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THE ROLES OF FIBER IN RABBIT NUTRITION

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1.- Fiber as an energy source

Fiber content has an overall negative effect on gross energy digestibility (Ed) and on efficiency of conversion of digestible energy (DE) for growth (see Figure 1). However, these relationships do not mean that fiber has a negative energy value, but a lower energy content than the other components of the diet.

Fiber digestibility in single ingredients can be estimated using the difference method, with substitution of a basal diet (Table 1).

A first look to the values of this table shows an important variability (from 7 to 72%) of fiber digestibility among feeds. Although there are some differences between the two sets of values, both studies agree in a higher digestibility for corn fiber (30 - 40%) in relation to that of other cereals (10 - 20%), both for grains and byproducts. Low digestibilities were also observed for forages and grape marc. Fiber digestibility for protein concentrates was intermediate, with higher values for soyabean than for sunflower meal. Finally, low lignified byproducts, as beet and citrus pulps gave the highest values.

It is also important to take into account that the estimations presented in Table 1 had a high variability. As shown in Figure 2, the 95% confidence interval for the means tended to increase when decreasing the fiber content of the ingredient. In the case of corn grain, this interval included the range of digestibility values from 0 to 100%. So, this method is only useful for high fibrous feeds.

Some of the variability was linked to the methodology used. For instance, an interaction was observed between fiber content in the basal diet and ADF digestibility of beet and citrus pulps, the highest the fiber content in the basal diet, the lowest the estimations obtained (de Blas and Villamide, 1990). Some variation is also related to the level of inclusion of the ingredient in substitution of the basal diet (de Blas and Villamide, 1989; Villamide et al, 1991).

Another consideration in relation to this subject is that of the heterogeneity of the different cell wall components. In this way, Figure 3 shows the composition in structural carbohydrates in three feedstuffs (grape marc, alfalfa hay and beet pulp) with a similar content in crude fiber (about 20%).

As a consequence of the differences in the degree of lignification and also in the proportion of highly digestible pectins, substitution of these ingredients in the diet leads to highly significant differences in dietary Ed (Figure 4). As shown in this figure, there were parallel differences in weight of cecal content, showing a positive correlation between cecal volume and fiber degradation.

The use of the Van Soest scheme permits to correct part but not all of these differences. So, with the analytical methods available at present, the source of fiber is a factor to take still into account in the evaluation of the dietary DE content.

For instance, Figure 5a shows the deviations with respect to a general equation obtained for a large number of diets, for the Ed of those diets containing beet or citrus pulps. The differences between the actual values obtained and those estimated from the equation at the same level of ADF were linearly related to the proportion of pulp in the diet (Figure 5b). The opposite effect occured for diets including a high proportion of wheat straw, and again in this case the differences between the actual and predicted values were related to the amount of wheat straw in the diet (de Blas et al, 1992).

2.- The role of fiber in prevention of digestive disorders

Some relations between nutrition and development of digestive disorders have been suggested by several authors working in vitro (Prohaszka, 1980; Borriello and Carman, 1983). According to these studies, a possible connection between type of diet and diarrea incidence would be through its effect on cecal fermentation traits which affect proliferation of cecal pathogenic flora, the lowest the pH and ammonia concentration and the highest the volatile fatty acid concentration, the lowest the proliferation of E. coli.

Type of diet can also affect the amounts of digestible nutrients (especially protein and starch) which, if reaching yhe hindgut, would promote proliferation both of E. coli and C. spiroforme. This effect would be especially important around the weaning age when coincides a drastic change of diet with a non completely established enzimatic capability.

In relation to the first of these points, Figure 6 shows some results obtained in our Department about the effect of dietary fiber level on several cecal fermentation traits, in diets containing traditional sources of fiber (alfalfa hay, wheat bran, wheat straw).

According to these results, low fiber diets only imply a slight decrease in cecal pH in relation to normal fiber diets, with no significant influence on ammonia or volatile fatty acid concentrations.

So, in relation to the cecal conditions which promote proliferation of E. coli, none of these changes help to explain the high diarrea incidence observed with low fiber diets.

With the information available at present, the more probable explanation for the protective effect of fiber against diarrea would be its diluting effect on the dietary content of digestible nutrients, especially starch, as suggested by Cheeke and Patton (1980).

In this way, Figure 7 shows how in weanling rabbits the use of diets with a high starch content imply a significant increase in the amount of starch reaching the ileum. This effect was independent of the fiber content in the diet and did not reach significant levels at later ages (42 and 65 d), probably because of the parallel increase of the amylasic activity in the small intestine.

On the other hand, Figure 6 also shows that high fibrous diets (21% crude fiber), with a high proportion of wheat straw (30%) led to a significant increase in cecal pH and to a significant decrease in cecal volatile fatty acid concentration, creating conditions which could elicit proliferation of E. coli according to the work by Prohaszka (1980).

At a given dietary fiber content, type of fiber is another factor to take into account when trying to predict cecal fermentation traits in relation to diet composition.

As shown in Figure 8a, with respect to reference diets containing alfalfa hay and wheat straw as fiber sources, inclusion of a highly lignified byproduct, as grape marc, implies a slightly higher rate of increase of cecal pH, which is instead reduced when including beet pulp in the diet. Opposite effects of the substitution of alfalfa hay for grape marc or beet pulp were also found for volatile fatty acid and ammonia cecal concentrations (Figure 8b).

