid composition of the red blood cell membrane is possibly responsible for its hemolytic tendencies.

DIET: 25 cal % sun-flowerseed oil



25 cal % hardened palm oil
25 cal % RAPESEED OIL

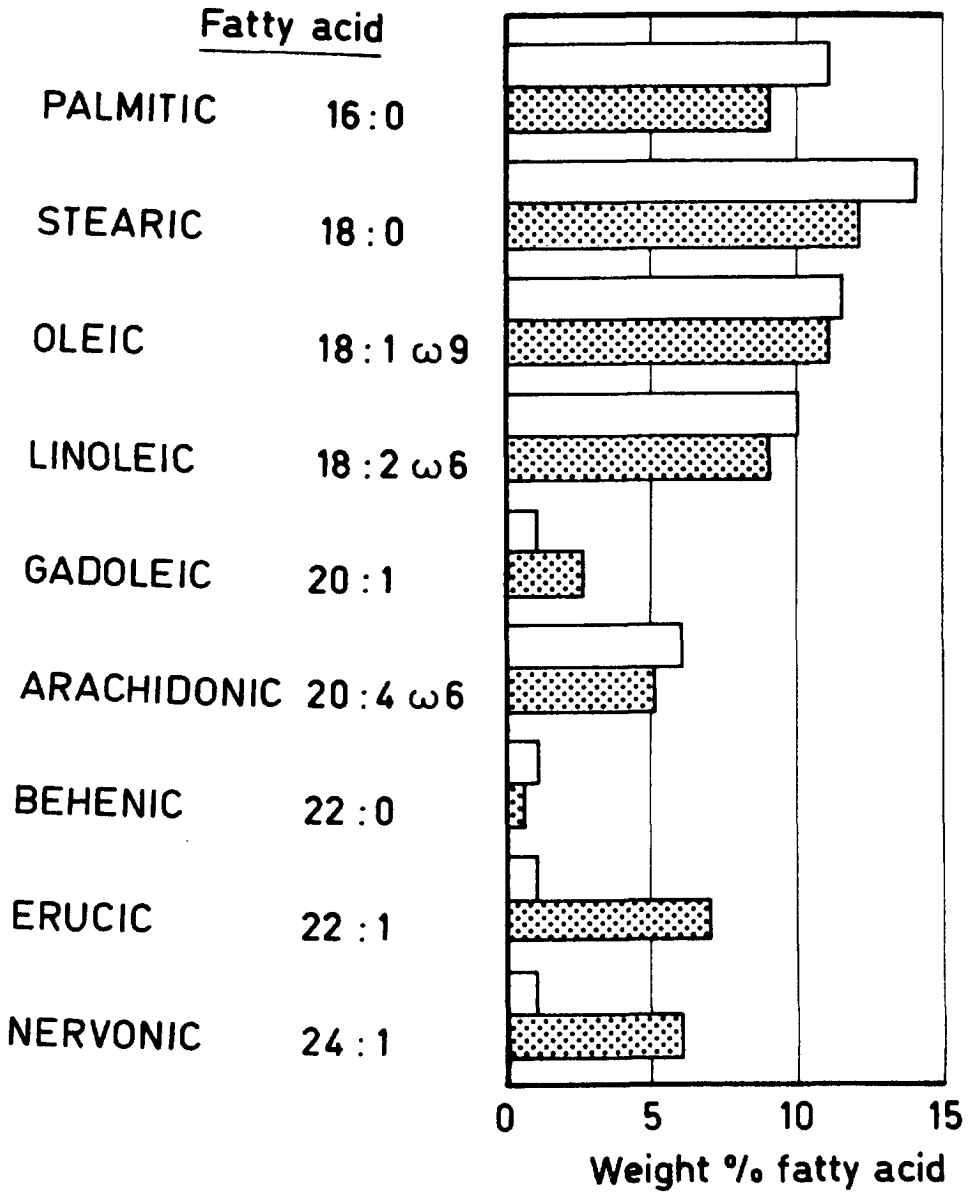


FIGURE IX

EFFECTS OF RSO FEEDING ON THE FATTY ACID COMPOSITION OF THE ERYTHROCYTE MEMBRANE OF GUINEA PIGS

ACKNOWLEDGEMENT

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SUMMARY

The influence of hardened palm oil on the effect of rapeseed oil (RSO) in guinea pigs and ducklings has been studied by feeding them isocaloric fat mixtures containing constant amounts of erucic acid and varying levels of palmitic acid.

In ducklings, the palmitic acid-rich diet did not correct all the effects of RSO; it improved growth, decreased the hydropericardium, splenic and liver changes but did not improve the changes in heart and skeletal muscles.

In guinea pigs, an increase in the amounts of hardened palm oil in the RSO diet resulted in an improvement of spleen and liver morphology and also improved the values for hemoglobin content, packed cell volume and non-electrolyte hemolysis.