EFFECT OF FAT LEVEL AND FIBER NATURE ON PERFORMANCES, DIGESTIBILITY, NITROGEN BALANCE AND DIGESTIVE ORGANS IN GROWING RABBITS

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Abstract - Six feeds were formulated with similar CP and NDF contents, wheat bran and pea hulls as main NSP sources and with 0, 4 or 8% tallow. They were given to 6x10 New Zealand White rabbits, in individual cages, about 5 weeks old, during 5 weeks. The feed intake and live weight were recorded. During the last week the faeces and the urine were collected to apparent digestibility and nitrogen balance determinations. In the end the rabbits were killed and their digestive organs were weighted. Daily growth and feed/gain is better in wheat bran than in pea hull diet. Increasing dietary fat reduced daily intake, the daily gain, FCR; which were worse on the pea hull diets. Pea hull diets has a lower DM, OM, energy (5 point), CP (6 point) and EE (10 point) digestibility than wheat bran diet. The fiber nature did not affected cell wall fractions digestibility, except NDF. The addition of fat reduced DM, OM and energy digestibilities but increased the digestibilities of NDF, ADF, hemicellulose and cellulose. The digestibilities of fat and CP were not affected by fat level. Wheat bran diets have 10 point higher CRN and CUP than pea hull diets. These results were improved by the fat additions. The tallow increased about 50% the relative weight of the caecum. Our results show that adding fat to high-energy feeds reduced the apparent digestibilities of DM, OM and energy. The reductions varied with the fiber nature and energy level of the diet. Fat digestibility was not affected by fat addition, was affected by the composition of the basal feed to which it was added. Digestibilities of cellulose and hemicellulose were independent of fiber nature and improved with fat addition.

INTRODUCTION

The addition of fats to the feeds of growing rabbits makes it possible to increase their energy level without compromising on their maximum starch and minimum fiber levels (MAERTENS, 1992).
Growing rabbits digest fats efficiently. A synergistic effect from fats has been described, with fats of animal or vegetable origin increasing the digestibility of other components of the diet (MAERTENS *et al.*, 1986; FEKETE *et al.*, 1990). According to FEKETE *et al.* (1990) fat addition only improves the digestibility of carbohydrates (CF and NFE) in low-energy feeds.
Fiber nature has an effect on several aspects of digestion, and consequently can affect the digestibility of other fractions of the diet of rabbits (BELTRAN *et al.*, 1984; FALCÃO e CUNHA, 1988). An effect of fiber nature on fat utilisation has been described in several species as in the pigs (KNUDSEN *et al.*, 1993).
The present work was designed to study the effect of fat addition to growing rabbits feeds containing different cell wall carbohydrates on growth performances, digestibility, nitrogen balance and size and weight of digestive organs.

MATERIALS AND METHODS

Six feeds were formulated to contain similar CP and NDF contents. Wheat bran and pea hulls were the main non-starch polysaccharides (NSP) sources used. Fat addition was tested by adding 0, 4 or 8% tallow to the feeds.
These experimental feeds were given *ad libitum* to 6 groups of 10 young New Zealand White rabbits of about 5 weeks age. Groups were as much as possible balanced for live weight and litter origin. Animals were housed in individual cages, and given a 3-day adaptation period to the experiment. Feed intake (daily) and live weight (weekly) were then recorded during a 5-week period. During the fifth week faeces were also collected (daily) to allow for apparent digestibility and nitrogen balance determinations.
In the end of the trial the rabbits were killed and their digestive organs were weighted, both with and without their contents.

DM of feeds was determined by 24 h heating at 103° C, OM by ashing at 550° C overnight. N was determined by the Kjeldahl method, and CP calculated as 6,25 N. CF was determined by the standard Weende method and NDF, ADF and ADL according to ROBERTSON and VAN SOEST (1981). Hemicellulose was calculated as NDF-ADF, cellulose as ADF-ADL. EE of feeds and faeces were determined in a Soxlet extractor (Tecator Soxtec System – extraction unit), after acid hydrolysis pre-treatment (Tecator Soxtec System – hydrolysing unit). Energies of feeds and faeces were determined in an isoperibol bomb calorimeter (Parr model 1261).

