

A NOTE ON THE EFFECT OF CAECECTOMY IN PIGS FED DIFFERENT AMOUNTS OF DIETARY FIBRE

UNA NOTA SOBRE EL EFECTO DE LA CECECTOMÍA EN CERDOS ALIMENTADOS CON DISTINTOS NIVELES Y FUENTES DE FIBRA.

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Palabras claves adicionales: Tiempo de retención media. Digestibilidad aparente.

Additional Keywords: Mean Retention Time. Apparent Digestibility.

Summary

Dehydrated Lucerne (Lu), Dried Sugarbeet pulps (Bp), Straw (St) and Oats (Ot) were used to formulate diets containing 5% or 10% of crude fibre (CF). The resulting diets (Ot5, Lu5, Bp5, St5, Lu10, Bp10, and St10) were given to 14 pigs of which, those having even numbers suffered caecectomy. Four (1, 3, 5 and 7) normal (N) pigs and four (2, 4, 6, and 8) modified (M) were allocated to the 5% diets; another three N (9, 11 and 13) or M (10, 12 and 14) pigs were given the 10% diets. All pig-groups followed a latin-square diet rotation. Feeds, refusals and feces were assayed for Organic Matter (OM), Crude Protein (CP); Fibres: Crude (CF), Neutro-Detergent (NDF), Acid-Detergent (ADF); and Gross Energy (GE) to asses the Apparent Digestion Coefficient (DC, $g \times kg^{-1}$) of each component (DCOM, DCCP, DCCF, DCMDF, DCADF, DCHCELL, DCGE respectively). Chromiun dioxide was given to asses Mean Retention Time (RT). Type of pig (N or M) significatively affect RT, (30,8 vs 27,3 h respectively). The 10% CF diets presented lower DC values except for ADF.

RT did no varied between CF levels. Pigs consuming Bp resulted on higher DCOM and most F fractions and, despite lower intakes, had longer RT. In the conditions of this trial caecectomy had not any deleterious effect upon digestibility or RT .

Resumen

Se utilizó alfalfa deshidratada (Lu), pulpa de remolacha deshidratada (Bp), paja de cereal (St), y avena (Ot), para formular dietas con el 5% o 10% de fibra bruta. Los piensos resultantes (Ot5, Lu5, Bp5, St5, Lu10, Bp10 y St10) se distribuyeron a 14 cerdos de los cuales, los que tenían numeración par, sufrieron cecectomía. Cuatro (1, 3, 5 y 7) cerdos normales (N) y cuatro (2, 4, 6 y 8) modificados (M) consumieron los piensos con el 5% mientras que otros tres N (9, 11 y 13) o M (10, 12 y 14) recibieron los del 10% de fibra bruta, realizándose en cada caso una rotación en cuadrado latino. Los piensos, rehusados

Recibido: 11-1-90. Aceptado: 15-5-90.

y heces se analizaron para Sustancia orgánica (OM), Proteína bruta (CP); Fibras bruta (CF), neutro-detergente (NDF), ácido-detergente (ADF) y energía bruta (GE); para determinar el coeficiente de digestibilidad aparente (DC, g x kg⁻¹) de cada componente (DCOM, DCCP, DCCF, DCMDF, DCADF, DCHCELL y DCGE respectivamente). Se distribuyó óxido de cromo para determinar el tiempo medio de retención (RT). El tipo de cerdo (N o M) afectó al RT, significativamente (30,8 vs 27,3 h respectivamente). Los piensos con el 10% de CF tuvieron DC más bajos excepto para FAD. El RT no varió entre niveles de F. Los cerdos que consumieron Bp tuvieron un DCOM, así como de la mayoría de las fracciones de fibra, más elevado, y, a pesar de las más bajas ingestiones, manifestaron un RT más largo. En las condiciones de este experimento la cecectomía no tiene efecto negativo sobre la digestibilidad o RT.

Introduction

The digestion of Fibre (F) in the Large Intestine (LI) of pig and the accompanying microbial activities have been recently reviewed (Cramwell 1969, Lawrence 1987, Low 1985, Rerat 1978, Steven *et al.* 1980, Varel *et al.* 1978).

The contribution of cecum (C) to the overall digestibility is far from clear, in fact the colon is the primary site of LI fermentation in mammals, acting the C (if present) as an extension of it (Hume and Warner 1980). For most feeds, the overall Mean Retention Time (RT) inside the intestine is of capital importance regarding digestibility again the information concerning the contribution of C to RT is not clear.

