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Research Article
Nutrient Digestibility of Diets with Different Levels of Dried Distillers Cassava with Solubles (DDCS) in Growing and Finishing Pigs

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Abstract

Background and Objectives: This study was designed to evaluate the effects of supplementing 4 levels of dried distillers cassava with solubles (DDCS) on nutrient digestibility in growing and finishing pigs. **Materials and Methods:** Fifteen female crossbred pigs were allocated to 5 treatments and 3 replicates with a completely randomized design (CRD). Each pig was kept in a solitary cage and received the following diets: control diet with no added DDCS; control diet supplemented with 5, 10, 15 and 20% DDCS for growing pigs and control diet supplemented with 10, 20, 30 and 40% DDCS for finishing pigs. **Results:** The chemical components of DDCS comprised dry matter (DM, 91.63%), crude protein (CP, 5.64%), crude fat or ether extract (EE, 1.28%), crude fibre (CF, 26.78%), ash (11.71%), calcium (Ca, 0.89%), phosphorus (P, 0.43%) and gross energy (GE, 3,434 kcal kg^{-1}). The nutrient digestibility of DM, CP and ash in the diets supplemented with DDCS in both the growing and finishing periods decreased as the level of DDCS increased (linear effect, $p<0.05$), whereas the digestibility of EE or fat and CF increased (linear and quadratic effect, $p<0.05$) when the DDCS content increased. **Conclusion:** The inclusion of graded levels of 5, 10, 15 and 20% DDCS in growing pig diets and 10, 20, 30 and 40% DDCS in finishing pig diets decreased the nutrient digestibility of DM, CP and ash but increased the digestibility of EE and CF as the levels of DDCS increased.

Key words: Dried distillers cassava with solubles, pig diet, nutrient digestibility, growing pigs, finishing pigs

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Globally, a greater dynamic increase in livestock production is occurring relative to other agricultural sectors. As countries become more affluent, the demand for livestock-derived food has substantially increased, thus leading to a major transformation of animal feed production. Pig production is the fastest growing and industrialized livestock subsector and has experienced annual production growth rates of 2.6% over the past decade[1]. In general, the feed costs for growing and finishing pigs account for 60-70% of the total production cost[2] because of the increasing price of the raw materials of the diet. To reduce production costs, the use of agro-industrial residues with a low price may represent an alternative. In Thailand, bioethanol fuel is mainly produced by a fermentation process using the sugar from fresh cassava[3]. After ethanol is harvested, considerable residue is generated. Dried distillers cassava with solubles (DDCS) is obtained during the fermentation process and this residue has a low cost and still presents nutritive value, particularly from yeast used in the fermentation process[4]. The DDCS composition is as follows: 74.92% moisture, 35.72% fibre, 7.27% protein, 1.07% fat and 40-45% carbohydrates[5]. This by-product offers an opportunity for cost savings in animal feed rations and will be available in abundant quantities in coming years. Therefore, the aim of this experiment was to investigate the effects of incorporating various levels of DDCS on diet digestibility in growing and finishing pigs and its potential as a nutritional feed stuff.

MATERIALS AND METHODS

Animals and diets: Fifteen crossbred female [Duroc×(Large White×Landrace)] growing pigs and fifteen female finishing pigs were allotted into 5 treatments with 3 replicates according to a completely randomized design (CRD). The growing pigs had an average body weight (BW) of 25±1 kg, while the finishing pigs had an average BW of 60±1 kg. All pigs were fed one of 5 diets; T1: Control diet with no added DDCS; T2: Control diet with 5% DDCS for growing pigs and 10% DDCS for finishing pigs, T3: Control diet with 10% DDCS for growing pigs and 20% DDCS for finishing pigs, T4: Control diet with 15% DDCS for growing pigs and 30% DDCS for finishing pigs and T5: Control diet with 20% DDCS for growing pigs and 40% DDCS for finishing pigs.

Pig management: The pigs were kept in solitary cages for 10 days (7 days adaptation and another 3 days for the feeding trial). All pigs were fed diets at 80% the voluntary intake in the last 3 days, chromic oxide was added (0.3% w/w) in the diets as a marker for the digestibility measurements. Sufficient water was supplied throughout the feeding trial. The diets and faeces of each treatment were collected and the chemical compositions of the diets and faeces for both the growing and finishing pigs were analysed and are listed in Table 1.

