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The effect of elevated dietary citrus pulp on the growth, feed efficiency, carcass merit, and lean quality of finishing pigs

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ABSTRACT

The objective of this study was to evaluate the effect of elevated dietary citrus pulp (DCP) on the growth, feed efficiency, carcass merit, and lean quality of finishing pigs. Over a 49-d trial period, pigs (n = 40) were fed 1 of 4 diets: a corn–soybean meal control diet (CON; n = 10) or the same diet with DCP replacing 15% (n = 10), 22.5% (n = 10), or 30% (n = 10) of the total diet DM. Pigs fed the CON and 22.5% DCP diets had greater ($P < 0.02$) G:F than pigs fed 30% DCP. Fat over the LM received greater ($P < 0.04$) lightness values in animals fed the CON diet than those consuming either 22.5 or 30% DCP diets. Pigs fed CON or 15% DCP exhibited lower ($P \leq 0.03$) lean redness scores than lean from pigs fed 22.5 or 30% DCP. When evaluated objectively, bellies from CON-fed pigs were firmer ($P < 0.01$) than all other dietary treatment groups, but bellies from CON- and 15% DCP–fed pigs garnered greater ($P < 0.04$) subjective firmness scores than pigs fed 22.5 or 30% DCP. Belly thickness at both the blade and flank ends decreased with increasing DCP, whereas pigs fed the CON diet exhibited the thickest ($P < 0.03$) bellies. Overall, DCP inclusion above 15% of the diet DM appeared to be economically detrimental to overall production because of negative effects on growth performance and pork belly quality.

Key words: pork, citrus, by-product

INTRODUCTION

In recent years, feed cost has escalated for livestock producers, because of competition for feedstuffs, especially corn for feed or fuel. During the 2012 federal fiscal year, 43% of United States corn production was used for fuel (USDA-ERS, 2014a,b). Currently, high-fiber feedstuffs such as citrus pulp, which was previously said to be of limited quality (Cunha et al., 1950), are again being explored for their use in swine finishing diets (Crosswhite et al., 2013). In Florida, dried and pelleted citrus pulp has become a common feed ingredient for dairy and beef cattle diets, primarily because of its availability within the region and limited cost (Arthington et al., 2002). Calcium carbonate is added to pressed whole citrus pulp, and the pressed pulp is then heated to make dried citrus pulp, which increases DM content to about 90% (Kale and Adsule, 1995).

In 2013 approximately 7.1 million tonnes of citrus fruit was processed in the United States (USDA-NASS, 2013), with one of the primary by-products being in the form of dried citrus pulp. Dried citrus pulp typically includes a high ratio of Ca:P (3.5 ± 1.7% Ca: 0.34 ± 0.07% P) and low CP (7.2 ± 0.2%), fat (3.0 ± 1.0%), ADF (16.9 ± 2%), and NDF as a feedstuff (19.3 ± 1.3%; DM basis; Bampidis and Robinson, 2006). Typically, dried citrus pulp also has high concentrations of pectin (20 to 40%; Arthington et al., 2002). Because dried citrus pulp is inexpensive and available in the region, citrus pulp has been evaluated for use in swine diets over several decades. Recent citrus-pulp work has shown no negative effects of dried pulp at 15 or 20% of the diet DM on feed efficiency of pigs (Watanabe et al., 2010; Crosswhite et al., 2013). These recent studies have contradicted earlier assessments (Baird et al., 1974; Milligan et al., 1998). Thus, the objective of this research was to study the effects of dietary citrus pulp at inclusions up to 30% on the growth and performance, carcass merit, and lean quality parameters of finishing pigs.

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Table 1. Composition of the experimental diets (%, DM basis)

	Diet[1]			
Ingredient	CON	15	22.5	30
Corn	80.75	64.10	54.75	45.90
Dried citrus pulp	0.00	15.20	22.80	30.40
Soybean meal	16.50	16.50	17.10	17.10
Vegetable oil	0.00	2.00	3.50	5.00
Limestone	1.25	0.60	0.25	0.00
Monocalcium phosphate	1.00	1.10	1.10	1.10
Salt	0.30	0.30	0.30	0.30
Trace mineral–vitamin premix[2]	0.20	0.20	0.20	0.20

[1]CON = corn–soybean meal control diet; 15 = diet containing 15% dried citrus pulp; 22.5 = diet containing 22.5% dried citrus pulp; 30 = diet containing 30% dried citrus pulp, on a DM basis.