The motricity of food through the intestine of pig has been studied with

the help of undigestible markers and because unsuitability of measurements of initial and final disappearance, the method outlined by Castle and Castle (1956 and 1957) has been widely accepted. This trial aims to add information to the effect of surgical removal of C (caecectomy) over Mean Retention Time (RT) and Apparent Digestion (AD) of food in pigs fed compounded diets varying in F content.

Material and Methods

Supplementary F sources (S) were: Dehydrated Lucerne (Lu), Dried Sugarbeet Pulp (Bp) and Straw (St) to give two F levels : 5 and 10% of the total diets. At the low F level another diet containing Oats (Ot) was also formulated. The composition of the resulting diets (Ot5, Lu5, Bp5, St5, Lu10, Pu10, and St10) are shown in table I. After analysis, the ingredients were separately grounded (3mm screen sieve), mixed in batches of 150 kg (rotation mixing), packed in several plastic bags of 2.5 kg (to avoid segregation during manipulation) and stored in a cool room at 4° C.

Fourteen male pigs (Belgium Landrace), numbered 1 to 14 were weaned and caged at eight weeks of age and those having even numbers suffered caecectomy. After 24 h feed withdrawal, a tranquilizer, (intramuscular) and a general anesthetic (direct injection in aorta) were administered. Pigs were immobilized in dorsal recumbency, the abdomen shaved, carefully washed and sterilized; thereafter a local anesthetic as well as atropine were infiltrated. After, an 8 cm long

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Table I. The composition of the diets. (Composición de las dietas).

INGREDIENTS (g/100g)	Fibre content						
	5%			10%			
	Ot	Lu	Bp	St	Lu	Bp	St
WHEAT	24,5	48,5	40,5	47,5	-	-	-
OATS	30,0	-	-	-	20,0	20,0	20,0
BARLEY	30,0	30,0	30,0	30,0	50,0	32,5	50,0
LUCERNE ^a	-	8,0	-	-	15,0	-	-
BEETPULPS ^a	-	-	14,0	-	-	30,0	-
STRAW	-	-	-	6,0	-	-	10,5
SOYBEAN MEAL	12,0	10,0	12,0	13,0	11,0	14,0	16,0
MEAT MEAL	3,0	3,0	3,0	3,0	3,0	3,0	3,0
MIN-VIT MIX	0,5	0,5	0,5	0,5	0,5	0,5	0,5
ANALYSIS (g x kg ⁻¹)							
DRY MATTER	887	884	886	886	895	899	895
CRUDE PROTEIN	162	166	165	165	168	166	160
FIBRES							
CRUDE	57,2	51,7	53,4	68,0	92,1	98,2	98,8
NEUTRE DETERGENT	184	168	161	170	224	243	248
ACID DETERGENT	81	75	84	73	124	135	137
HEMICELLULOSES	103	93	77	97	100	108	111
GROSS ENERGY ^b	4.15	4.15	4.14	4.15	4.07	4.10	4.13

^a Dehydrated

^b kcal x g⁻¹

incision was made on the left side starting at a point midway between *umbilicus* and *pubis*, and approximately 3 cm lateral to mid line. The *caecum* was located and exteriorized, the ileo-caecal artery was ligated and caecectomy practiced at the ileo-caecal valve level. The caecal stump was closed by mean of discontinuous sutu-

re, *peritoneum* and associated muscles were closed with a continuous suture. Then the incision was closed by mean of discontinuous suture.

After operation, pigs remained in their cages with continuous access to fresh water but in fasting. After 3 days some dry feed was given, reaching *ad lib.* conditions 10 days later. Four

(1,3,5 and 7) normal (N) pigs and four (2,4,6 and 8) modified (M) were allocated to the 5% diets, each animal rotated all diets following and latin square design. Another three N (9,11, and 13) or M (10,12 and 14) pigs were allocated to the three 10% diets following also a rotation between diets.

After two weeks of adaptation, all pigs received diets containing Chromium dioxide to evaluate RT; followed by a total fecal collection period of 4 d -except in period 4 (5% diets only) that was of three d. To keep refusals at around 15% of the daily allowance, half of a 2.5 kg bag of the corresponding diet was distributed daily at 08.30 h; at 11.00 h and again at 15.00 h extra food was given if the previous ration had been consumed. Feces were collected continuously, dried at 60° C during 72 h and the difference between fresh and dry feces, assumed as Fecal Moisture (FM), ground and stored for subsequent analysis; thereafter an aliquot is again dried at 92° C 24 h. Feed, refusals and feces followed the same analytical procedure.