These results suggest a possible interest of combining different sources of fiber when trying to substitute alfalfa hay in the diet.

Direct substitution of grape marc for alfalfa hay might enhance enteritis problems because of the lower production of volatile fatty acids and the increase in cecal pH. Furthermore Figure 9 shows a trend for higher amounts of starch reaching the terminal ileum and the cecum when increasing the level of substitution of grape marc for alfalfa hay.

At the other extreme, levels of inclusion of sugar beet pulp in the diet higher than 15% imply an impairment of growth performance and of efficiency of conversion of DE for growth (García et al, 1992 a, b, c).

3.- Optimum of fiber for maximal growth performance

According to several works (de Blas et al., 1986; Partridge et al., 1989; García et al., 1992 a, b, c), ADF dietary content is highly related to variations in average live weight gain during the fattening period, irrespectively of the source of fiber used. Maximal groth rates were obtained for an interval from 19 to 22 % ADF on DM.

A possible explanation for the decrease of growth rate observed for low fiber diets would be a parallel accumulation of digesta in the cecum for diets with less than 20% of ADF on DM (de Blas et al., 1986). An increase of weight of cecal content, and a decrease of growth rate, have also been obtained for increasing levels of substitution of sugar beet pulp for barley grain (García et al., 1992 a, c). This accumulation of digesta in the cecum was also responsible for an impairment of carcass dressing percentage.

In conclusion, both a minimum (19) and a maximum (22% of ADF on DM) should be included in the diet to get maximal growth performance, along with a maximum of starch (15 - 16%) and a maximum of digestible fiber. Also, according to the results presented, substitution of byproducts for traditional sources of fiber should be made carefully to avoid digestive imbalances.

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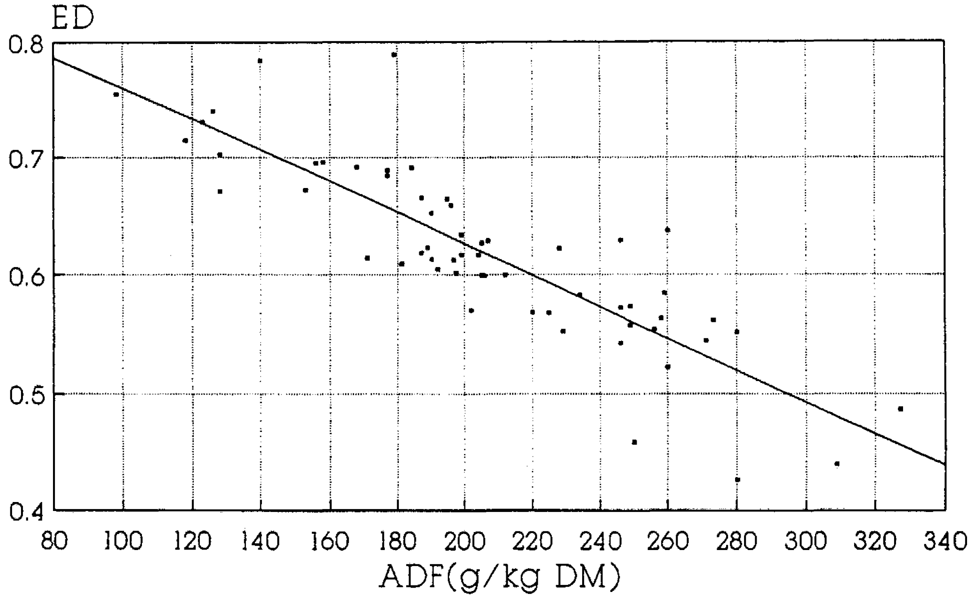
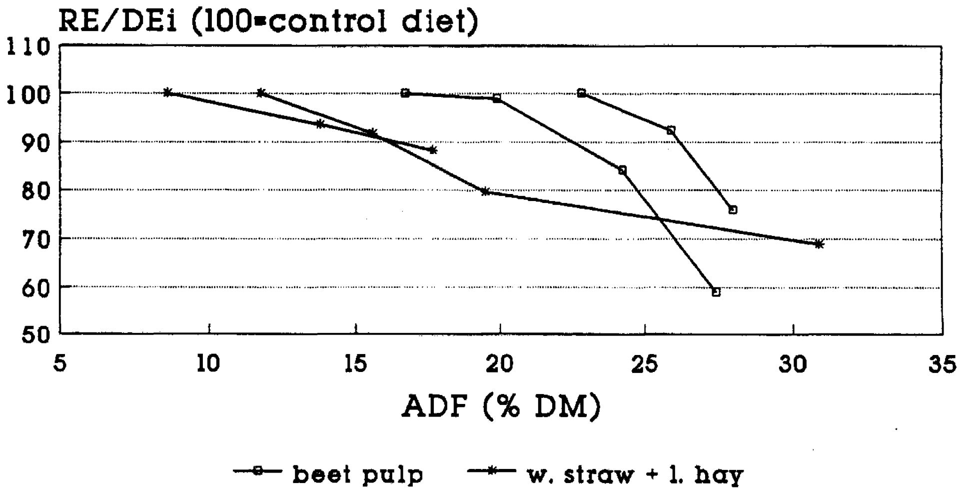
Figure 1a.- Effect of dietary ADF content on energy digestibility (ED)



de Blas, Wiseman and Villamide, 1992

Figure 1b.-Effect of a substitution of starch with several sources of fiber on DE efficiency for growth