[2]Supplied the following per kilogram for trace premix: 5,500 IU of vitamin A; 680 IU of vitamin D_3; 5.5 mg of vitamin K activity; 7 mg of riboflavin; 23 mg of D-pantothenic acid; 34 mg of niacin; 140 mg of choline chloride; 27 mg of vitamin B_{12}; 100 mg of zinc (ZnO); 50 mg of iron ($FeSO_4$); 27 mg of manganese (MnO); 5 mg of copper ($CuSo_4$); 0.8 mg of iodine (CaI_2); and 0.15 mg of selenium ($NaSeO_3$).

MATERIALS AND METHODS

Animals

The University of Florida Institute of Food and Agricultural Sciences Animal Research Committee approved all experimental procedures and animal-handling methods before this project. Forty crossbred barrows and gilts at 70.0 ± 2.07 kg were blocked by weight and allocated into 20 pens, which were randomized to the 4 experimental diets. There were 5 replicates per treatment and 2 pigs per pen. Pens were mixed sex, each including one barrow and one gilt. All pigs were housed in concrete-floored, partially slatted pens (3 m^2 per pig) in an open-sided building with ad libitum access to feed and water. All pigs were given 7 d for acclimation to the experimental diets. During the following 49-d trial, pigs (n = 10) were either fed a corn–soybean meal finishing ration containing 0.78% lysine (**CON**) or a basal diet replaced with either 15, 22.5, or 30% dietary citrus pulp (**DCP**) on a DM basis (Table 1). Nutritional information for DP was obtained from Jurgens and Bregendahl (2007). All diets were isolysinic. Dietary energy values were 3,370, 3,380, 3,450, and 3,390 Kcal of ME/kg, respectively, for CON, 15, 22.5, or 30% (Table 2). Weights were taken on pigs and feeders on d 21, 42, and 49, with feed disappearance recorded to determine ADG, G:F, and ADFI.

Cost per kilogram of live gain per pen of pigs was calculated by using current wholesale prices for all ingredients. Transport costs for the citrus by-product were calculated as {[(440 km roundtrip ÷ 4.25 km/L) × \$0.93/L] ÷ 1,360 kg of citrus by-product}. The costs per kilogram of the diets on a DM basis were calculated to be \$0.40, \$0.38, \$0.38, and \$0.37 for the CON, 15, 22.5, and 30% rations, respectively. Cost of gain per pen was calculated as [(total DMI per pen × \$/kg diet) ÷ live weight gain per pen].

Table 2. Chemical composition of experimental diets (DM basis)[1]

	Diet[2]			
Nutrient composition	CON	15	22.5	30
DM, %	88.4	88.6	90.1	91.6
ME, kcal/mg	3,370	3,380	3,450	3,390
CP, %	15.5	14.3	15.2	12.8
NDF, %	6.7	9.8	11.1	14.8
Crude fat, %	4.3	5.9	7.1	7.7
Lysine, %	0.78	0.78	0.78	0.78
Calcium, %	0.77	0.87	0.79	0.93
Phosphorus, %	0.62	0.58	0.57	0.41

[1]Chemical analysis from Dairy One forage testing laboratory (Ithaca, NY).

[2]CON = corn–soybean meal control diet; 15 = diet containing 15% dried citrus pulp; 22.5 = diet containing 22.5% dried citrus pulp; 30 = diet containing 30% dried citrus pulp, on a DM basis.

Carcass Fabrication and Lean Quality

Pigs were commingled and transported 3 km to the University of Florida Meats Processing Center at the close of the feed trial and provided access to water ad libitum over a 14-h period. All pigs were humanely slaughtered using electronic stunning methods in accordance with the Humane Methods of Slaughter Act of 1978. Hot carcass weights were taken from each animal before entering the storage cooler. All carcass merit and meat-quality measurements were taken from right carcass sides. The pH of the LM was measured 1 h postmortem between the 10th and 11th rib with a temperature-compensating pH meter (model 99163, Hanna Instruments USA., Woonsocket, RI), and a pH reading was also recorded within the semimembranosus muscle. At 24 h postmortem, right carcass sides were fabricated into primal cuts according to the National Association of Meat Purveyors (**NAMP**) guidelines (NAMP, 2007). The unskinned loin (NAMP #413) was cut between