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► To cite this version:

Christine Cherbut, J.L. Barry, Monique Wyers, J. Delort-Laval. Effect of the nature of dietary fibre on transit time and faecal excretion in the growing pig. *Animal Feed Science and Technology*, 1988, 20 (4), pp.327-333. hal-02720333

HAL Id: hal-02720333

<https://hal.inrae.fr/hal-02720333>

Submitted on 1 Jun 2020

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Short Communication

Effect of the Nature of Dietary Fibre on Transit Time and Faecal Excretion in the Growing Pig

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(Received 20 October 1986; accepted for publication 30 December 1987)

ABSTRACT

Cherbut, C., Barry, J.L., Wyers, M. and Delort-Laval, J., 1988. Effect of the nature of dietary fibre on transit time and faecal excretion in the growing pig. *Anim. Feed Sci. Technol.*, 20: 327-333.

When added to a fibre-free diet, polyethylene, a substance not modified in the digestive tract and devoid of water-holding capacity, reduces mean transit time (MTT) in the gut of the growing pig from 101.3 to 88.8 h and increases faecal water excretion from 2 to 43 g day⁻¹. It does not modify the digestibility of the other components of the diet.

However, with the same amount of added wheat bran, more pronounced effects (MTT: 75.7 h; daily faecal water output: 119 g) are observed. The mechanical properties of indigestible material, therefore, only partly explain its effect on transit time and faecal excretion in the pig.

INTRODUCTION

Dietary fibre may be defined as the dietary fraction not digested by endogenous enzymes of the digestive tract (Trowell, 1972). It plays a key role in digestive physiology and particularly in the regulation of gastrointestinal transit time: a low fibre diet decreases intestinal motor function (Ruckebusch, 1981) and, conversely, fibre addition contributes to restoring a normal transit time (Canguilhem and Labie, 1977).

From digestibility experiments with ileo-caecal cannulated pigs, Just (1982) concludes that an increasing dietary fibre content results in a higher proportion of digestible nutrients disappearing in the large intestine. At high levels of inclusion, pure cellulose or vermiculite added to fibre-free diets tend to reduce transit time and to increase faecal excretion of energy, protein and water (Henry and Etienne, 1969). However, the way in which dietary fibre acts is not fully understood. One of the most recent hypotheses involves a mechanical effect (Bardon and Fioramonti, 1983) which could explain why coarse bran is

more effective than fine bran in accelerating the passage of digesta (Kirwan et al., 1974; Heller, 1980). Nevertheless, the primary importance of this effect over other dietary fibre properties supposed to be effective, such as pancreatic enzyme activity in the gut (Schneeman, 1982), water-holding capacity (Eastwood et al., 1983) or ability to generate fermentation end-products (Hellen-doorn, 1978), is not well established.

Difficulties in determining the main property involved in transit time regulation come from the coexistence of several characteristics of the indigestible fraction, such as particle size, water-holding capacity (Kirwan et al., 1974) or fermentability. The aim of the present experiment was to evaluate the influence of an organic diluent, polyethylene (PE), devoid of water-holding capacity and chemically inert, on transit time and faecal excretion. The effect of this supplement, added to a fibre-free diet, was measured in balance and transit time studies on growing pigs and compared to wheat bran, a common source of dietary fibre in one-stomach animals and man.

MATERIALS AND METHODS

Animals and diets

Eight castrated male Large White pigs, ~3 months old and with a mean initial bodyweight of 30 kg were used. They were housed in metabolism crates at constant temperature (18–20°C) and light (14 h day⁻¹) throughout the experiment.

The basal diet fed throughout the experiment was a commercial milk replacer consisting mainly of skim milk powder enriched with animal fat, dried whey, starch, minerals and vitamins. It contained <0.5% neutral detergent fibre (Goering and van Soest, 1970). The source of indigestible material was either commercial wheat bran as a source of fibre or PE as an inert product. Both supplements were ground in a hammermill, then passed through a 1.6-mm sieve. The finer fractions, passed through a 1-mm screen, were discarded.

A marker added to the control and experimental diets consisted of 30 small flexible discs of coloured polyethylene, ~3 mm in diameter and 0.3–0.5 mm thick. Their colours were different in order to distinguish the marker added on the same day to the morning and evening meals.

Experimental design and procedures

Animals were weighed once a week and fed twice daily with the basal diet in a wet form at a level of 1% of their liveweight. They had free access to water.

The experimental design consisted of two 14-day experimental periods, each preceded by 7 days of adaptation to the experimental diet. During the first experimental period, all the animals were fed the basal diet alone. During the

second period, they received the same basal diet and a supplement of 100 g day⁻¹ of either bran or PE. Faecal excretion and transit time were measured on all the animals during each experimental period.

For transit time determination, markers were added to the morning and evening meal of the first day of each experimental week. Faeces were collected at 8.00 a.m., 1 and 6 p.m. during the next 6 days.

Preparation and analysis of samples

Aliquot samples of feeds and faeces were dried and pooled for each animal and each experimental week. They were analysed for dry matter (DM), nitrogen (N) and neutral detergent fibre (NDF). PE particle content was obtained by centrifugation of an aliquot of the pooled dry faeces dispersed in distilled water.

Coloured markers were taken by hand from each dried sample of faeces collected during the experiment. The mean transit time (MTT) was calculated for each single dose, according to Cummings et al. (1976) as follows:

$$MTT = \frac{\sum_1^n x_i t_i}{\sum_1^n x_i}$$

where x_i is the number of coloured particles present in the stool passed after the time interval t_i . Comparisons of feed intake, faecal excretion and mean retention time of the marker were analysed using the Student's *t*-test and variance analysis.