The statistical model used to compare growth performances and digestibilities included fiber nature, fat level and their interaction, analysed in a 2 x 3 factorial design. Analysis of covariance was used to compare the nitrogen balances of the growing rabbits, with nitrogen intake (g/day) as the independent covariate. Contrast statements were used to test differences between diets, and fat effects were partitioned into linear and non-linear components by using orthogonal polynomial coefficients. All statistical analyses were performed using the GLM procedure of SAS (1989).

Table 1 : Centesimal and chemical composition of the experimental diets

	wheat bran			pea hull		
	0%	4%	8%	0%	4%	8%
Centesimal Composition (%)						
Maize	24	12	0	24	12	0
Soybean meal	12	13	14	11	12	13
Wheat straw	6	7	8	6.5	7.5	8.5
Alfafa	6	7	8	6.5	7.5	8.5
Wheat bran	50	52	54	---	---	---
Pea hull	---	---	---	50	52	54
Tallow	---	4	8	--	4	8
Bentonite	---	3	6	---	3	6
Calcium carbonate	0.7	0.7	0.7	0.7	0.7	0.7
Dibasic calcium phosphate	0.6	0.6	0.6	0.6	0.6	0.6
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Trace minerals/vitamins (1)	0.2	0.2	0.2	0.2	0.2	0.2
Chemical Composition (p. 100 DM)						
Dry matter	89.8	90.2	90.1	90.8	90.0	90.5
Ash	7.5	7.8	9.0	10.0	10.0	13.5
Crude Protein	17.8	18.0	18.4	18.2	18.1	20.2
Ether Extract	4.6	8.3	11.3	3.9	6.6	10.6
Crude Fibre	10.2	10.9	11.8	15.9	16.9	16.0
Neutral detergent fibre	35.7	38.4	39.8	37.1	36.9	38.6
Acid detergent fibre	12.3	13.7	15.3	19.6	20.9	21.8
Acid detergent lignin	3.2	3.4	3.9	3.2	3.4	3.1
Cellulose (ADF-ADL)	9.1	10.2	11.4	16.4	17.6	18.7
Hemicellulose (NDF-ADF)	23.4	24.8	24.5	17.5	16.0	16.9
Gross Energy (kcal/kg DM)	4 403	4 648	4 796	4 224	4 463	4 589
Starch (estimation)	23.2	16.3	9.4	17.4	10.3	3.2

Wheat bran chemical composition (%):
DM: 89.4%; ASH 5.1%; CP 16.3%; CF 10.2%; NDF 45.3%; ADF 12.4%; ADL 4.7%
Pea hulls chemical composition (%):
DM: 89.4%; ASH 12.3%; CP 16.8%; CF 19.7%; NDF 44.4%; ADF 27.1%; ADL 5.6%.

(1) Mineral and Vitamin Supplement for the composition FALCÃO-E-CUNHA and FREIRE (1993)

RESULTS

Growth performance (Table 2)

Fiber nature did not affect feed intake. But the wheat bran diets gave 15% better daily growth ($P < 0.01$) and 25% better feed conversion rate (FCR) ($P < 0.001$) than the pea hull diets.

Increasing dietary fat reduced the daily intake in a linear fashion ($P < 0.001$) and the daily gain both linearly ($P < 0.001$) and quadratically ($P < 0.02$). FCRs were worsened by increasing fat addition, both in linear ($P < 0.001$) and quadratic ($P < 0.1$) fashion. Both the daily gain and the FCR responses to fat addition were more severe in the pea hull than in the wheat bran diets.

