Formaldehyde protection of syrup off based diets for pigs. Feeding value and nutrient utilization

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ABSTRACT: Two trials, each involving 12 crossbred (YLD) pigs, were conducted to evaluate diets containing 61.7% syrup off protected or not with formaldehyde (2 mL/kg). The remaining 38.3% of the diet was torula yeast, minerals and vitamins. In trial 1 higher ($P < 0.05$) voluntary feed intake and rate of gain were observed in finishing pigs (50-90 kg) fed the protected as opposed to unprotected syrup off stored at ambient temperature. In trial 2, unprotected syrup stored under refrigeration was consumed in slightly greater quantity than the protected material. Digestibility of DM and OM were unaffected ($P < 0.10$) by dietary variables and, although formaldehyde protection depressed ($P < 0.05$) energy and N digestibility, there were no differences between treatments in N and energy retention. The protection of syrup off for pig feeding by formaldehyde addition is suggested as a useful option.

Key words: Digestibility, energy balance, growth, nitrogen balance, pigs, syrup off

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Protección con formaldehído de dieta de sirope de refinería para cerdos. Valor alimentario y utilización de nutrimentos

RESUMEN: En dos pruebas, cada una con 12 cerdos de raza cruzada (YLD), se evaluaron dietas incluyendo 61.7% de sirope de refinería protegido o no con formaldehído (2 mL/kg). El resto de la dieta (38.3%) se componía de levadura torula y fuentes de minerales y vitaminas. En la prueba 1 se observó mayor ($P < 0.05$) consumo voluntario y tasa de ganancia en cerdos en acabado (50-90 kg) alimentados con sirope protegido contra el no protegido al realizar el almacenaje del mismo a temperatura ambiental. En la prueba 2, el sirope no protegido almacenado bajo refrigeración fue consumido en cantidad levemente mayor que el protegido. La digestibilidad de materia seca y materia orgánica no acusó efecto ($P < 0.10$) de las variables dietéticas y, aunque la protección con formaldehído disminuyó ($P < 0.05$) la digestibilidad de energía y nitrógeno, no hubo diferencias entre tratamientos en la retención de energía y N. Se sugiere que la protección del sirope de refinería destinado a la alimentación porcina con formaldehído es una opción útil.

Palabras clave: Digestibilidad, balance de energía, crecimiento, balance de nitrógeno, cerdos, sirope de refinería

Introduction

In many sugarcane growing areas of the world, including Cuba, syrup off is a locally available source of energy for possible use as an animal feed. It is a by-product of raw sugar refining. However, being a liquid with high sucrose content, it is difficult to handle if no provision is made to prevent the spontaneous fermentation that commonly occurs in such materials (Pérez, 1997).

The efficacy of using low levels of formaldehyde to prevent deterioration of liquid feeds fed to pigs has been demonstrated (Barber *et al.*, 1956; Fevrier *et al.*, 1993; Larrahondo and Preston, 1989).

Earlier studies at this institute on the use of syrup off protected with formaldehyde, indicated improved performance in pigs fed this material (Ly and Castillo, 1983). The present work was conducted to further evaluate the effects of formaldehyde protected syrup off on the performance of pigs. A further objective was to determine digestibility and N and energy balances in pigs fed a diet based on protected syrup off.

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Materials and Methods

The syrup off used in this study was obtained in a single batch from a sugar refinery located in Havana Province. Analysis of samples showed the syrup off to contain 72.2% dry matter (DM) and in the DM 94.5% sucrose, 0.95% ash and 3.97 kcal gross energy/g. The N content in syrup off was negligible (0.06%) and its pH value was 5.1. This syrup was divided in two batches which were treated or not with a concentrated formaldehyde solution (37%) at the rate of 2 mL/kg syrup.

Trial 1. Twelve cross bred (YLD) pigs of mean initial weigh 50.5 kg were randomly assigned (three female and three castrated males) to each of two treatments: a basal diet of syrup with or without formaldehyde protection and torula yeast (Table 1). The animals were housed in individual concrete-floor pens with open-front shelters. Individual feeding stalls and automatic water troughs were provided and the pigs were fed ad libitum the experimental diets for 50 days.

The treated and untreated syrup off was mixed daily with the other dry ingredients of the diet before offering to the animals. Syrup off was stored at ambient temperature (approximately 25°C) in covered, metallic containers. At the end of the experiment, grab samples of feces were obtained. These were immediately homogenized and pH was estimated by use of a glass electrode. Aliquot fecal samples were dried in a forced-air oven at 60°C for 72 hr. After drying, the samples were allowed to equilibrate with atmospheric moisture and ground through a 1 mm mesh screen in a small cyclone-type mill. Dry matter and ash were estimated in feeds and feces by standard methods (AOAC, 1990). The organic matter fraction (OM) was defined as 100 - % ash. Acid insoluble ash was determined in feed and feces as outlined by Van Keulen and Young (1977), for use as an internal digestibility indicator.

