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COMPARISON OF THE PERFORMANCE AND HISTOLOGICAL CHANGES IN THE TISSUES OF PIGS FED DIETS CONTAINING HIGH OR LOW ERUCIC ACID RAPESEED OILS OR SOYBEAN OIL

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The nutritive value of rapeseed oil has been studied with ten animal species but the majority of the experiments have been with rats (AAES-JORGENSEN, 1972; ROCQUELIN et al., 1973). In many of these experiments the use of rapeseed oil in rat diets had a growth depressing and appetite reducing effect.

AAES-JORGENSEN (1972) cited the results of ROINE and UKSILA (1958) in which young rats given free choice access to diets consumed slightly more of a diet with rapeseed oil than soybean oil at the 10 percent level, whereas at the 20 percent oil level the animals showed a distinct preference for the soybean oil diet. BEARE et al. (1959) reported reduced food consumption and weight gain by rats pair-fed or ad libitum-fed diets containing 20 percent rapeseed oil diets compared with diets containing an equal level of corn oil. The reduced food consumption and weight gain on the rapeseed oil diet were ascribed to an apparent depressed appetite early in the feeding period followed by an adaption to the oil during the experiment.

Relatively few experiments have used pigs as the experimental animal in determining the nutritive value and histopathological effects of dietary rapeseed oils. AAES-JORGENSEN (1972) cited the work of PALOHEIMO et al. (1959) in which these authors observed no significant difference in performance of young pigs fed restricted levels of diets containing either 10 percent soybean oil or rapeseed oil. However, when the pigs were fed ad libitum the animals fed the soybean oil diet showed a better appetite and faster growth than those fed the rapeseed oil diet.

A significant growth depression was observed by CRAMPTON et al. (1960), with pigs fed 20 percent rapeseed oil as compared with those fed the same level of butterfat. These authors concluded that swine were not able to utilize dietary rapeseed efficiently, the coefficient of digestibility being 78 percent, as compared with 95 percent for butterfat. These results are in contrast to the 100 percent digestibility coefficient reported for rapeseed oil by PALOHEIMO and JAHKOLA (1959).

ROINE et al. (1960) reported that pigs fed diets containing 28 cal percent of rapeseed oil or soybean oil showed histological evidence of thyroid hyperfunction, interstitial myocarditis and inflammatory reaction in the gastric mucosa. BEARE et al. (1972) also observed myocardial fat droplets in miniature and commercial piglets fed 20 % rapeseed oil in their diets.

ROCQUELIN et al. (1973) reviewed the results of two recent experiments in which accumulation of neutral lipids and abnormalities in size and number of mitochondria and necrosis in the myocardial cells have been observed in pigs fed 13 % rapeseed oil in their diets for period of 20 to 180 days.

There are, however, very few experiments with pigs in which the long term effects of feeding rapeseed oils of varying erucic acid content on tissue histopathology have been evaluated. The objectives of this experiment were to study long term effects of feeding high or low erucic acid rapeseed oils on feed intake, pig performance, energy (DE) and nitrogen (DN) digestibility and histopathological condition of different tissues and organs.

Materials and methods

Three experiments were conducted to compare high (RSO) or low (Span) erucic rapeseed oils with soybean oil (SBO) when the oils were fed at a level of 15 percent of the diet for pigs from 26 to 90 kg liveweight. The regular rapeseed oil (RSO) contained 20.6 percent erucic acid and the Span rapeseed oil, originating from Brassica campestris cultivar Span, contained 4.0 percent erucic acid. A fourth diet containing no supplemental oil served as a control diet in experiments 1 and 3. Water was allowed ad libitum in all experiments.

In experiment 1, 48 crossbred pigs of an average initial weight of 25 kg liveweight were allotted to the four dietary treatments (Table 1) on the basis of sex and initial weight. The pigs were fed ad libitum and penned in groups of three pigs per pen, replicated four times.

In experiment 2, 48 crossbred pigs were allotted to the three oil diets used in experiment 1. In this experiment the pigs were assigned to treatments on the basis of sex and the experiment began when the pigs reached 25 kg liveweight. These pigs were penned individually and fed at a level of approximately 80 percent of the caloric intake of the pigs in experiment 1.

In experiment 3, 16 crossbred pigs were allotted to 4 groups of 4 pigs. The groups were balanced for sex and started test at an average liveweight of 25 kg. Each group of pigs was allowed continuous free-choice access to each of the 4 diets used in experiment 1.

Digestibility of the rations was determined in all three experiments using the 4 N-HCl method described by McCARTHY et al. (1974). In experiments 1 and 3, fecal samples were collected from each pig on four consecutive days when the pigs weighted approximately 85 kg liveweight. For the individually-fed pigs in experiment 2 fecal samples were collected from 4 pigs (2 male, 2 female) per treatment when the pigs weighed approximately 38 kg liveweight. For the pigs in experiment 3 the feed sample selected for chemical analysis was a composite of all 4 diets, mixed in the same ratio as the pigs had eaten these diets during the digestibility trial.