Table 2 : Effect of fat level and fiber source on average performances of growing rabbits

	wheat bran			pea hull			Statistical significance(1)			
tallow level	0%	4%	8%	0%	4%	8%	fiber	fat	fxf	RSD
Initial weight (g)	914	894	875	879	846	894	NS	NS	NS	133
Final weight (g)	1 963^{a}	1 882^{a}	1 566^{b}	1 939^{a}	1 690^{b}	1 323^{c}	**	**	NS	192
Daily food intake (g/d)	98.5^{ab}	91.2^{a}	77.2^{c}	107.9^{b}	94.9^{a}	70.9^{c}	NS	**	NS	11.2
Weight daily gain (g/d)	30.0^{a}	28.3^{a}	19.7^{c}	30.3^{a}	24.1^{b}	12.3^{d}	**	**	*	4.1
Feed/gain (g/g)	3.29^{a}	3.36^{a}	4.24^{b}	3.46^{ab}	3.89^{ab}	6.20^{c}	**	**	**	0.86

(1) Effets: NS : Not significant; *: P<0.05; **P< 0,01; RSD residual standard deviation; different letters on the same line indicate that means differ significantly (P<0.05)

Digestibility (Table 3)

Pea hull diets had on average 5 point lower DM, OM and energy digestibilities, a 6 point lower CP digestibility, and a 10 point lower EE digestibility than wheat bran diets (P < 0.01). The digestibility of the cell wall fractions was not affected by fiber nature except in the case of NDF, which was 39.2% digested in the wheat bran and only 32.0% digested in the pea hull diets (P < 0.01).
The addition of fat to the feeds reduced DM, OM and energy digestibilities linearly (P < 0.001), but increased, both linearly (P < 0.0001) and quadratically (P < 0.05), the digestibilities of NDF, ADF, hemicellulose and cellulose. This effect was more pronounced in the wheat bran diets.
The apparent digestibilities of fat (79.1%) and CP (75.8%) were not affected by fat level of diet.

Table 3 : Effect of fat level and fiber source on the apparent digestibility of diet on growing rabbits

	wheat bran			pea hull			Statistical significance (1)			
tallow level	0%	4%	8%	0%	4%	8%	fiber	fat	fxf	RSD
Digestibility coefficient										
Dry matter	68.6^{a}	65.0^{b}	66.0^{ab}	65.0^{b}	60.1^{c}	58.0^{c}	**	**	NS	3.2
Ash	51.3^{a}	53.7^{a}	57.8^{b}	53.0^{a}	51.1^{a}	47.1^{c}	*	NS	**	5.6
Organic matter	70.0^{a}	65.9^{b}	66.8^{b}	66.4^{b}	61.1^{c}	59.7^{c}	**	**	NS	3.0
Crude protein	78.3^{a}	79.3^{a}	79.1^{a}	74.3^{b}	72.8^{b}	70.8^{b}	**	NS	TS	2.7
Extract Ether	82.2^{ab}	86.1^{b}	84.4^{b}	77.9^{ac}	73.1^{cd}	71.2^{d}	**	NS	*	5.4
Crude fibre	20.1^{ab}	19.0^{b}	26.5^{a}	24.5^{ab}	21.8^{ab}	25.8^{a}	NS	TS	NS	7.2
Neutral detergent fibre	35.5^{ad}	36.3^{ad}	45.8^{c}	31.1^{ab}	28.0^{b}	37.0^{d}	**	**	NS	5.3
Acid detergent fibre	13.5^{a}	13.4^{a}	30.2b	17.6^{ac}	17.8^{ac}	19.4^{c}	NS	**	**	6.3
Acid detergent lignin	11.0^{a}	5.9^{ab}	12.8^{a}	13.3^{a}	7.6^{a}	-11.8^{b}	NS	**	TS	19.1
Hemicellulose (NDF-ADF)	47.0^{a}	48.9^{a}	55.5^{c}	46.3^{ab}	41.2^{b}	59.8^{c}	NS	**	**	5.5
Cellulose (ADF-ADL)	14.0^{a}	16.0^{a}	36.3^{b}	18.4^{ac}	19.6^{ac}	24.5^{c}	NS	**	**	7.5
Energy	71.8^{a}	69.0^{ab}	69.9^{ab}	67.9^{b}	63.7^{c}	62.6^{c}	**	**	**	3.0

(1) Effets: NS : Not significant; *: P<0.05; **P< 0,01; RSD residual standard deviation; different letters on the same line indicate that means differ significantly (P<0.05)

Nitrogen balance (Table 4)

For a similar nitrogen intake wheat bran diets have approximately 10 point higher CRN and CUP than pea hull diets. Daily nitrogen retention was 20% higher in the former than in the latter diets. These results were improved by the 4% and the 8% fat additions, irrespective of fiber nature of diet.