Trial 2. Twelve YLD castrated male pigs weighing 24.9 kg initially were randomly assigned to the same treatments described in trial 1, except that in this case syrup off was stored at 5ºC until used. The animals were randomly divided in two groups of six pigs and fed twice daily at a level of 40 g DM per kg body weight. Each pig received each diet for a 14-day period, of which the first seven days were spent in individual pens and the last seven days in metabolism cages. Feces and urine were collected during the last five days according to procedures described elsewhere (Ly *et al.,* 1991). The homogenized excreta and urine were stored at –20°C until analyzed.

Nitrogen content in the diets, feces and urine was determined in undried samples by the macrokjeldahl procedure (AOAC, 1990). Gross energy determinations were made with an adiabatic bomb calorimeter following standard procedures. The pH values were measured in fresh feces with a glass electrode. Fecal DM and OM were estimated as in trial 1. Urinary fructose content was determined by the anthrone method as outlined by Ly and Macias (1979).

Table 1. Formula and nutrient composition of the basal diet (dry basis).

Component	Content
Ingredients (%)	
Syrup off	61.7
Torula yeast	35.8
Calcium carbonate	1.0
Sodium chloride	0.5
Vitamins and trace elements premix[1]	1.0
Chemical analysis	
DM (%)	71.4
N x 6.25 (%)	17.0
Ash (%)	4.2
Crude fibre (%)	0.9
Gross energy, kcal/g DM	4.10

[1]Provided the following per kg of diet: 600 IU vitamin A; 160 IU vitamin D_3; 20 IU vitamin E; 2 mg thiamin; 3 mg riboflavin; 15 mg pyriodoxin; 5 mg calcium panthotenate; 25 µg vitamin B_{12}; 300 mg choline chloride; 0.5 mg folic acid; 2 mg menadione sodium bisulphate; 0.4 mg cobalt; 10 mg iron; 0.5 mg iodine.

The data from both trials were subjected to analysis of variance in a completely random design (SAS, 1982), meaning a simple classification model (Steel and Torrie, 1980).

Results and Discussion

The pigs remained healthy throughout the trials and no symptoms of animal discomfort were observed, Postmortem examinations revealed no gross abnormalities.

Trial 1. Mean values for performance criteria during the finishing phase are shown in Table 2. There was a tendency ($P < 0.05$) for higher voluntary feed intakes (2.93 vs. 2.69 kg) and daily gain (824 vs. 744 g) in pigs fed the protected syrup off. There was no difference ($P > 0.05$) between dietary treatments in feed/gain ratio. The relative reduction in voluntary feed intake (8.2%) of pigs fed the untreated syrup off may have been due to deterioration of the syrup, which decreased markedly in pH value (from 5.10 to 4.75) at the end of the trial. In a previous study, pigs fed syrup off showed better production performance than those fed sugarcane molasses during the finishing phase (Ly and Castro, 1984).

No differences were found between the dietary treatments in the digestibility indices. The high levels of DM and OM digestibility of these diets containing syrup off can be ascribed to their high sucrose content (94.5% on the dry basis). The very high digestibility of sucrose has been established previously (Ly, 1992; Ly *et al.,* 1995).

Trial 2. Although not a significant difference ($P < 0.10$), relative intake of the formaldehyde-treated diet was less (94.7%) than that of the untreated diet (Table 3). Similar results were reported by Patterson *et al.* (1989) in studies on

Table 2. Rate and efficiency of liveweight and fecal characteristics of pigs fed diets on protected or unprotected syrup off (Trial 1).

Variable	Formaldehyde protection		SE[1]
	(-)	(+)	
Growth characteristics			
Initial weight (kg)	50.5	50.4	0.5
Final weight (kg)	87.7	91.6	1.5*
Daily feed intake (kg)	2.69	2.93	0.04*
Daily gain (g)	744	824	25*
Feed/gain	3.61	3.60	0.11
Fecal characteristics			
DM (%)	21.5	24.3	1.2
pH	6.3	6.3	0.2
Digestibility (%)			
DM	93.9	93.7	0.9
OM	94.8	94.6	1.5

[1]Standard error of difference
*P < 0.05.

pigs fed swill protected with graded levels of formaldehyde. However, these results are in opposition to those of trial 1, in which the inclusion of fermented, unprotected syrup off decreased the voluntary feed intake. Perhaps this discrepancy can be explained by the different conditions of storage of the syrup off in the two trials. In fact, certain signs of pig aversion to the organoleptic characteristics of dietary formaldehyde could explain the lower intake of this diet than that of the diet based on unprotected syrup off stored at low temperatures. (Trial 2). In contrast, in trial 1, when storage of syrup off occurred at the rather high environmental temperature, acidity of the unprotected diet might have been associated with subclinical illness (Houpt *et al,* 1979), and consequently lessened feed intake.