Table 1: Formulation and chemical composition of diets

Ingredients (%)	RSO	SPAN	SBO	Control
Cereal grains	61.0	61.0	61.0	83.1
Protein supplement	22.5	22.5	22.5	14.0
Oil	15.0	15.0	15.0	--
Vitamin-mineral premix	1.5	1.5	1.5	2.9
Chemical composition (%)				
Dry matter	89.4	89.4	89.3	87.1
Crude protein	18.4	18.3	18.3	15.8
Gross energy (kcal/kg)	4757	4730	4685	3719
Ether extract	16.5	16.5	16.5	2.9
Fatty acids:				
C16:0	7.2	6.6	13.5	--
C18:1	47.1	64.9	28.3	--
C18:2	19.3	17.5	51.3	--
C20:1	5.5	1.7	0.2	--
C22:1	14.0	3.0	--	--

Pigs from experiment 2 were slaughtered at 46, 69 and 90 kg liveweight. Pigs from experiments 1 and 3 were slaughtered at 92 kg liveweight. Four pigs were slaughtered at 25 kg before the experiments commenced. The following organs were collected and fixed in 10 % buffered formalin from each pig at each of the different slaughter weights: Thyroid, heart, liver, spleen, kidneys and adrenals. Samples of muscle from the L. dorsi and S. membranosis, blood samples and fat samples from the back and belly were also collected. Histopathological examinations were conducted on samples of heart, liver, spleen and kidney.

Tissues were embedded in paraffin, sectioned at 6 microns and stained routinely with hematoxin and eosin stain. Selected tissues were fixed in formalin, sectioned with the cryostat and stained with oil red 0.

Results

Two of the one-hundred and two pigs started on test died during the course of the experiment. The cause of death in each case was not related to the treatments used.

The results of experiment 1 are presented in Table 2. There was no significant difference in average daily gain on any of the four treatments. As would be expected because of the lower caloric density of the control diet, average daily feed intake and feed to gain ratio were significantly ($P < 0.01$) greater for pigs fed this diet. There were no significant differences in ave-

Table 2: The performance of pigs fed ad libitum on diets containing high or low erucic acid rapeseed oils, soybean oil or no added oil - Experiment 1

Treatment	RSO	SPAN	SBO	Control
No. days on experiment	86.8	86.6	85.5	86.9
Av. daily feed intake (kg)	2.01[a]	2.13[a]	2.06[a]	2.74[b] **
Av. daily gain (kg)	0.78	0.78	0.79	0.80
Feed: gain ratio	2.61[a]	2.75[a]	2.62[a]	3.22[b] **
GE Mcal/kg gain	12.39	12.82	12.33	12.10
DE Mcal/kg gain	9.58	9.57	9.62	9.14

[1] There were 3 pigs per pen
** Significant treatment difference ($P < 0.01$)
a, b Means with same letter or no letter were no significantly different ($P < 0.05$)

rage daily feed intake or feed to gain ratio between any of the oil diets. The total feed intake of pigs fed the oil based diets was 75 percent of the intake of the pigs fed the control diet. The gross energy and digestible energy required to produce a kilogram of liveweight gain were not significantly different for the four treatments.

The performance data of pigs from experiment 2 are presented in Table 3.

Table 3: The performance of pigs fed to scale on diets containing high or low erucic acid rapeseed oils or soybean oil - Experiment 2

Treatment	Slaughter Weight	RSO	SPAN	SBO
Av. daily feed intake (kg)	46 kg	1.17	1.18	1.16
	71 kg	1.44	1.45	1.40
	90 kg	1.69	1.62	1.66
Av. daily gain (kg)	46 kg	0.45	0.45	0.46
	71 kg	0.58	0.59	0.56
	90 kg	0.57	0.58	0.58
Feed: gain ratio	46 kg	2.64	2.61	2.52
	71 kg	2.48	2.46	2.48
	90 kg	2.97	2.84	2.85
No. days on experiment	46 kg	52.9	49.0	48.9
	71 kg	81.1	79.3	85.0
	90 kg	119.1	115.1	114.0

The feed intake of the pigs fed the oil based diets in this experiment was 80 percent of that observed with the ad libitum fed pigs in experiment 1. There were no significant differences between the treatments in either average daily gain, feed to gain ratio, number of days on experiment of total feed intake. As a result of the lower feed intake the pigs achieved an average daily gain of 73 percent of that of the ad libitum fed pigs, and took 30 days longer to reach 90 kg liveweight.

