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SUBSTITUTION OF BARLEY GRAIN BY SUGAR-BEET PULP IN DIETS FOR FINISHING RABBITS. 2. EFFECT ON GROWTH PERFORMANCE

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Abstract

Sixty New Zealand x California weanling rabbits were used to study the effect of replacing barley grain by sugar-beet pulp (SBP) on several growth and digestive traits in the fattening period. Three diets, formulated by substituting partial or totally barley grain by SBP in a control diet, and two slaughter weights (2 or 2.5 kg) were used in a 3 x 2 factorial arrangement. Inclusion of SBP significantly impaired (around 14% between extreme diets) live weight gain, lenght of the fattening period, total DM intake, and feed conversion rate, the differences being greater when proportion of SBP increased from 15 to 30 % than from 0 to 15%. Type of diet did not affect mortality rate, which averaged 6.25%. A higher dietary content of digestible fiber also implied a significant decrease of pH of cecum content, and a significant increase of stomach and cecum weights and of their contents, the differences among extreme diets ranging from 15 to 25%. As a consequence, carcass dressing percentage decreased ($P < .001$) from 59.9% in the control diet to 56.6% in the diet with a 30% of SBP. Weight at slaughter did not affect significantly live weight gain, but increased ($P < .001$) lenght of fattening period (by 16 days) and total DM intake (by 2.87 kg per animal as average); thus, feed conversion rate (gain/feed) was impaired ($P = .005$) by 10%. Stomach and cecum weight and weight of their contents were significantly lower for rabbits slaughtered at 2.5 than at 2 kg, which led to a significant increase of carcass dressing percentage (from 57.2 to 59.5%). Interaction diet x slaughter weight had not a significant effect on any of the variables studied.

Introduction

Several works (Franck and Seroux, 1980; Harris and Johnston, 1980; Martinez and Fernandez, 1980; Motta, 1990; Garcia et al., 1992a) have shown that inclusion of moderate levels of sugar-beet pulp (SBP) in diets for growing rabbits do not affect growth traits. However, maximum level of inclusion of SBP which allows to maintain animal performance varies from 15 to 45% among studies. Part of this variation may be due to interactions among major dietary components (starch, digestible and indigestible fiber), since those works differ in the type of feedstuffs substituted by SBP (cereal grains, alfalfa hay and mixtures grain/forages), and then in the chemical composition of the experimental diets.

Sugar-beet pulp contains a high proportion (70-80%) of low-lignified cell wall components, and a low content of starch (1-2%) and sugars (7-10%). This high concentration of digestible fiber, together to physical characteristics of SBP (especially swelling capacity), lead to major digestive and metabolic changes when SBP is included in the diet, especially in substitution of cereal grains (Garcia et al., 1992a). Digestive changes include i) a higher retention time of digesta in stomach and cecum (Fioramonti et al., 1978; Candau et al., 1979; Pairet et al., 1986, Bouyssou et al., 1988; Fraga et al., 1991), which implies a low value of its fibrous fraction to promote an adequate transit time in the gut, and ii) a greater extension of cecal fermentation, as measured by the increase in NDF digestibility (de Blas and Villamide, 1990; Motta, 1990; Garcia et al., 1992a, 1992b) or by the decrease in pH of the cecal content (Motta, 1990; Garcia et al., 1992a). In addition, there are also some indications that effects of SBP on digestion might be affected by the composition of the rest of the diet, especially indigestible fiber content (de Blas and Villamide, 1990; Garcia et al., 1992a).

The aim of this work has been to study the interaction among dietary carbohydrate fractions on growth performance and several digestive traits, by substituting barley grain with SBP at higher level of alfalfa hay (60 vs 30%) than that used in a previous work (Garcia et al., 1992a).

Material and Methods

Diets. Chemical composition of barley grain, SBP and experimental diets were the same as described in a previous presentation (Garcia et al., 1992b).

Growth Trial. The three experimental diets and two slaughter weights (2 and 2.5 kg), a range which includes extreme values of this variable in commercial farms, were used in a 3 x 2 factorial arrangement. Sixty male and female New Zealand White x California rabbits were assigned to treatments at random. Four animals died during the experiment, and were inmediately replaced to get ten replicates per each treatment combination; distribution of mortality rate was not related to type of diet. Rabbits were weaned at 30 d and were given ad libitum access to feed until they reached the preestablished slaughter weight. Feed intake and length of the experimental period were recorded for each rabbit. Animals were slaughtered at 1800, in order to avoid the period of soft feces excretion. Stomach and cecum weight, weight and pH of their contents and carcass dressing percentage of each animal (excluding gastrointestinal tract, skin, blood, tail and hooves) were determined.