De Blas et al. 1985; Ortiz et al. 1988; Garcia et al 1992 a,b

TABLE 1.- FIBER DIGESTIBILITY (%) OF SEVERAL FEEDSTUFFS FOR RABBITS

	Maertens et al ,1989 (CFd)	Villamide & de Blas,1989 (ADFd)
Oats, grain	12	15
Barley, grain	15	30
Corn, grain	40	43
Wheat bran	18	10
Corn gluten feed	42	28
Wheat straw	7	14
Alfalfa hay	10 - 20	-
Grape marc	12	7
Soyabean meal 44%	25	37
Sunflower meal 38%	-	29
Sunflower meal 32%	15	17
Beet pulp	60	38 - 72
Citrus pulp	-	68 - 83

Figure 2.- 95% CONFIDENCE INTERVALS FOR ADF DIGESTIBILITY (%)

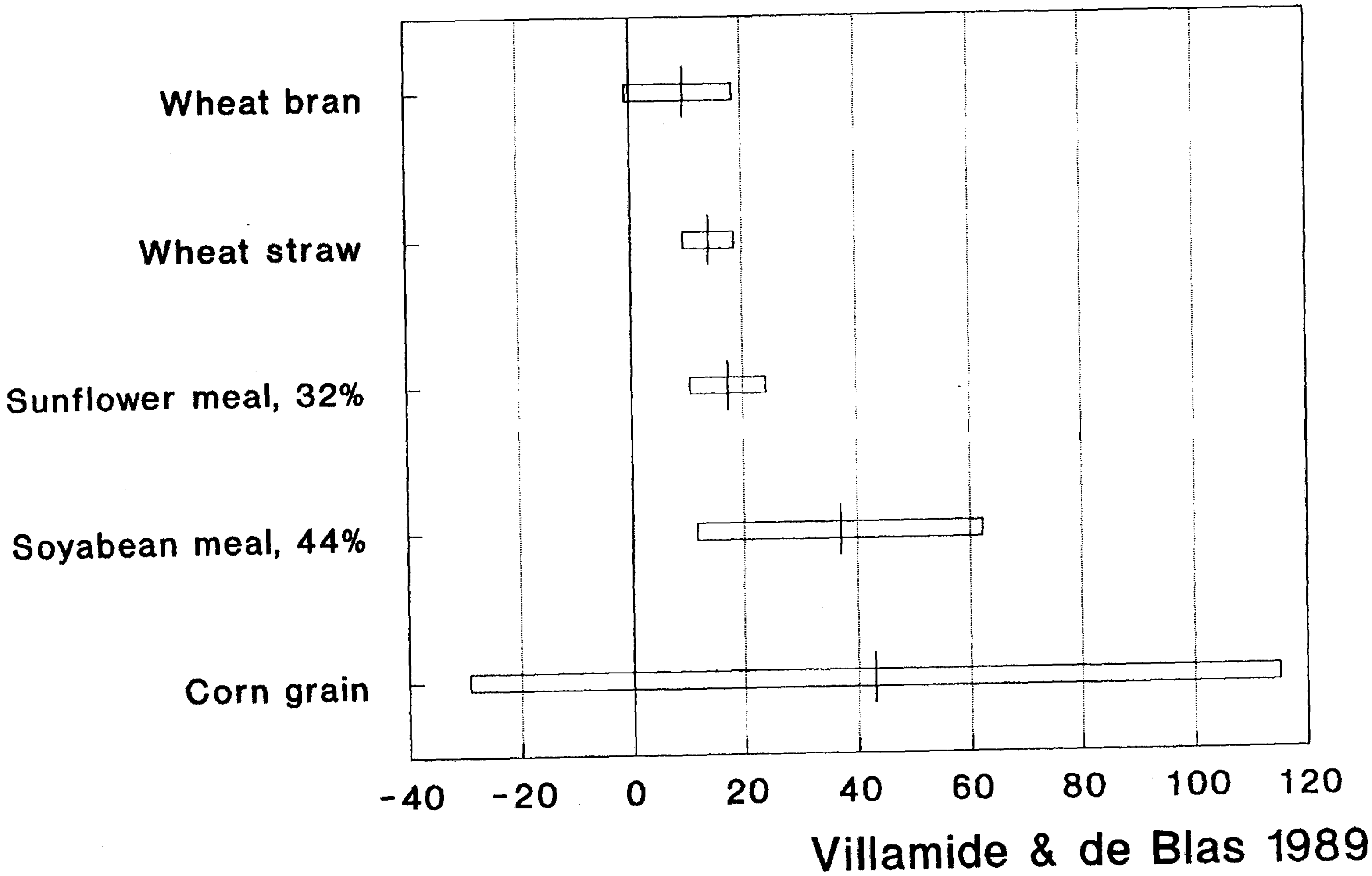


Figure 3.- Cell wall components in several sources of fiber

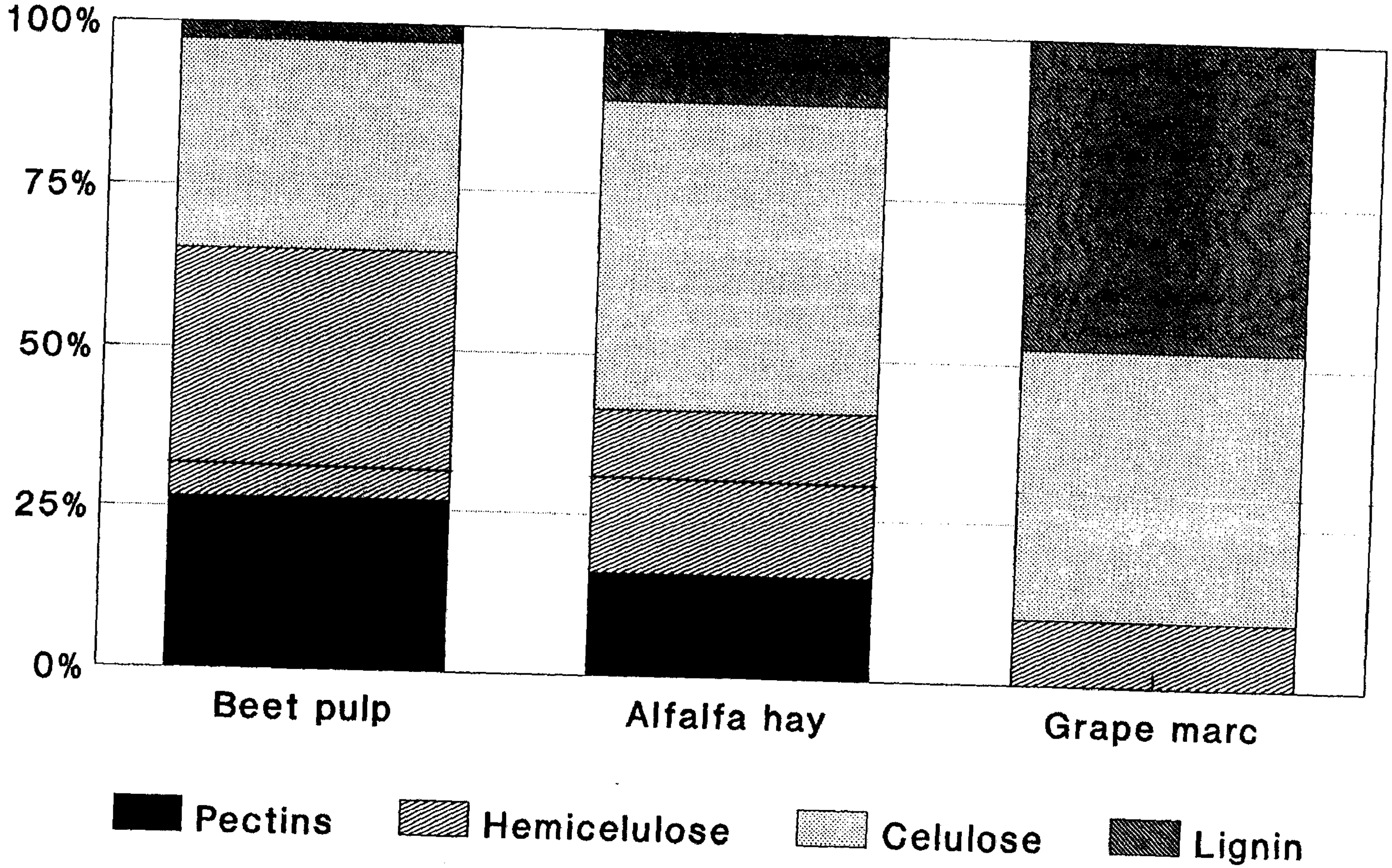
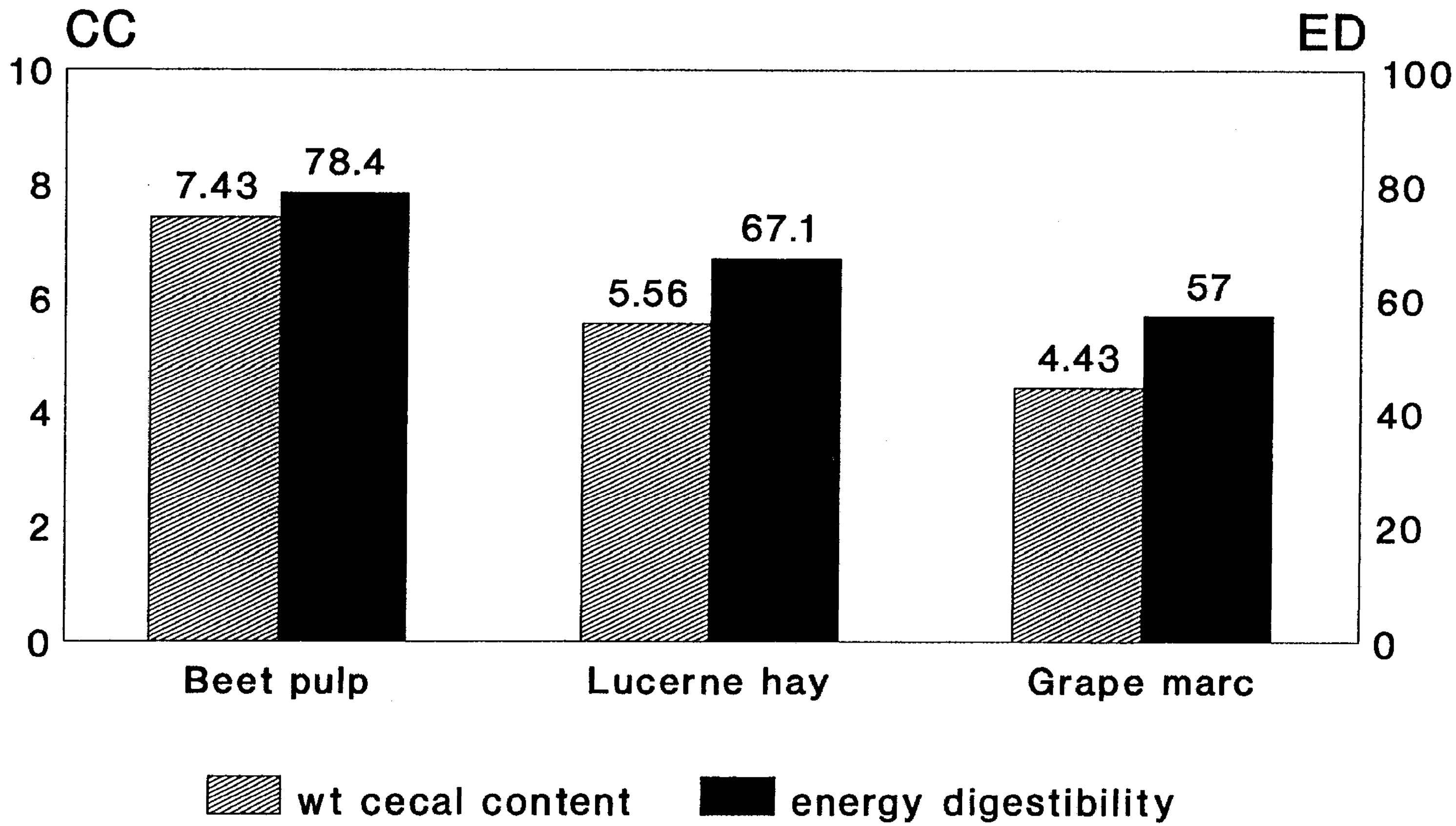
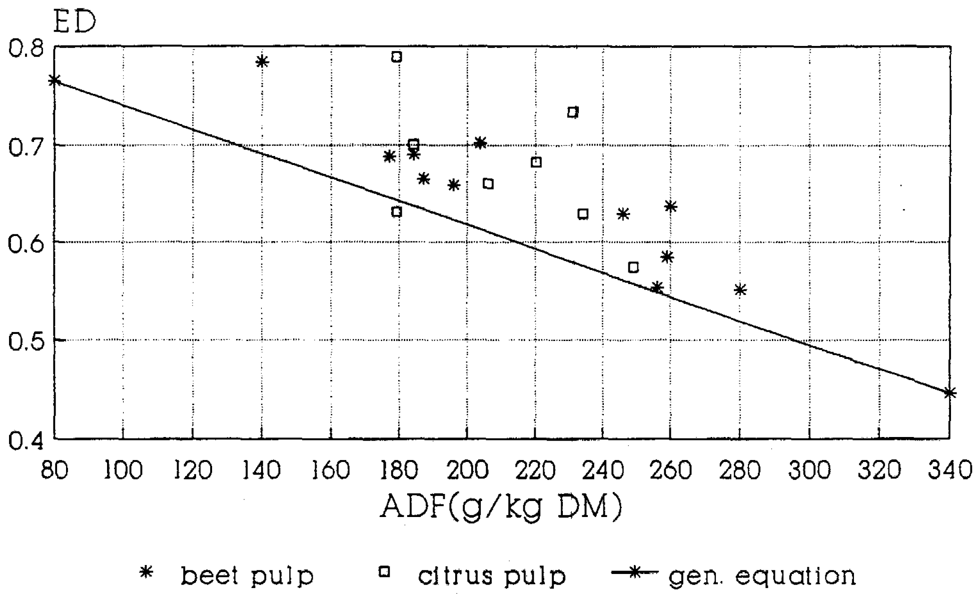