Table 4 : Effect of fat level and fiber source on nitrogen balance in growing rabbits. Means values adjusted to the nitrogen intake

	wheat bran			pea hull			Statistical significance(1)				
tallow level	0%	4%	8%	0%	4%	8%	fiber	fat	cov	fxf	RSD
CUP	45.8^{a}	50.0^{a}	61.0^{b}	38.1^{a}	45.3^{a}	42.7^{a}	**	*	*	NS	10.2
CRN	58.9^{a}	64.0^{a}	78.0^{b}	50.0^{a}	61.5^{a}	60.6^{a}	*	*	**	NS	13.3
N ret	1.1^{a}	1.2^{a}	1.4^{b}	0.9^{a}	1.1^{a}	1.1^{a}	**	*	**	NS	0.3

(1) Effets: NS : Not significant; *: P<0.05; **P< 0,01; RSD residual standard deviation; different letters on the same line indicate that means differ significantly (P<0.05)

Internal organs (Table 5)

Wheat bran diets gave higher absolute stomach weights, with or without contents ($P < 0.01$), but lower relative caecum weights, with or without contents ($P < 0.05$), than pea hull diets.
The addition of tallow increased linearly the weight of the stomach, both with contents ($P < 0.0004$) and without ($P < 0.0042$), irrespective of the cell wall carbohydrates of the diet. The addition of 8% of tallow increased about 50% the relative weight (g/kg liveweight) of the caecum, with or without contents.

Table 5 : Effect of fat level and fiber source on the digestive organs growing rabbits

	wheat bran			pea hull			statistical significance (1)			
tallow level	0%	4%	8%	0%	4%	8%	fiber	fat	fxf	RSD
Stomach - full										
- g	82.0^{ac}	100.6^{b}	87.9^{ab}	77.8^{a}	73.0^{a}	66.6^{c}	**	NS	NS	18.6
- g / kg LW	39.8^{a}	50.3^{bc}	54.6^{b}	39.3^{a}	43.0^{ac}	48.0^{ab}	TS	**	NS	9.0
- % full gastrointestinal tract	18.5^{ac}	21.9^{b}	19.9^{ab}	17.1^{ac}	16.5^{c}	15.2^{c}	**	NS	NS	3.4
Caecum - full										
- g	142.8^{abc}	135.2^{ab}	153bc	136.9^{abc}	131.6^{a}	156.0^{c}	NS	**	NS	20.0
- g / kg LW	71.0^{a}	68.2^{a}	96.8^{b}	69.8^{a}	75.5^{a}	114.2^{c}	*	**	NS	12.9
- % full gastrointestinal tract	32.1^{ac}	30.0^{c}	35.2^{ab}	30.7^{c}	29.7^{c}	36.2^{b}	NS	**	NS	3.7
Stomach - empty										
- g	18.7^{a}	20.8^{ab}	23.2^{b}	19.9^{ab}	18.4^{ac}	15.2^{c}	**	NS	**	3.9
- g / kg LW	9.3^{a}	10.5^{a}	15.2^{b}	10.0^{a}	10.7^{a}	11.0^{a}	NS	*	TS	3.4
Caecum - empty										
- g	39.3	37.0	40.9	36.5	39.1	44.4	NS	TS	NS	6,8
- g / kg LW	19.6^{a}	18.8^{a}	26.1^{b}	18.5^{a}	22.5^{ab}	32.4^{c}	*	**	TS	4.6

(1) Effets: NS : Not significant; *: $P<0.05$; **$P< 0,01$; RSD residual standard deviation; different letters on the same line indicate that means differ significantly ($P<0.05$)