Housing. Rabbits were kept in a closed building with partial environmental control. Temperature during the experimental period ranged from 16 to 20° C. A cycle of 16 h light and 8 h dark was used throughout the experiment.

Statistical Analysis. Data were analysed using the ANOVA procedure of SAS (1985) with type of diet and slaughter weight as main sources of variation. Weaning weight was introduced as a covariate in growth traits analyses; for these traits data are presented as least square means. Tests for differences among diets were made using a t-test, except for mortality rate, where a chi-square test was used.

Results and discussion

The effect of type of diet on growth performance is shown in Table 1. Proportion of SBP in the diet significantly impaired (around 14% between extreme diets) live weight gain, length of fattening period, total DM intake and feed conversion rate; the differences were smaller (not reaching significant levels) between diets 30:0 and 15:15 than between diets 15:15 and 0:30. Part of the decrease in feed conversion rate was due to a decrease in energy digestibility with increasing levels of SBP in the diet (Garcia et al., 1992b).

The effects of dietary level of fiber on live weight gain and feed conversion rate obtained in this work are presented in figure 1 in comparison with other studies, where the increase of fiber level was made by inclusion of digestible fiber at lower levels of indigestible fiber (Garcia et al., 1992a), or by inclusion of 'traditional' fibrous feeds as grass meal (Partridge et al., 1989) or alfalfa hay and wheat straw (de Blas et al., 1986); in all the cases the fibrous sources mainly replaced cereal grains in the diet. Figure 1 shows a consistent relationship between ADF content and both growth traits, in spite of the great variations in the relation starch:digestible fiber:indigestible fiber among the different diets; however, feed conversion rate tended to increase when increasing proportion of digestible fiber at a given level of ADF content. Dietary DE concentration was a worse predictor than ADF of variations of growth performance, mainly because failed to detect impairment related to diets with a high proportion of digestible fiber. A similar conclusion can be derived from works where SBP was included in the diet at expense of other sources of fiber (Franck and Seroux, 1980; Motta, 1990), since no significant differences in live weight gain were found among isofibrous diets with varying proportions of indigestible and digestible fiber, although energy digestibility (and feed conversion rate) were improved with substitution of indigestible by digestible fiber. Figure 1 also shows that live weight gain tended to increase slightly for diets containing around 20% ADF on DM with respect to low-fiber diets, and to decrease linearly for higher ADF levels; feed conversion rate tended to decrease continously with total ADF content, the rate of decrease being slowlier when level of fiber was lower than 20% ADF on DM.

Inclusion of SBP in the diet elicited a significant accumulation of digesta in the cecum (see Table 1), in agreement with results of previous studies (Candau et al., 1979; Motta, 1990; Fraga et al., 1991; Garcia et al., 1992a). As shown in Figure 2a, the effect of fiber level on weight of cecal content is affected by type of fiber added, since no increments were observed when 'traditional' (and more lignified) sources of fiber were used (de Blas et al., 1986). Part of the variation is corrected when using indigestible ADF as independent variable.

Low intestinal motility and high cecal content have been related by numerous authors to the high diarrhea incidence observed in low-fiber diets. Nevertheless, mortality rate was not affected by type of diet in this work (see Table 1), neither in previous studies using levels of inclusion of SBP of 30-50% (Franck and

TABLE 1. EFFECT OF DIET COMPOSITION AND SLAUGHTER WEIGHT ON SEVERAL PRODUCTIVE AND DIGESTIVE TRAITS

	Barley:SBP[a], %					Slaughter wt (kg)			
Item	30:0	15:15	0:30	SE[b]	P	2.0	2.5	SE[c]	P
Live wt gain, g/d	33.5^{x}	32.0^{x}	28.9^{y}	.86	.006	31.5	31.5	.70	NS
Length of fattening period, days	50.2^{x}	52.2^{x}	57.5^{y}	1.6	.022	45.3	61.3	1.3	.001
Total DM intake, kg	6.55^{x}	6.74^{x}	7.52^{y}	.21	.004	5.50	8.37	.17	.001
Feed conversion rate, live wt gain/DMI	.258^{x}	.250^{x}	.225^{y}	.01	.016	.257	.231	.01	.005
Mortality rate, %	4.76	4.76	9.09	.24	NS	6.25	6.25	.19	NS
Stomach content wt, % of BW	3.10^{x}	3.31^{xy}	3.82^{y}	.18	.021	3.67	3.15	.15	.015
organ wt, % of BW	1.05^{x}	1.16^{y}	1.28^{z}	.03	.001	1.21	1.10	.02	.002
Cecum content wt, % of BW	4.88^{x}	5.24^{xy}	5.61^{y}	.20	.047	5.53	4.95	.16	.016
organ wt, % of BW	1.44^{x}	1.65^{y}	1.78^{y}	.05	.001	1.74	1.51	.04	.001
pH	5.84^{x}	5.78^{xy}	5.76^{y}	.03	.050	5.80	5.78	.02	.001
Dressing percentage	59.9^{x}	58.6^{y}	56.6^{z}	.43	.001	57.2	59.5	.35	.001

[a]SBP = Sugar-beet pulp.

