Research Note

WASTE WATER FROM A CARAMEL INDUSTRY AS A PARTIAL SUBSTITUTE IN DIETS FOR PIGS[1]

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Liquid by-products, fresh, acidified, or fermented, are being used extensively as feed ingredients in swine rations because of the urgent need to minimize production costs, reduce environmental pollutants and to improve the animals' gastro-intestinal microbial community (Lawlor et al., 2002; Sánchez et al., 2001; Scholten et al., 2002). Occasionally, producers have an opportunity to use non typical sources of feedstuffs as substitutes for standard ingredients such as corn and soybean meal. These non-typical feedstuffs are more attractive when costs of traditional sources are higher than normal. Recent research suggests that the addition of water in swine rations can increase feed intake and rate of gain in early weaned pigs (Zijlstra et al., 1996; Kim et al., 2001). This increase might be due to the fact that the addition of water changes the physical form of the diet to semiliquid and improves animal acceptance. If this theory is correct, the addition to diets of feedstuffs with high moisture content could also improve palatability and therefore voluntary feed intake. Waste water from the caramel industry (WWCI) has a nutrient content that might make it useful in swine rations (Table 1). Given the fact that feed represents approximately 70% of the total cost of swine production in Puerto Rico and that WWCI is at present a pollutant, but could be an economical feed resource, this research was undertaken. A study was conducted at the Experimental Swine Farm of the Department of Animal Industry of the University of Puerto Rico in Lajas. Eleven (six castrated males and five females) 40-day-old crossbred (Yorkshire × Duroc) growing pigs were used. Each animal was randomly assigned to one of eleven pens equipped with nipple waterers. The daily feed offering was approximately 8% of body weight (BW), and was

TABLE 1.—*Chemical composition of waste water from a caramel processing plant.*

Nutrient, %	Mean[1]
Dry matter	11.9
Organic matter[2]	96.9
Inorganic matter[2]	3.10
Crude protein[2]	4.01
Water soluble carbohydrates[3]	7.89

[1]N = three replications.
[2]Dry matter basis.
[3]Wet matter basis.

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TABLE 2.—*Least Square Means for chemical composition of experimental diets.*

	Levels of WWCI substitution (%)		
Item (%)	0[1]	2.5[1]	5.0[1]
Dry matter	74.33 ± 0.70	73.00 ± 0.70	72.04 ± 0.82
Organic matter[2]	94.92 ± 0.14	94.76 ± 0.14	95.16 ± 0.16
Inorganic matter[2]	5.08 ± 0.14	5.24 ± 0.14	4.84 ± 0.16
Crude protein[2]	14.87 ± 0.32	15.34 ± 0.32	14.59 ± 0.37
NDF[2]	17.87 ± 0.68	17.32 ± 0.68	17.82 ± 0.80

[1]No significant differences (P ≥ 0.05) among treatments.
[2]Dry matter basis.

adjusted weekly throughout the experimental period. A commercial basal pig diet (14% CP) was partially replaced at levels of 0% (control), 2.5%, and 5% with WWCI. BW was recorded weekly. All pigs were fed their corresponding diet daily at 8:00 a.m. until reaching a final average weight of 36.36 kg. Orts were collected to determine feed intake. The diets were prepared twice a week and samples collected to determine chemical composition by standard procedures (AOAC, 1990; Van Soest et al., 1991). Animal performance data were analyzed as a complete randomized design (CRD) for the control (n = 3), 2.5% (n = 4), and 5% WWCI (n = 4) groups. Initial BW was included in the model as a covariate. The dependent variables analyzed included days to reach a final average weight of 36 kg, feed intake, weight gain, feed conversion efficiency, and carcass characteristics such as backfat thickness and area of longissimus dorsi muscle. Differences among treatments for all variables measured were expressed as Least Square Means (LSM) calculated according to the General Linear Model (GLM) of SAS (SAS Institute, 1990).

Among the three diets (Table 2), no significant differences (P ≥ 0.05) were found for contents of dry matter, crude protein, inorganic matter, organic matter, or neutral deter-

TABLE 3.—*Least Square Means for days in the experiment, final weight, total feed intake, daily feed intake, total weight gain, daily gain, feed:gain, feed efficiency, backfat thickness, and area of longissimus dorsi muscle for the different levels of WWCI substitution.*

	Levels of WWCI substitution (%)		
Item	0[1]	2.5[1]	5[1]
Days in the experiment, d	32.34 ± 3.14	29.49 ± 2.55	30.75 ± 2.58
Final weight, kg	39.17 ± 1.06	37.33 ± 0.86	38.33 ± 0.87
Total feed intake, kg	46.63 ± 2.52	42.61 ± 2.05	43.05 ± 2.07
Daily feed intake, kg/d	1.46 ± 0.08	1.44 ± 0.06	1.44 ± 0.06
Total weight gain, kg	21.93 ± 1.06	20.08 ± 0.86	21.09 ± 0.87
Daily gain, kg/d	0.69 ± 0.05	0.68 ± 0.04	0.69 ± 0.04
Feed: gain	2.12 ± 0.05	2.11 ± 0.04	2.06 ± 0.04
Feed efficiency	0.47 ± 0.01	0.47 ± 0.01	0.48 ± 0.01
Backfat thickness, cm	1.15 ± 0.13	1.09 ± 0.10	1.05 ± 0.10
Area longissimus dorsi, cm^2	8.84 ± 5.88	13.19 ± 4.77	13.91 ± 4.84

[1]No significant differences (P ≥ 0.05) among treatments.

TABLE 4.—*Least Square Means for days in the experiment, final weight, total feed intake, daily feed intake, total weight gain, daily gain, feed:gain, feed efficiency, backfat thickness, and area of longissimus dorsi muscle for males and females.*

	Sex	
Item	Females	Males
Days in the experiment, d	29.55 ± 2.42	32.17 ± 2.22
Final weight, kg	37.99 ± 0.82	38.56 ± 0.75
Total feed intake, kg	41.60 ± 1.95	46.78 ± 1.78
Daily feed intake, kg/d	1.42 ± 0.06	1.47 ± 0.06
Total weight gain, kg	20.75 ± 0.82	21.32 ± 0.75
Daily gain, kg/d	0.70 ± 0.03	0.67 ± 0.03
Feed: gain	0.49 ± 0.01 a[1]	0.45 ± 0.01 b
Feed efficiency	2.00 ± 0.03 a	2.19 ± 0.03 b
Backfat thickness, cm	1.02 ± 0.10	1.18 ± 0.09
Area longissimus dorsi, cm^2	11.86 ± 4.54	12.09 ± 4.16

[1]Means in the same row followed by different letters differ ($P < 0.05$).

gent fiber. The levels of dietary WWCI inclusion did not significantly affect the number of days in the experiment, final BW, total feed intake, daily feed intake, total weight gain, daily gain, feed efficiency, backfat thickness, and area of longissimus dorsi muscle (Table 3). The female animals slightly out performed the males in growth rate and feed conversion efficiency, and there was no significant ($P > 0.05$) interaction of treatment × sex (Table 4). In summary, no detrimental effects on the performance and carcass characteristics of pigs consuming diets containing WWCI were observed relative to the control group. This finding suggests that WWCI can be incorporated in diets for growing pigs at levels up to 5% without sacrificing animal performance. Further research should be conducted across a wide range of WWCI incorporation levels to study their effects on growth, feed efficiency and carcass characteristics.

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