Figure 4.- Effect of type of fibre on weight of cecal content (CC, % body weight and energy digestibility (ED, %)

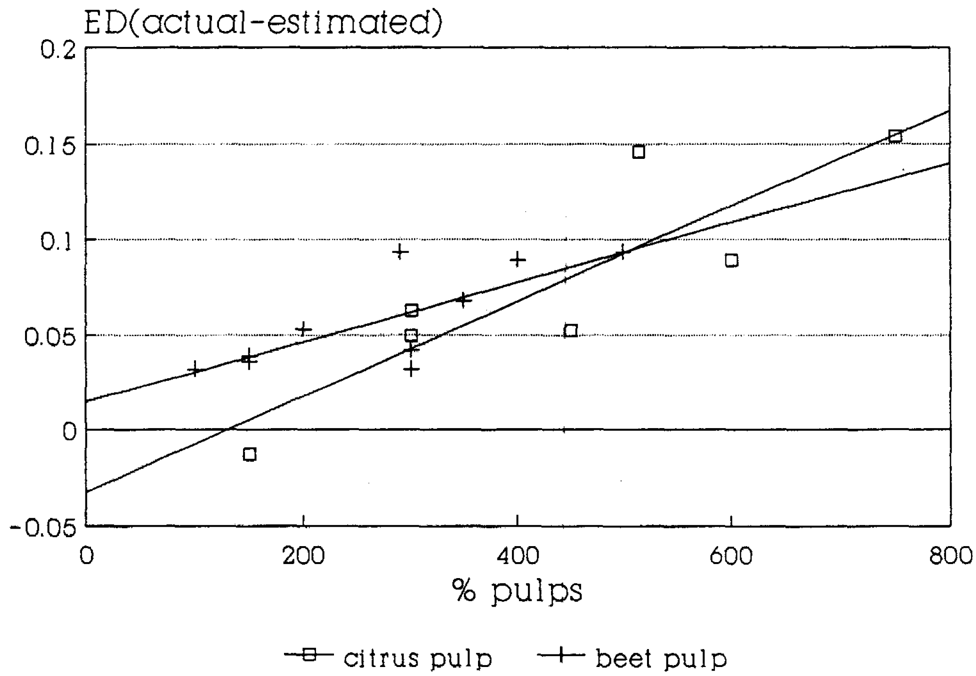


Fraga et al, 1991

Figure 5.- Energy digestibility (ED) in diets including beet and citrus pulps

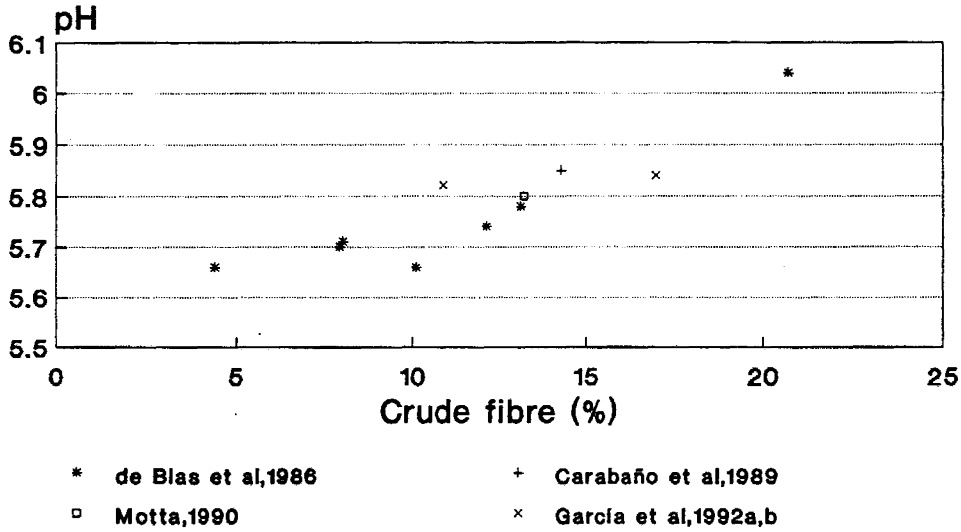