Organic Matter (OM) content was determined by ashing a 500° C; Crude Protein (CP, N x 6.25) by the Kjeldahl method (AOAC, 1984) in a kjel-foss equipment. Crude Fibre (CF) by the Weende method (AOAC, 1981) and other fibre analysis accordingly to Goering and Van Soest (1970) methods for Neutral-Detergent (NDF) and Acid-Detergent (ADF) fibre, the difference between these assumed as Hemicelluloses (HCELL). Gross Energy (GE) was assessed by triplicate combustions in a calorimetric bomb (ba-

listic, Gallemkamp) calibrated with benzoic acid. In each period, samples of diets and refusals (if any) were analyzed to assess the actual intake. The difference between ingested and excreted, relative to ingestion is called Apparent Digestion Coefficient (DC, $g \times kg^{-1}$) of each of the chemical components analyzed (DCOM, DCCP, DCCF, DCNDF, DCAFD, DCHCELL, DCGE respectively), RT was estimated following the method of the momentums (Castle and Castle 1956, 1957) as updated by Thielemans *et al.* 1981. Chromium was analyzed by means of titration with Mohr salts (Francois and Thill, 1978) after complete mineralization of dry feces.

Statistical analysis (General Linear Models, SAS 1982), ignoring 0t diets, assessed the effect of Type of pig (T), Source of fibre (S), Level of F (L) and the interactions TxS, SxL and TxL following a regression approach. Regression analysis, T-test and Multiple Comparisons of Means by Scheffé's test were performed using SPSS/PC+ package (Norusis, 1986).

Results and Discussion

Some functions have been attributed to the caecum, such the retention of small feed particles and excess water and electrolytes to ensure the enrichment of the digesta in microbes (Bjornhag, 1987; Hume and Warner, 1980). Feces from M pigs contained more FM than those from N (table II); and a relationship between FM and RT (table III) is very evident in the N animals ($r=0,56$, $p<0,004$) but not in

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M, suggesting that in caecectomized pigs this function (elimination of excess liquids) may be somehow diminished and, consequently, both RT (30,8 vs 29,3 h $P < 0,04$) and FM (26,1 vs 24,0 $p < 0,001$) increases. Only in Bp-diets (presenting the longest RT, see table III) FM is independent of RT. Therefore it is likely that, in M pigs, the digesta was retained in the LI until a certain level of DM was attempted. It has been reported that F tends to increase water relation (Lawrence 1987) from duodenum to feces (Graham *et al.* 1988, Kass *et al.* 1980b, Munchow *et al.* 1986 and Warner 1981) but in this trial FM did no changed significantly between the two F groups.

Table III shows the grands means and the least squares means for each of the factors analyzed and, in the table IV, the result of the analysis of the variance is given. It can be seen that type of pig (N or M) was the only main

factor affecting RT, presenting the caecectomized group longer RT (30.8 vs 27.3 h) than N; also the M pigs showed greater OM ingestion. It is not know if the removal of C could have had any influence in the emptying rate of duodenum therefore allowing higher voluntary intake. Regarding F, the higher level presented lower AD values except for ADF; RT did no varied.

Because no effect of caecectomy on the DC of the fractions analyzed here, it is unlikely that microbial activity could have been restrained by caecectomy. Anyhow caecectomized pigs scored lower values for the DC of all fibre fractions specially at the higher F level. Shorter RT (reducing time of exposition to microbial enzymes) and lower digestibilities have been reported in diets rich in F, but on restricted intake, longer RT has been also reported (Ehle *et al.* 1982b, Evets *et al.*

Table II. Moisture content (%) of fecal matter, each figure represents the mean daily observation including all periods. (Humedad de la materia fecal. Cada cifra representa la media diaria de todos los períodos).