The performance of pigs in experiment 3 given continuous free-choice access to all four diets was similar to that of pigs fed ad libitum in experiment one. From 25 to 46 kg liveweight there was no significant difference in the amounts of each of the 4 diets selected by the pigs (Table 4). However, during the period 46 to 90 kg liveweight the pigs selected significantly ($P < 0.01$) less of the RSO diet. There was no significant difference in the feed consumption of any of the other three diets. For the whole period (25 to 90 kg) intake of the RSO diet was significantly lower than that of the other three diets, and intake of the Span diet was significantly ($P < 0.05$) greater than that of the SBO diet.

Table 4: The feed intake of pigs given continuous free-choice access to diets containing high or low erucic acid rapeseed oils, soybean oil or no added oil - Experiment 3

Treatment	RSO	SPAN	SBO	Control
Total feed intake/pen (kg)[1]				
26 to 46 kg	66.7_{b}	77.1_{a}	70.3_{a}	73.5_{a} **
46 to 90 kg	44.9_{c}	214.1_{a}	123.8_{b}	157.4_{ab} **
Total	111.5_{c}	291.2_{a}	194.1_{b}	230.9_{ab} **

[1] There were 4 pigs per pen

** Significant treatment different ($P < 0.01$)

a, b, c Means with same letter or no letter were not significantly different ($P < 0.05$)

The digestibility coefficients obtained on all three experiments are presented in Table 5. There were no significant differences in the DE or DN coefficients for any of the four diets fed in experiment 1. The percentage digestible lipids was significantly ($P < 0.01$) lower for the control diet than for any of the oil-based diets. There was no significant ($P < 0.05$) difference in the percentage digestible lipids for the soybean oil or rapeseed oil diets. The digestibility coefficients for DE, DN and digestible lipids obtained in experiment 3 for the composite diet selected by the pigs were similar to those obtained for the diets containing oil in experiment 1.

In experiment 2, DE and DN were significantly ($P < 0.05$) lower for the SBO diet than for either of the rapeseed oil diets. The percentage digestible lipids of the Span oil diet was significantly ($P < 0.05$) higher than for either of the other two diets.

Table 5: Digestibility coefficients of diets containing high or low erucic acid rapeseed oils, soybean oil or no added oil

Treatment	RSO	SPAN	SBO	Control
	Ad libitum intake (Expt. 1)			
Digestible energy %	77.1	74.7	78.0	75.5
Digestible nitrogen %	78.5	74.9	77.7	77.8
Digestible lipids %	77.7[a]	76.5[a]	80.8[a]	52.2[b] **
	Restricted intake (Expt. 2)			
Digestible energy %	82.8[a]	83.7[a]	76.7[b]	-- **
Digestible nitrogen %	83.8[a]	83.1[a]	78.7[b]	-- *
Digestible lipids %	79.4[a]	85.4[b]	74.7[a]	-- **
	Self-selection (composite of all 4 diets) (Expt. 3)			
Digestible energy %	78.0			
Digestible nitrogen %	78.0			
Digestible lipids %	77.3			

* Treatment effect significant ($P < 0.05$)
** Treatment effect significant ($P < 0.01$)
a, b Means with same letter or no letter were no significantly different ($P < 0.05$)

Sections of liver taken from pigs on all three feeding programs revealed lesions due to migration of Ascaris suum larvae in 57 percent of the livers examined.

Focal areas of interstitial myocarditis with eosinophils, lymphocytes and a few plasma cells were present in 35.8 % of hearts examined from all pigs. Foci of muscle fiber degeneration were present in six pigs. Three of these pigs were in the restricted feeding trial with two occurring in the group fed SPAN oil and one in the group fed soybean oil. Three pigs were affected in the ad lib feeding trial - one from the control and two from the soybean oil group.

Vacuoles appeared to be present in cardiac muscle fibers in varying degrees from one heart section to the next. Special staining for fat did not reveal these vacuoles to contain fat. In many of the hearts with increase vacuoles, the capillaries were noted to be dilated. These capillaries in many instances run parallel to fibers and into fibers. It is thought that the vacuoles present in these pigs were actually dilated capillaries. Therefore, no significant changes were discovered in the muscle, liver or spleen of pigs fed on the various diets in this experiment.

Summary

Ascaris suum larvae are known to migrate through other tissues besides liver and lung and it is recorded that they can cause lesions in kidney and in heart.

It is cautioned that further research into this subject must carefully consider the problems that Ascaris suum migration may bring to interpretation of liver and heart lesions.

The incorporation of high or low erucic acid rapeseed oil in the diets of pigs at a level of 15 % did not reduce pig performance when such diets were fed from 25 to 90 kg either ad libitum or at a restricted level. When not given a choice of feed, pigs selected as much of a rapeseed oil diet as they did of a Span, soybean oil or control diet. When given a choice of feed, pigs acquired a dislike for the RSO diet and consequently selected more of a Span soybean oil or control diet. The DE and DN coefficients obtained for rapeseed oil diets were similar or better than those obtained for a soybean oil or control diet.

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