Pig faecal and urine collection: Pig faecal and urine samples were collected twice daily (8:00 a.m. and 5:00 p.m.) for 3 consecutive days. The faecal samples were placed in plastic bags and then 5 mL of 3% H_2SO_4 was added. The samples were then stored in a freezer (-10°C) before analysis. The samples were dried at 60°C and ground and kept in a refrigerator (4°C) before analysis. Urine samples were collected and 100 mL of 10% H_2SO_4 was added. All urine samples were stored in a freezer (-10°C) prior to analysis using the procedure of Schnider and Flatt[6].

Nutrient composition, digestibility and total energy of all diets in faecal and urine samples: The total energy of the diets was determined by the ballistic bomb calorimeter method according to the AOAC[7]. The total energies of faecal and urine samples were determined by the ballistic bomb calorimeter method and chromic acid oxidation was analysed as described by Stein *et al.*[8]. The nutrient composition of the diets and faecal samples was determined and the digestibility of the dry matter and nutrients was calculated as follows:

$$\text{Digestibility of dry matter (DM\%)} = (1-I_d)\times 100/I_f$$

where, I_d represents the percentage of the indicator in the DDCS-based diets and I_f represents the percentage of indicator in the faecal samples.

$$\text{Nutrient digestibility (\%)} = (I_f N_d - I_d N_f)\times 100$$

where, I_d and I_f represent the percentage of indicator in the DDCS-based diets and faecal samples, respectively and N_d and N_f represent the percentage of nutrient values in the diets and faecal samples, respectively.

Statistical analysis: Data for all response variables were analysed through a one-way analysis of variance using the general linear model (GLM) procedure using SPSS[9]. Duncan's New Multiple Range Test was used to determine the treatment differences[10]. Linear and quadratic contrasts were compared to determine the effects of increased dietary DDCS levels. All statements of significance were based on a probability level of 0.05.

Table 1: Composition of the experimental basal diets for growing and finishing pigs

	Level of DDCS for the growing pigs (%)					Level of DDCS for the finishing pigs (%)				
Ingredients	T1: 0	T2: 5	T3: 10	T4: 15	T5: 20	T1: 0	T2: 10	T3: 20	T4: 30	T5: 40
Broken rice	10.00	10.00	10.00	5.00	-	15.00	15.00	15.00	8.00	8.00
Corn	43.45	36.90	30.35	30.40	28.00	37.5	34.15	33.00	29.22	16.25
Rice bran	15.00	15.00	15.00	12.90	12.60	20.00	11.00	-	-	-
DDCS	-	5.00	10.00	15.00	20.00	-	10.00	20.00	30.00	40.00
Fat	1.22	2.45	3.72	5.00	5.00	0.70	1.70	4.90	5.40	8.00
Soybean meal (44%)	23.50	22.20	20.90	19.00	12.10	17.70	17.25	17.55	17.70	16.55
Full fat soybean	2.50	4.05	5.55	8.17	17.65	5.00	5.00	5.00	5.00	6.30
L-lysine	0.12	0.14	0.16	0.17	0.25	0.10	0.17	0.25	0.27	0.32
DL-methionine	0.05	0.07	0.10	0.12	0.14	0.05	0.08	0.13	0.18	0.23
L-Threonine	0.03	0.05	0.07	0.09	0.11	0.05	0.08	0.12	0.16	0.21
Limestone	2.00	2.00	2.00	2.00	2.00	1.60	2.85	1.90	1.96	2.06
Dicalcium phosphate (P21)	1.17	1.18	1.18	1.18	1.20	1.30	1.50	1.15	1.11	1.08
Salt	0.46	0.46	0.47	0.47	0.45	0.50	0.72	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Price kg^{-1} (Baht)	11.32	11.29	11.24	11.18	11.16	10.60	10.43	9.92	9.80	9.73
Composition by calculation										
Gross energy (GE, kcal kg^{-1})	3,150.10	3,150.00	3,150.00	3,150.00	3,150.40	3,000.00	3,000.00	3,000.00	3,000.00	3,000.00
Crude protein (CP)	17.50	17.51	17.50	17.50	17.53	16.00	16.04	16.00	16.00	16.01
Ether extract (EE)	5.10	5.90	5.10	5.57	5.30	5.60	4.84	4.79	7.83	10.41
Crude fibre, (CF)	4.61	5.75	6.88	7.92	8.23	4.65	6.42	7.80	10.21	12.50
Calcium (Ca)	0.85	0.85	0.85	0.85	0.86	2.73	1.10	0.80	0.80	0.80
Total phosphorus (P21)	0.60	0.60	0.60	0.60	0.60	0.53	0.76	0.51	0.51	0.52
L-Lysine	1.01	1.00	1.00	1.00	1.01	0.58	0.80	0.57	0.56	0.55
DL-methionine	0.35	0.36	0.38	0.38	0.38	0.90	0.90	0.92	0.90	0.90