[b]SE = Standard error of treatment means for diet, n = 20.

[c]SE = Standard error of treatment means for slaughter wt, n = 40.

^{x,y,z}Means within a row lacking a common superscript letter differ ($P < .05$)

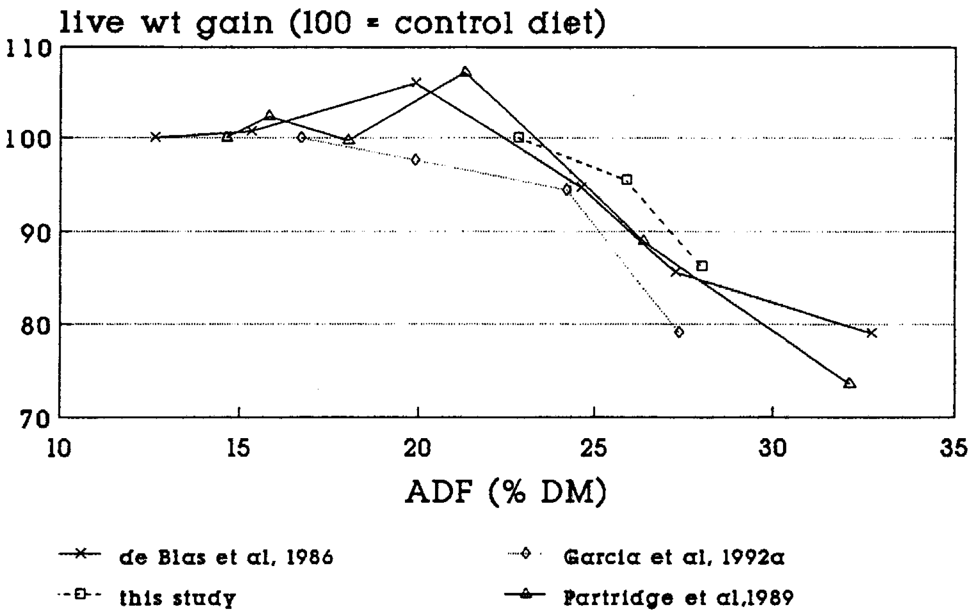

Figure 1a

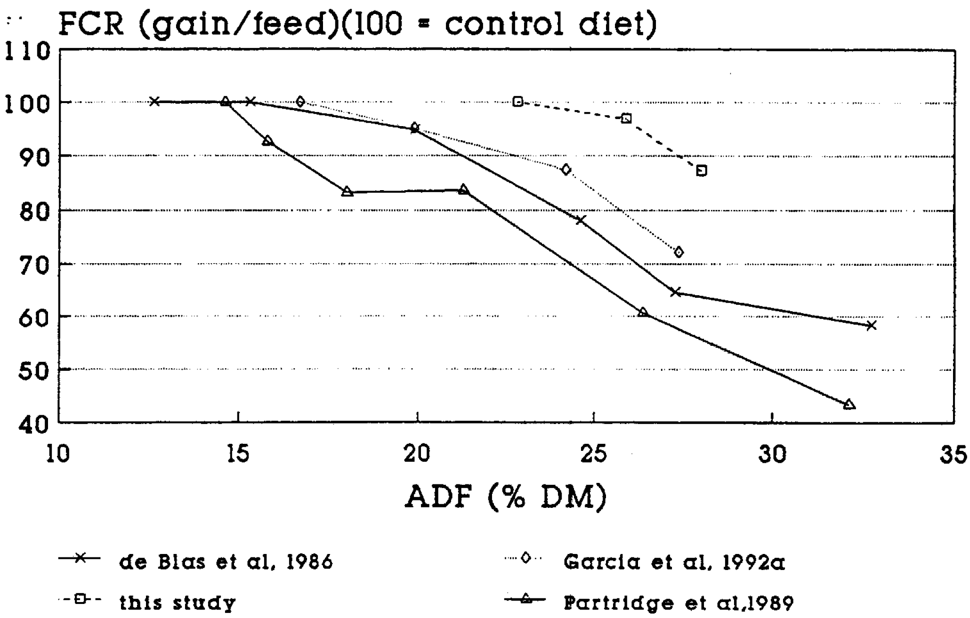

Figure 1b

Figure 1. Effect of dietary ADF content on a) average live weight gain and b) feed conversion rate in the fattening period, according to different studies.