Pig Type	Grand Mean	All Diets		5% crude fibre				10% crude fibre			EEM	p
		5%	10%	0t	Lu	Bp	St	Lu	Bp	St		
N	24,0	23,6	24,7	26,7 ^b	23,1 ^{ab}	23,7 ^{ab}	20,9 ^a	26,5 ^b	23,7 ^{ab}	24,5 ^{ab}	3,16	0,001
M	26,1	26,1	26,2	28,6 ^c	26,3 ^{abc}	25,1 ^a	24,0 ^a	28,2 ^{bc}	25,1 ^a	25,7 ^{ab}	2,20	0,001
M-N	+2,1	+2,4	+1,5	+1,9	+3,2	+1,4	+3,1	+1,7	+1,4	+1,2	0,21	
*	<0,001	<0,001	0,03	0,05	0,005	N.S.	<0,001	0,03	N.S.	N.S.	-	

* t-test N vs M within same columns

a, b, c: Scheffé test, unequal letter within same row indicate significative differences ($p < 0,05$).

Table III. Coefficient of apparent digestibility (g/kg-1), organic matter intake, mean retention time (RT), and apparent absorption of OM, GE and CP. The figures shown represent the least square means according to fibre level, type of pig (normal or cecectomized) and fibre source. (Coeficientes de digestibilidad aparente ingestión de materia orgánica, tiempo medio de retención y absorción aparente).

Digestibility Coefficients	Grand Mean	Factors								
		Level ^a		Type ^b		Source ^c			EEM	F-ratio Probability
		5%	10%	N	M	Lu	Bp	St		
Organic Matter	0,787	0,823	0,743	0,748	0,792	0,775	0,820	0,767	0,0271	<0,0001
Crude Protein	0,763	0,793	0,725	0,768	0,759	0,759	0,756	0,774	0,0366	<0,001
Gross energy ^d	0,738	0,791	0,671	0,740	0,736	0,724	0,776	0,713	0,0356	0,001
Fibres										
Crude	0,285	0,252	0,267	0,263	0,255	0,140	0,478	0,149	0,1695	0,0001
Neutro Detergent	0,433	0,458	0,402	0,424	0,442	0,384	0,579	0,333	0,1082	0,0001
Acid Detergent	0,334	0,289	0,380	0,321	0,346	0,253	0,533	0,210	0,1158	0,0001
Hemycellulose	0,482	0,589	0,346	0,490	0,474	0,496	0,620	0,330	0,2861	0,014
Mean Retention Time ^e	29,1	29,3	28,8	27,3	30,8	29,0	30,5	27,8	5,29	NS
Ingestion of Organic Matter ^f	2029	2416	1642	1934	2168	2213	1898	1976	430	nc

^a Ignoring type of pig and source of fibre.

^b Adjusted for fibre level.

^c Adjusted to fibre level and type of pig.

^d cal/cal.

^e DECIMAL TIME

^f gxd-1

nc. Non comparable because semi ad libitum feeding to avoid segregation.

1982b, Fernández and Jorgenssen 1986, Giusi *et al.* 1987, Maenhot *et al.* 1987, Moore *et al.* 1987, Morgan *et al.* 1984, Pond *et al.* 1986, Roth and Kirchgessner 1985, Sandoval *et al.* 1987). In this

experiment the lower intakes on the F rich diets may have lead to equal RT. In an interesting finding Drochner *et al.* (1987a) increase RT by inducing very high fermentation levels in the LI

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Table IV. F ratio probability of the main factors and interactions corresponding to table III. Each of the factor analyzed is adjusted by the preceeding (Regression Approach). Nivel de probabilidad de F en los principales factores e interacciones correspondientes a la tabla III. Cada uno de los factores analizados es ajustado por el precedente.

EFFECTS	MAIN FACTORS			INTERACTIONS		
	Fibre Level	Type of Pig	Fibre Source	Level x Type	Level x Source	Source x Type
OM	<0,001	NS	<0,001	NS	NS	NS
CP	<0,001	NS	NS	(0,06)T	NS	NS
GE	<0,001	NS	<0,001	(0,07)T	NS	NS
CF	NS	NS	<0,001	NS	NS	NS
ADF	0,03	NS	<0,001	NS	NS	NS
NDF	NS	NS	<0,001	NS	NS	NS
HCELL	0,01	NS	0,04	NS	NS	NS
RETENTION TIME	NS	0,04	NS	NS	NS	NS

t, TEEND (0,01 P>0,05).