RESULTS AND DISCUSSION

Chemical composition of DDCS and experimental diets: The chemical composition of the DDCS and experimental diets is shown in Table 2. The DDCS contained 91.63% DM, 5.64% crude protein (CP), 1.28% crude fat or ether extract (EE), 26.78% crude fibre (CF), 11.71% ash, 0.89% calcium (Ca), 0.43% phosphorus (P) and 3,434 kcal kg^{-1} gross energy (GE). The growing pigs' diets supplemented with 0, 5, 10, 15 and 20% DDCS contained an average of 83.25, 16.70, 7.33, 0.93, 0.66 and 4,262 kcal kg^{-1} DM, CP, ash, Ca, P and GE, respectively. The EE and CF in the diets increased as the level of DDCS in the diet increased. The EE values of the diets containing 0, 5, 10, 15 and 20 DDCS were 3.50, 4.56, 4.68, 4.75 and 4.81%, respectively, while the CF values were 4.16, 4.66, 5.14, 5.33 and 5.93%, respectively. The finishing pigs' diets supplemented with 0, 10, 20, 30 and 40% DDCS contained an average of 87.28, 15.83, 8.28, 0.89, 0.65 and 4,185 kcal kg^{-1} DM, CP, ash, Ca, P and GE, respectively. The EE and CF in the diets also increased as the level of DDCS increased. The EE values of the diets containing 0, 10, 20, 30 and 40% DDCS were 4.34, 5.81, 6.75, 7.54 and 8.14%, respectively, while the CF values were 4.58, 5.81, 6.81, 7.90 and 8.89%, respectively.

Nutrient digestibility of the diets with different levels of DDCS in the growing and finishing periods: The digestibility of DM, CP and ash was reduced (linear effect, $p<0.05$) when DDCS was added to the diets in the growing period (Table 3). However, the digestibility of EE (or fat) and CF was increased when DDCS was added to the diets (linear effect and quadratic effect, $p<0.05$). The same results for the digestibility of DM, CP, EE, CF and ash nutrients were also observed during the finishing period (Table 4), with the inclusion of the four graded levels of DDCS (5, 10, 15 and 20% for growing and 10, 20, 30 and 40% for finishing) causing linear decreases in digestibility ($p<0.05$) when compared with the unsupplemented control diets. However, the digestibility of EE and CF showed linear and quadratic increases (linear effect and quadratic effect; $p<0.05$) when DDCS was added to the diets (Table 3 and 4). This response is related to the replacement of corn and rice bran in the diet with higher levels of DDCS, which leads to an increase in the fat and fibre in the diets. As a result, the digestibility of EE and CF showed linear and quadratic increases ($p<0.05$) when DDCS was increased in the diets. However, the digestibility of DM, CP and ash in both diet periods (growing and finishing pigs) decreased as the levels of DDCS increased in the diets. The results of this study were

Table 2: Chemical composition of the experimental diets

		Level of DDCS for the growing pigs (%)						Level of DDCS for the finishing pigs (%)					
Items	DDCS*	T1: 0	T2: 5	T3: 10	T4: 15	T5: 20	Average	T1: 0	T2: 10	T3: 20	T4: 30	T5: 40	Average
DM	91.630	84.560	84.270	83.360	82.440	81.630	83.250	86.290	87.870	87.430	87.320	87.510	87.280
CP	5.640	16.820	16.750	16.720	16.610	16.600	16.700	16.050	15.850	15.730	15.710	15.810	15.830
EE	1.280	3.500	4.560	4.680	4.750	4.810	4.460	4.340	5.810	6.750	7.540	8.140	6.520
CF	26.780	4.160	4.660	5.140	5.330	5.930	5.040	4.580	5.810	6.810	7.900	8.890	6.800
Ash	11.710	6.590	7.210	7.550	7.700	7.590	7.330	8.440	8.350	8.290	8.200	8.110	8.280
Ca	0.890	0.950	0.960	0.910	0.910	0.910	0.930	0.930	0.910	0.880	0.870	0.840	0.890
P	0.430	0.690	0.660	0.650	0.650	0.630	0.660	0.660	0.660	0.650	0.630	0.640	0.650
GE (kcal kg^{-1})	3.434	4.226	4.256	4.285	4.271	4.274	4.262	4.222	4.164	4.185	4.178	4.177	4.185