RESULTS AND DISCUSSION

Digestive balance

Average intakes of DM, N and fibre are given in Table 1.

On the basal diet, pigs were highly constipated. This constipation was characterized by quite a low (5.3%) water content in the faeces, compared to the 25–40% figures usually found with more conventional diets. A decrease in the frequency of defaecation was also observed in the 8 animals. However, 2 pigs had an abnormally high faecal excretion during the first period, even after 7 days of adaptation to the basal diet. Their main component, lactose or more probably fibre residues from the pre-experimental period, were not analysed. The corresponding data are not included in the calculations.

During the second experimental period, the moisture content of the faeces was significantly higher (64.9%) with the bran diet than with the PE diet (24.8%). Several authors (Stephen and Cummings, 1979; Eastwood et al., 1983) explain the increase in faecal water excretion by the water-holding capacity of

TABLE 1

Average daily feed intake (g per animal)

	<i>n</i>	Dry matter	Nitrogen	Neutral detergent fibre
Period 1				
Basal diet	6	558 ± 0.6	20.7 ± 0.02	<3
Period 2				
Basal diet + PE	4	803 ± 18	26.2 ± 0.6	98.9 ± 0.1
Basal diet + bran	4	790 ± 17	28.3 ± 0.7	44.3 ± 0.1

TABLE 2

Faecal excretion of dry matter, nitrogen and neutral detergent fibre in pigs fed highly digestible diets either alone (Period 1) or supplemented with polyethylene or bran (Period 2)

	Water (g day ⁻¹)	Dry matter		Nitrogen		Neutral detergent fibre	
		g day ⁻¹	% intake	g day ⁻¹	% intake	g day ⁻¹	% intake
Period 1							
Basal diet	2	34.4	6.2	1.05	5.1	<1	—
Period 2							
Basal diet + PE	43	128.8	16.1	1.11	4.3	91.9	92.9
Basal diet + bran	119	64.7	8.2	1.48	5.3	27.1	61.2

the fibre. This explanation does not hold for PE which is devoid of water-holding capacity.

Despite a higher protein intake during the second experimental period, faecal nitrogen excretion remains constant with the PE diet (Table 2). On the contrary, faecal nitrogen excretion is increased with the bran diet. The observed difference between the data of the first (control) and second (experimental) periods is fully explained by the higher intake of the basal diet (+15% DM) and by the low digestibility of the bran protein.

Addition of fibre or PE to the basal diet increases the relative DM faecal excretion (Table 2). Recovery of PE particles is not complete over the 6 days of faeces total collection, but the measured loss does not correspond to a significant disappearance. In contrast, bran NDF shows a 38.8% disappearance. This figure tends to be lower than those previously reported by Ehle et al.

(1982) and Stanogias and Pearce (1985). It could be due to the fact that younger animals were used. The increase in DM faecal excretion is fully explained by the amount of fibre in the faeces: addition of fibre to the diet, at the level used in the present experiment, does not change the apparent digestibility of the non-fibrous constituents of the diet. This conclusion does not agree with those of Kass et al. (1980) and Stanogias and Pearce (1985), who explain the decrease in apparent digestibility of the non-fibre fraction of a more conventional diet by an increase either of the rate of passage of digesta or of microbial or endogenous faecal excretion.

Retention time measurement

Post-mortem histological examination of gastrointestinal wall showed no abnormalities; thus, the observed changes in digestive parameters do not seem to have a pathological origin.

Since, for the same diet, there were no statistically significant differences between mean retention time of the morning and evening meals, both sets of figures were distinguished no further. The proportion of coloured discs recovered from the 8 pigs averaged 64%.

The MTT, 101.3 h (s.d. = 22.8; $n=27$) with the basal diet, was reduced by the addition of fibre, either with PE ($m=88.0$ h; s.d. = 14.4; $n=16$) or with bran ($m=75.7$ h; s.d. = 21.2; $n=16$). These MTT values and their reduction after the addition of fibre to the diet are in good agreement with previously published results (Canguilhem and Labie, 1977; Fioramonti and Bueno, 1980; Bardon and Fioramonti, 1983); they are longer than those obtained by Henry and Etienne (1969) after the addition of high levels of pure cellulose and/or vermiculite to the diet.

Since PE particles are chemically inert and devoid of water-holding capacity, they reduce the mean retention time only by a mechanical action. This result is reminiscent of the stimulating influence of mechanical factors on rumen motility (Candau, 1973) and confirms the hypothesis of Bardon and Fioramonti (1983) who postulate that dietary fibre could act in a mechanical way on transit time. On the other hand, bran, though added in a lower amount on a total fibre basis, has a larger effect than PE on transit time: characteristics of bran, not found in PE, such as fermentability and water-holding capacity seem to play a part in the regulation of the digestive motor function. Similar observations have been reported with vermiculite versus cellulose in rabbits (Colin et al., 1976) and more recently with kaolin versus cellulose in mice (Goodlad and Wright, 1983). Nevertheless, the role of fermentation end-products, i.e., volatile fatty acids, has been questioned (Bardon and Fioramonti, 1983).

The fact that PE, devoid of water-holding capacity, simultaneously increased water faecal excretion and the rate of passage of digesta in the digestive

tract, seems to indicate that increased water faecal excretion after addition of fibre to the diet is partly a consequence of an accelerated transit time.

In conclusion, the present experiment shows that when added in limited amount to a fibre-free diet, dietary fibre acts mechanically by decreasing the mean retention time of food in the digestive tract. On the other hand, it clearly shows that increased faecal water output is partly independent of the water-holding capacity of the fibre source.

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