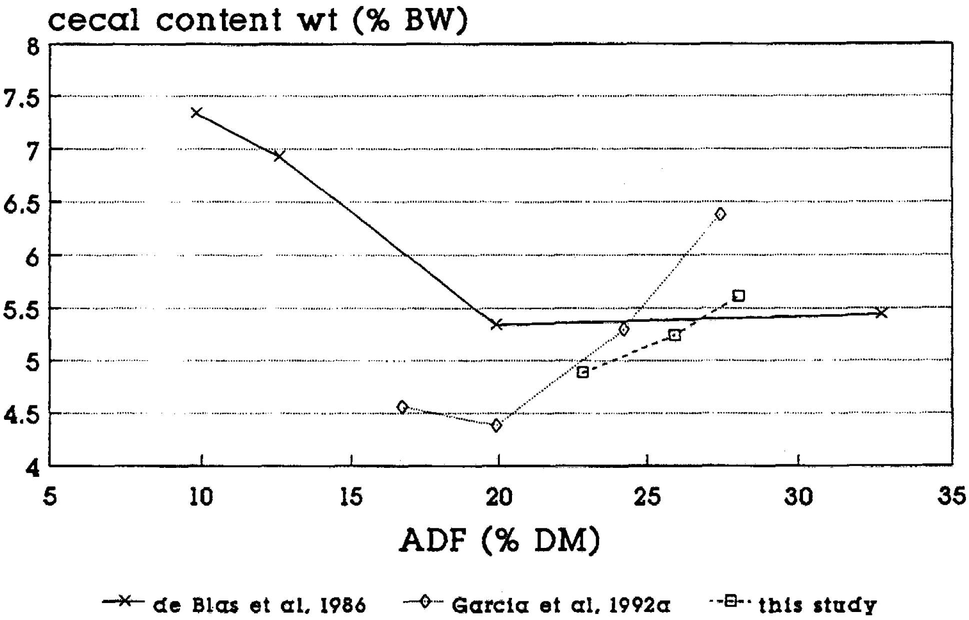

Figure 2a

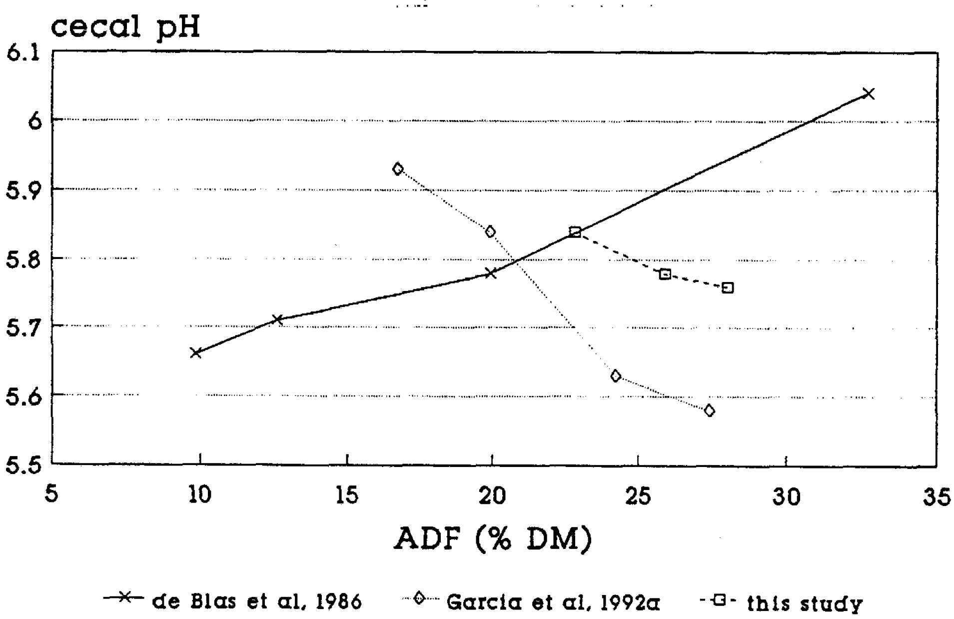

Figure 2b

Figure 2. Effect of dietary ADF content on a) weight of cecal content (% of total body weight) and b) cecal pH, according to different studies.