DISCUSSION

The growth performances of this trial were on the low side, but still reasonable except for the 8% tallow regimes. The lower growth rate and worse FCR of these regimes were in large measure the consequence of a lower feed intake. Since the digestible energies of the regimes are above 2.200 kcal/kg, the lower threshold for constant energy intake (MAERTENS, 1992), this lower intake may perhaps be explained by a lower palatability of these diets and/or a lower pellet quality.
It should not be forgotten, however, that the addition of 8% tallow to the diet caused an high replacement of fat for starchy carbohydrates, a replacement which may have altered the metabolism of the rabbits and so reduced their growth. In man (MUNRO *et al.*, 1959) as well as in other species of single-stomached animals (FULLER and CROFT, 1977; AKARBAWI *et al.*, 1974), a negative effect of total replacement of starch by fat on energy and protein metabolism is well known.
In this trial the addition of increasing levels of fat reduced the digestibilities of DM, OM and energy. This result is in agreement with LEBAS (1975a), according to whom the effect of fat addition on these parameters is a function of the initial energy of control feed – the effect being positive when the starting energy is low (FEKETE *et al.*, 1990), but negative when it is high (LEBAS, 1975b). In our trial the DE of the diets was average to high. It is worth mentioning, however, that the reductions were more marked in the pea hull diets, of about 2.600 kcal/kg DE, than in the wheat bran diets, which have an higher DE.
The fact that fat level did not influence CP either fat digestibility is in agreement with the some results as PARIGI-BINI *et al.* (1974), LEBAS (1975b) and FEKETE *et al* (1990).
The positive effect of fat on carbohydrate digestibility with both fiber sources is perhaps a consequence of a reduction in transit rate through the gut, an effect which was demonstrated in poultry (MATEOS and SELL, 1981). Furthermore, it was possible that the level of bentonite in the 8% fat diet may contribute to the alteration of digestion conditions. The fact that the rabbits which received the 8% tallow regimes had heavier guts, a possible consequence of higher fermentative activity, seems to confirm this idea.
Our results concerning the effects of fiber nature on the apparent digestibilities of DM, OM and energy are in agreement with DE BLAS *et al.* (1984) and BATTAGLINI and GRANDI (1984) according to whom ADF

and/or CF are the variables best correlated with these digestibilities. While our diets had similar NDF levels, their ADF and CF levels were not the same and the diet lower in ADF and CF had the higher overall and energy digestibilities.

The differences of 6 and 10 points in the digestibilities of CP and EE, respectively, seem to be too great to be explained by endogenous excretions varying with the fiber nature of the diets. In the case of CP part of the difference may have been a consequence of a lower real digestibility of the protein in the pea hulls. The content of trypsin inhibitors is low about 3000 IU/g (FREIRE, personal communication), so they may not interfere with CP digestibility. In the case of EE an interaction between fats of different nature may have been involved. It has been established that the addition of predominantly insaturated fat to a diet rich in saturated fat will enhance the absorption of the fat (WISEMAN, 1984). In the pea hull diets an important part of the EE is not real fat but pigments and other fat-soluble substances.

Although our nitrogen balance results suggest a positive effect of fat addition, and are thus in agreement with data from PARIGI-BINI *et al.* (1974), we must be cautious in their interpretation because of the great spread of feed intakes encountered. The lower nitrogen retention (expressed in % of absorbed, CNR) with the pea hull diets suggest a lower protein biological value of the diet, possible in relation with aminoacid imbalance of the hulls protein.

Part of the differences in internal organ weights is simply a reflection of widely different slaughter weights – so different that expressing these weights in relative terms is not enough to cancel this effect and to show the effect of the diet. The development of the gut is very precocious, being practically complete by 11 weeks of age (LEBAS and LAPLACE, 1972). Nevertheless, the greater weight of the fermentative compartments in the diets of greater cell wall digestibility, in agreement with results of FALCÂO-E-CUNHA (1988) may have been a consequence of their slower passage in these compartments.

CONCLUSION

Our results show that it is possible to add 4% tallow to growing rabbit feeds without negative effects on their growth performances.

In our trial adding fat to already high-energy feeds reduced the apparent digestibilities of DM, OM and energy. The reductions varied with the fiber nature and energy level of the diet. Fat digestibility was not affected by fat addition, was affected by the composition of the basal feed to which it was added. Digestibilities of cellulose and hemicellulose were independent of fiber nature and improved with fat addition, possibly as a result of a longer passage time in the caecum.

We think that it is possible to use pea hulls as a source of cell wall components in growing rabbit diets, as long as there is care with the protein quality of the other feeds that make part of the diet.

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