Some observation on fecal characteristics are given in Table 3. No differences were found between treatments for fecal DM concentration and pH values, which are in agreement with the results of trial 1. However, there was a trend (P < 0.10) for daily fresh feces outflow to be higher and DM and OM digestibility to be lower for the formaldehyde-treated syrup off diet. This was probably due to an increase in the contribution of the hindgut to overall digestion, as has been observed under other circumstances in pigs fed diets based on torula yeast and simple sugars (Ly, 1992). Patterson *et al.* (1989) did not find differences in DM and OM digestibility when pigs were fed diets based on swill and soybean meal treated or not with formaldehyde. However, these comparisons are difficult to assess, since in the cited study the level of feed intake was considerably lower and digestibility indices were also rather low.

Table 3. Fecal characteristics and digestibility of pigs fed diets based on protected or unprotected syrup off (Trial 2).

Variable	Formaldehyde protection		SE[1]
	(-)	(+)	
Dry matter intake (kg/day)	1.300	1.246	0.041
Fecal characteristics			
Fresh outflow (g/kg DM intake)	165	249	53[+]
Dry matter concentration (%)	25.4	24.8	1.5
pH	6.1	6.1	0.3
Digestibility (%)			0.7[+]
Dry matter	95.8	93.7	1.1[+]
Organic matter	96.7	94.6	

[1]Standard error of difference
[+] < 0.10

Data on urinary characteristics and energy balance are shown in Table 4. There were small differences between treatments in energy input due to the variation in DM intake (Table 3). Energy output in feces tended to be higher (P < 0.10) for pigs receiving the formaldehyde-treated syrup off, but there was little difference between the urinary energy losses of pigs receiving either dietary treatment. Therefore, the estimated energy digestibility was higher (P < 0.05) in the diet without formaldehyde. However, there was no treatment effect on any of the calculated energy retention indices. These results support the assumption that energy losses due to microbial activity in the alimentary canal could be responsible for the differences in energy digestibility values.

Table 4. Urine characteristics and energy balance in pigs fed diets based on protected or unprotected syrup off (Trial 2).

Variable	Formaldehyde protection		SE[1]
	(-)	(+)	
Urine characteristics			
Calorific value of N (kcal/g)	13.38	12.48	0.48
Fructose (mg/dl)	464	354	57
Energy balance (Mcal/day)			
Intake	5.33	5.11	0.17
Fecal excretion	0.18	0.28	0.07[+]
Digestion	5.15	4.83	0.16[+]
Urinary excretion	0.45	0.61	0.09
Retention	4.70	4.50	0.20
Digestibility (%)	96.7	94.5	0.6*
Retention (% intake)	88.2	88.0	0.5
Retention (% digestion)	91.2	93.2	0.3

[1]Standard error of difference.
[+]P < 0.10; *P < 0.05.

Table 5. Nitrogen balance in pigs fed diets based on protected or unprotected syrup off (Trial 2).

Variable	Formaldehyde protection		SE[1]
	(-)	(+)	
Balance (g/day)			
Intake	35.4	33.8	1.5
Fecal excretion	3.4	4.8	0.5[+]
Digestion	32.0	29.0	1.4
Urinary excretion	9.7	8.1	0.7
Retention	22.3	20.9	1.4
Digestibility (%)	90.3	85.6	1.4*
Retention (% intake)	63.0	61.8	2.9
Retention (% digestion)	69.7	72.0	2.3

[1]Standard error of difference.
[+]P < 0.10; *P < 0.05.

Energy retention values were not corrected for urinary N. In the present study the observed calorific value of urinary N was considerably higher than estimates obtained with diets devoid of sucrose (see for example, Müller and Kirchgessner, 1983; Ravindran *et al.,* 1984). This could be at least partially explained by the presence of fructose in the urine of pigs fed syrup off diets, in agreement with previous reports (Ly and Macias, 1979; Ly *et al.,* 1989).

Digestibility of N (Table 5) decreased (P < 0.05) as formaldehyde was added to the diet, reflecting increased fecal excretion of N (P < 0.10). However, N retention expressed in grams per day or percentage of either N intake or N digestion was unaffected by formaldehyde treatment of the diet. In this connection, the decrease in N digestion was similar to the depression in crude protein and DM digestion estimated *in vitro* for torula yeast treated with formaldehyde by Maylin *et al.* (1985). Thus, the small differences found *in vivo* in favor of the untreated syrup off diet, in OM and energy digestibility, might be further explained by a reduction in N digestibility caused by the action of formaldehyde on torula yeast.

Total tract apparent digestibility values obtained in this experiment for syrup off were somewhat lower when formaldehyde was added to the diet. Nevertheless, the absence of an influence of formaldehyde treatment on energy and N retention could reflect the inhibition of microbial activity in the alimentary canal. This in turn could render more nutrients available to the host, thus counteracting the apparent negative effect of formaldehyde on digestive processes, and supporting better animal performance. Therefore, on balance the protection of syrup off by formaldehyde during storage does not appear to adversely affect the feeding value and nutrient utilization in pigs. This hypothesis involves assumptions that could not be assessed in the present study and remains a matter for further research.

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