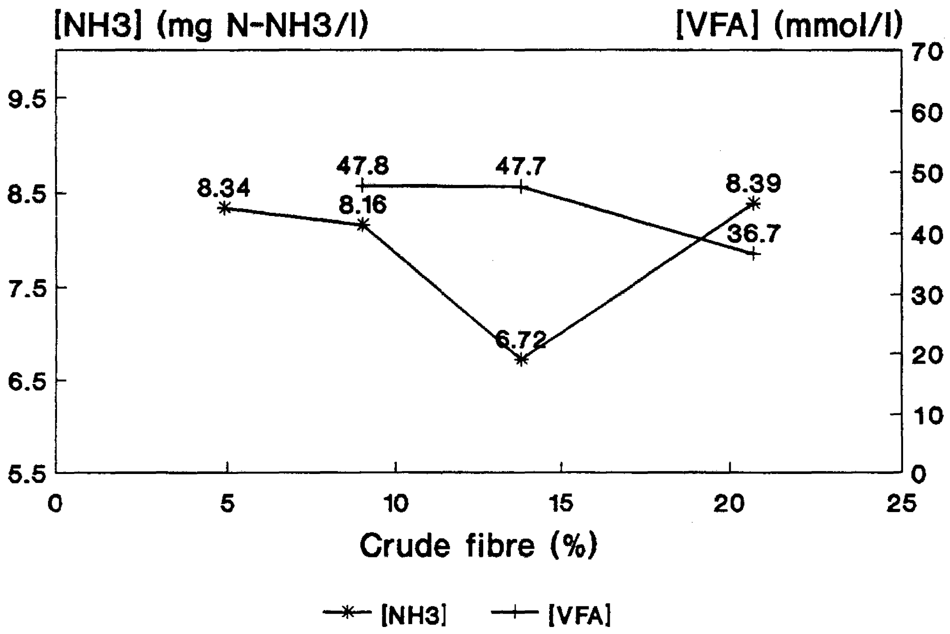
de Blas, Wiseman and Willamide, 1992



de Blas, Wiseman and Villamide, 1992

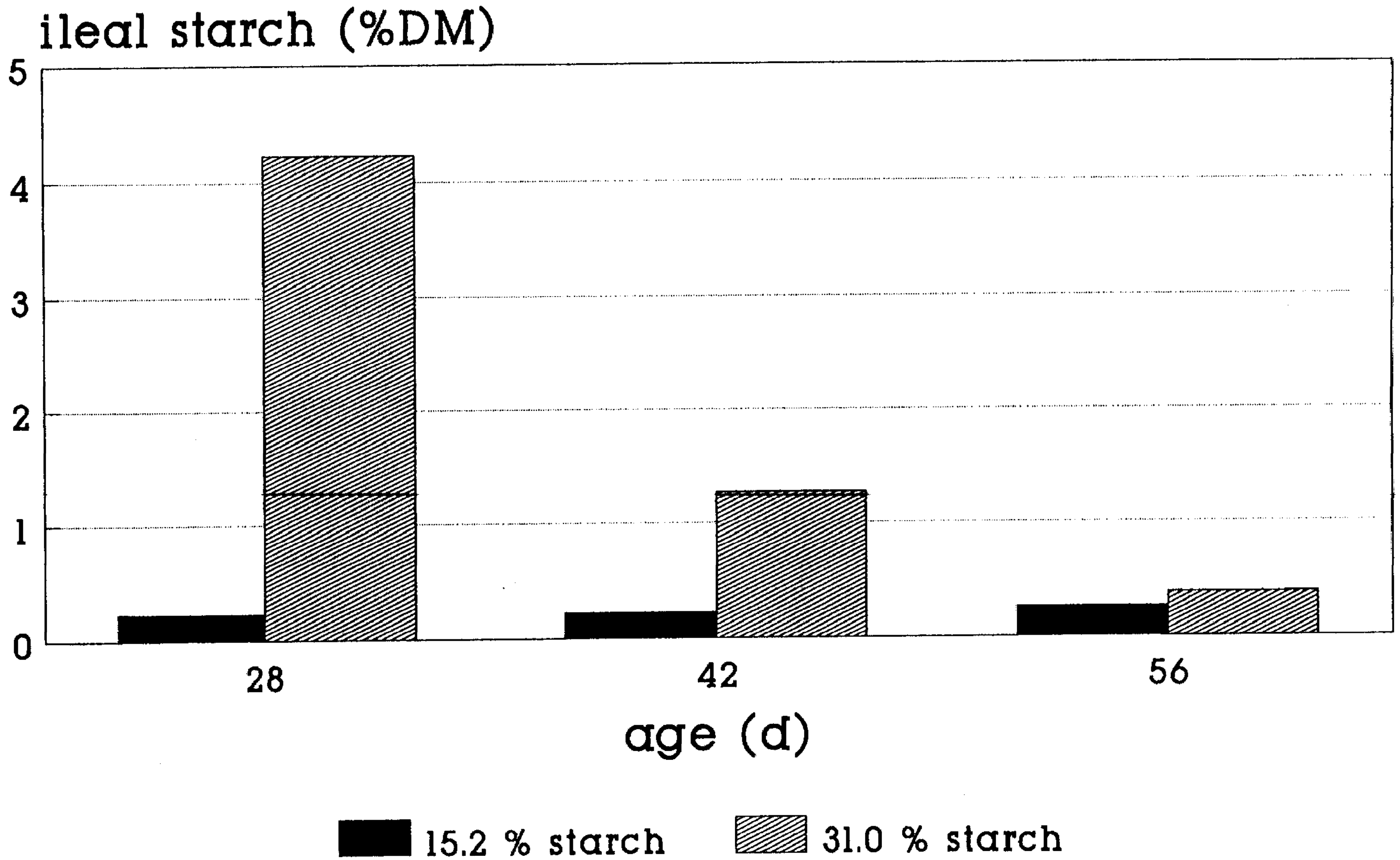
Figure 6.- Effect of dietary fibre content on several cecal parameters (traditional sources of fibre)