Seroux, 1980; Motta, 1990, Garcia et al., 1992a). These results seem to support the hypothesis that high dietary starch content, rather than gut motility, is the primary cause of diarrhea incidence in rabbits (Cheeke and Patton, 1980). In any case, a minimum and a maximum of indigestible and digestible fiber, respectively, should also be considered in diet formulation to obtain maximum growth performance.

On the other hand, Table 1 and Figure 2b, show that inclusion of digestible fiber, in contrast of replacement of cereal grains by alfalfa hay and wheat straw (de Blas et al., 1986; see Figure 2b), implied a decrease of cecal pH, which agrees with previous results (Motta, 1990, Garcia et al., 1992a). Furthermore, Prohaszka (1980) showed *in vitro* that low pH and high volatile fatty acid concentration in cecum content inhibit *Escherichia coli* proliferation. An increase of cecal pH has been reported for diets with a high content of indigestible fiber (Morisse et al., 1985; de Blas et al., 1986; Motta, 1990). For such diets, replacement of limited amounts of indigestible by digestible fiber might decrease the incidence of digestive disorders.

Inclusion of SBP implied a significant increase of weight of stomach and cecum and of their contents (Table 1); consequently, carcass dressing percentage decreased (by 3.3 percentage units, P < .001) between the extreme diets. As shown in Figure 3, these results agree with those obtained previously (Garcia et al., 1992a) with inclusion of SBP in diets with lower content in alfalfa hay. However, no significant differences in dressing percentage were observed when dietary ADF level increased through replacing cereal grains by grass meal (Partridge et al., 1989, see Figure 3).

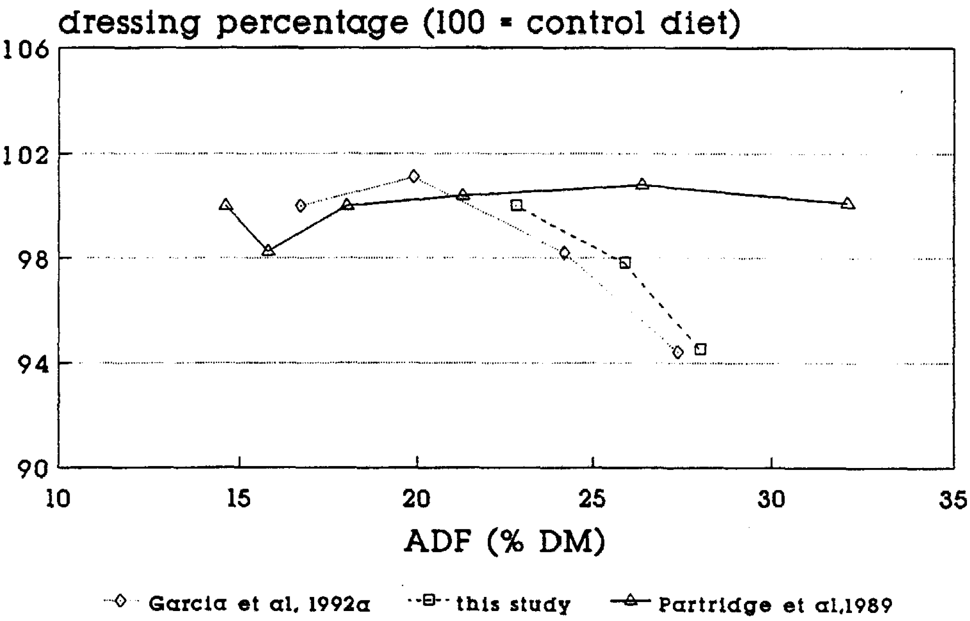

Figure 3.- Effect of dietary ADF content on carcass dressing percentage, according to different studies.

Slaughter weight did not affect either average live weight gain or mortality rate, but rabbits slaughtered at 2.5 kg showed a greater length of fattening period (by 16 days, $P < .001$), a higher total DM intake (by 2.87 kg, $P < .001$), and a lower feed conversion rate (by .026 units, gain/feed; $P = .005$) than those slaughtered at 2.0 kg (see Table 1). Increasing slaughter weight also implied a significant decrease (ranging from 9 to 14%) of weight of stomach and cecum and of their contents (expressed as % of total body weight); as a consequence, carcass dressing percentage increased significantly (by 2.3 units) for rabbits slaughtered at the heaviest weight.

Interaction type of diet x slaughter weight did not affect significantly any of the variables studied.

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