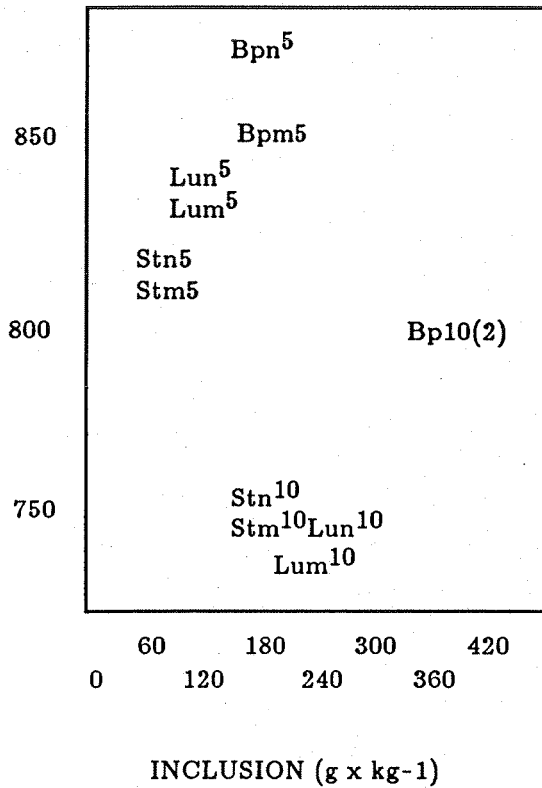
by mean of intracecal infusion of extra carbohydrates; therefore, the possibility remains that because less dry and fermented material entering the lower part of the intestine, extra fermentative activity could have been involved in longer RT in M pigs (P<0,04).

The rise in undigested material on F rich diets has been associated to an increase in the bulk of intestinal digesta hence greater intestinal load and shorter RT (Castle and Castle 1957, Ruckebush *et al.* 1981); in this case, and because lower intakes on the high F diets, the daily fecal output was very much the same and RT remained practically evident in those fed Bp

(R=-0,86, n=7, P<0,001) or St (R=-0,66, n=7, P<0,05,). This relationship in not evident in M pigs.

The source of supplementary fibre significantly affected DCOM, DCGE, DCCF, DCA DF, DCNDF and DCHCELL, reaching the highest values in beetpulp diets; none of these parameters significantly changed between N and M pigs. Figure 1 shows the relationship between DCOM (g x kg-1) and the inclusion level (g x kg-1) of the three main dietary sources indicating a negative effect upon the AD of other dietary components as shown by the negative regression coefficient (slope). This effect is very marked with straw and lucerne (-1,63,

Figure 1. Plot of DCOM (g x kg⁻¹) with inclusion (g x kg⁻¹) of the different supplementary fibre sources. (Coeficientes de digestibilidad de la M.O en relación con las fuentes suplementarias de fibra).



DIETS	INTERCEPT (S.E.)	SLOPE (S.E.)	r ²	SEE	(P)
LUCERNE	950(10,8)	-1,44(0,090)	0,992	6,32	0,004
BEETPULPS	905(13,9)	-0,35(0,059)	0,947	9,55	0,02
STRAW	912(14,5)	-1,63(0,169)	0,978	7,63	0,01

DCOM, Coefficient of Apparent Digestibility of the Organic Matter.

n, Normals.

m, Caecectomiced.

5, 5% fibre.

10, 10% fibre.

-1,44) while is very much lower in the case of beetpulp (-0,35).

It has been said that retention of each particular food in flexura coli and caecum is capital microbial activity, therefore longer RT on these sections of digestive tract was associated in most cases to increased digestibilities being the reverse also true (Kas *et al.* 1980a, LY 1986, Munchow *et al.* 1986, Roth and Kirchgessner 1985, Sandoval *et al.* 1987, Warner 1981) else the differences between the digestibilities being of several foods are partially explained by differences in their individual RT (Ehle *et al.* 1986). This is not the case in Bp diets as regardless the type of pig presented equal RT but higher DCOM for CF, NDF, ADF, and HCELL that Lu or St. Accordingly to Drochner *et al.* (1987) the possibility remains that Bp-

containing diets (a very fermentable material) compensated lower intake with longer RT and fermentation; another possibility is higher fermentation and longer RT being related to the lower intakes observed, because a "load effect". Better DC for BP as compared to other fibre sources have been previously reported by Morgan *et al.* 1984 in pig, as in another ceceum fermenter such it is the poney (Wolter *et al.* 1979).

The results reported here give support to an early finding by Lloyd *et al.* (1958) which observed that caecetomy had not deleterious effect on the growth rate of pigs fed either experimental or practical diets, being small the differences in the ability of caecetomized pigs to digest various constituents.

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