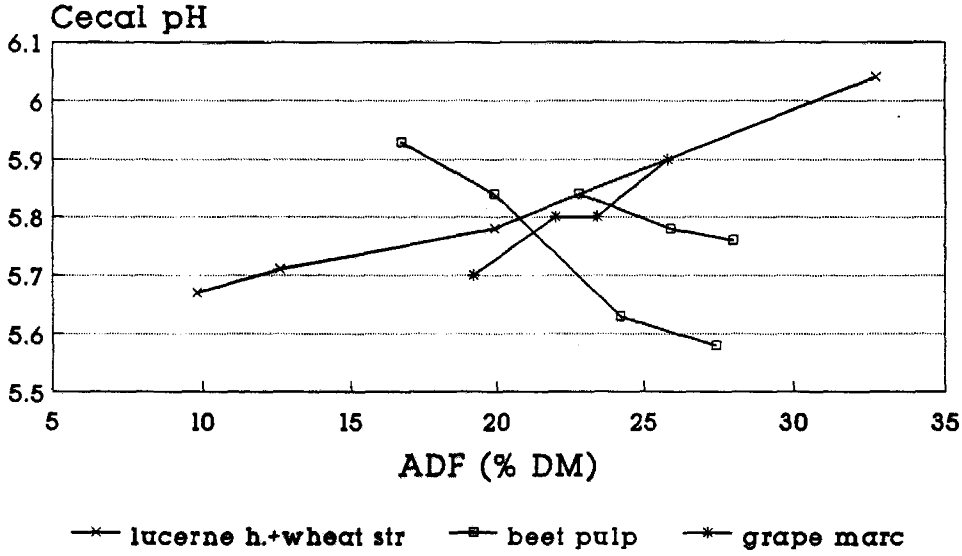
Carabaño et al. 1988

Figure 7.- Interaction age x dietary starch content on ileal starch content



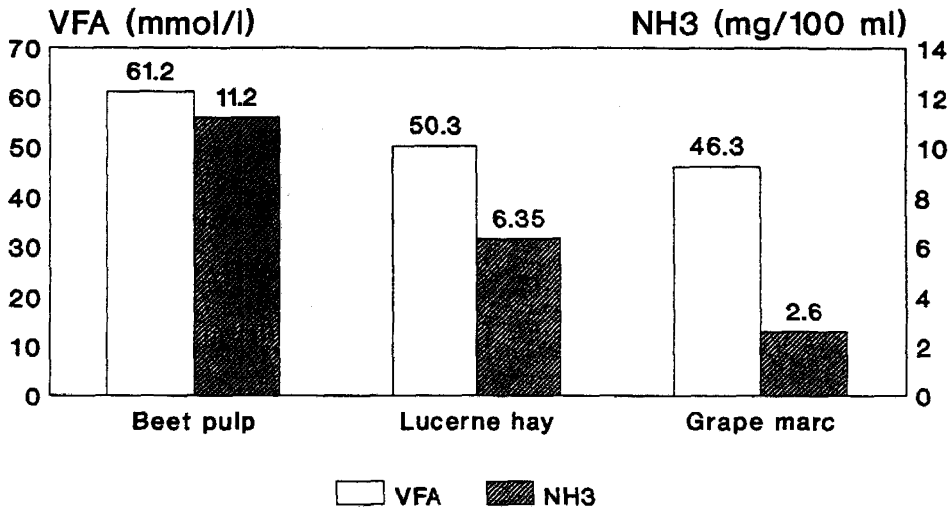
Blas (1986)

Figure 8a.-Effect of type and level of dietary fiber on cecal pH



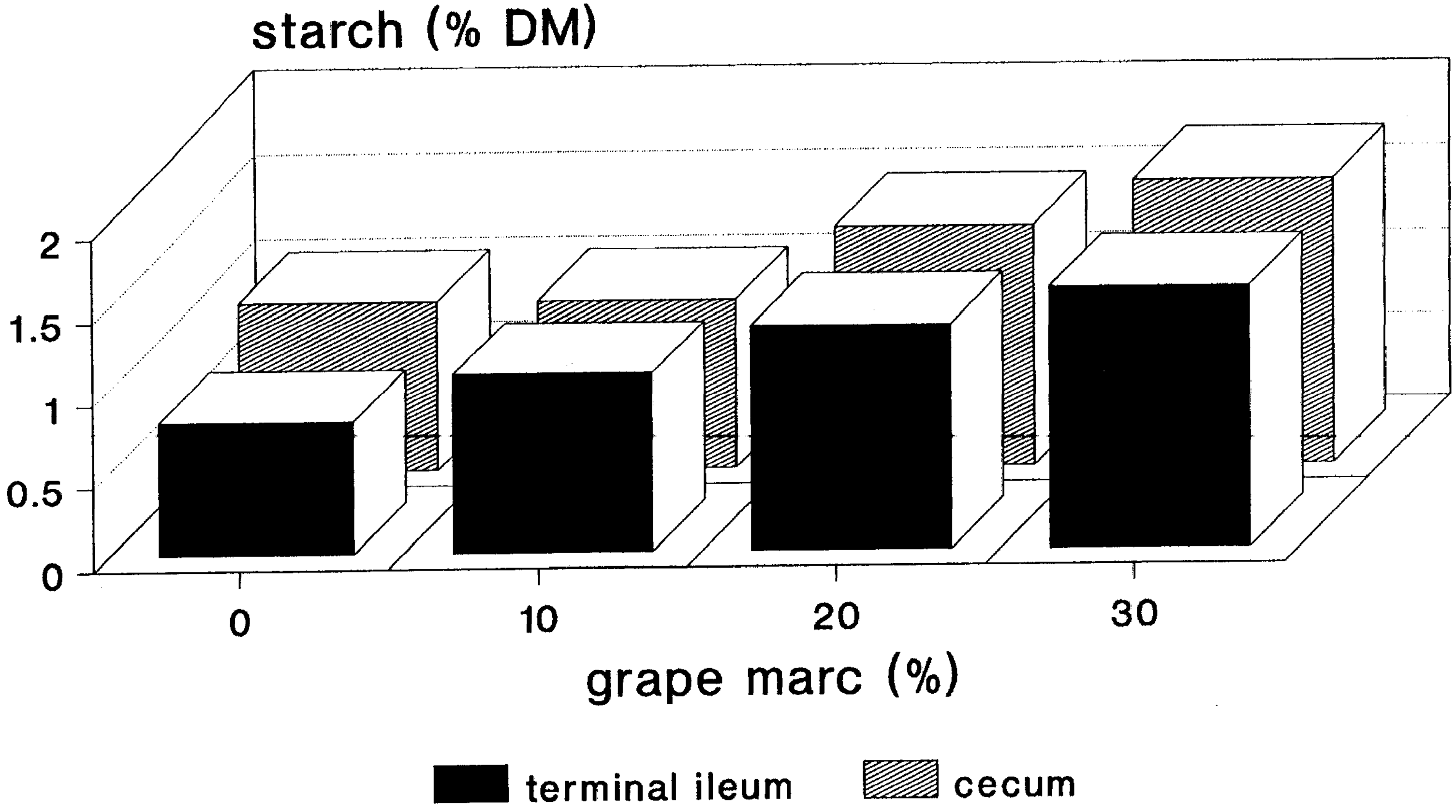
de Blas et al, 1986; Motta, 1990
Garcia et al, 1992a,b

Figure 8b.- Effect of type of fibre on cecal volatile fatty acid (VFA) and ammonia (NH3) concentration.



Fraga et al, 1991

Figure 9.- Effect of substitution of grape marc for lucerne hay on starch content in terminal ileum and cecum



Motta (1990)