*Dried distillers cassava with solubles

Table 3. Nutrient digestibility of diets with different levels of DDCS in growing pigs

	Level of DDCS in the diets (%)					
Items (%)	T1: 0	T2: 5	T3: 10	T4: 15	T5: 20	SEM
DM^{L}	85.09^{a}	85.03^{a}	83.92^{b}	82.30^{c}	81.61^{d}	0.381
CP^{L}	85.75^{a}	85.26^{b}	84.27^{c}	82.61^{d}	81.92^{e}	0.398
$EE^{L,Q}$	64.21^{d}	73.24^{c}	72.94^{c}	77.77^{b}	78.51^{a}	1.365
$CF^{L,Q}$	50.85^{c}	52.81^{b}	51.32^{c}	53.03^{b}	54.45^{a}	0.361
Ash^{L}	86.43^{a}	86.17^{b}	85.65^{c}	83.52^{d}	83.52^{d}	0.344

Different superscripted letters within the same row indicate highly significant differences ($p<0.05$), L: Linear effect of DDCS supplementation, Q: Quadratic effect of DDCS supplementation

Table 4: Nutrient digestibility of the diets with different levels of DDCS in finishing pigs

	Level of DDCS in the diet (%)					
Items (%)	T1: 0	T2: 10	T3: 20	T4: 30	T5: 40	SEM
DM^{L}	86.09^{a}	85.08^{b}	84.75^{b}	82.87^{c}	81.90^{d}	0.410
CP^{L}	79.43^{a}	77.01^{b}	74.02^{c}	72.05^{d}	70.42^{e}	0.876
$EE^{L,Q}$	50.12^{d}	54.76^{c}	57.59^{a}	57.56^{a}	56.46^{b}	0.754
$CF^{L,Q}$	55.26^{d}	60.23^{c}	65.14^{b}	64.94^{b}	66.28^{a}	1.102
Ash^{L}	86.27^{a}	85.79^{b}	85.57^{b}	83.80^{c}	83.43^{d}	0.305

Different superscripted letters within the same row indicate highly significant differences ($p<0.05$), L: Linear effect of DDCS supplementation, Q: Quadratic effect of DDCS supplementation

consistent with the results of Spiehs *et al.*[11], who reported that supplementation of dried distillers maize with solubles (DDMS) at 0, 10, 20 and 30% in growing pigs reduced the digestibility of DM, CP and EE. In previous studies conducted by Bowland *et al.*[12], Cole *et al.*[13] and Frank *et al.*[14] observed that higher levels of fibre in the diets reduced nutrient digestibility. Jorgensen *et al.*[15] found that high levels of fibre decreased the digestibility of protein because the faecal samples showed higher protein content, which is related to the fermentation of fibre by microorganisms in the large intestine, which provides more protein. The results of this study were similar to those of an earlier study by Pond and Maner[16], who showed that pigs fed diets with high fibre contents gradually adapted to the diets and developed the ability to digest more fibre. Moreover, the digestibility of CF also depended on the age of the animals. The finishing pigs showed greater levels of CF digestion and utilization compared with the growing pigs.

CONCLUSION

The inclusion of graded levels of DDCS of 5, 10, 15 and 20% in growing pig diets and 10, 20, 30 and 40% in finishing pig diets affected the nutrient digestibility of DM, CP and ash, which showed linear decreasing effects in both the growing and finishing pigs. However, supplementation with graded levels of DDCS as a replacement for both corn and rice bran led to higher levels of fat in both the growing and finishing diets, with linear and quadratic increases in EE and CF.

SIGNIFICANCE STATEMENT

This study revealed that DDCS, which is a by-product of ethanol production from cassava in Thailand, has high levels of protein and fibre. This study will help researchers uncover new raw materials that can be used as animal feed. DDCS can be used as a source of raw materials in growing and finishing pig feed. Additionally, DDCS should be suitable for use as a

feed ingredient for sows and pregnant sows that require high levels of fibre in their diet. Dietary fibre is increasingly considered a prerequisite for "Gut health" and improves the satiety welfare of pregnant sows.

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