Indian J. Anim. Res., 53(10) 2019: 1349-1353
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Effect of choline chloride with propylene glycol on growth performance and meat quality in finishing pigs

Yang Jiao, Sang In Lee and In Ho Kim*

Department of Animal Resource and Science,
Dankook University, Cheonan, Chungnam 330-714, South Korea.
Received: 18-02-2018 Accepted: 18-06-2018 DOI: 10.18805/ijar.B-922

ABSTRACT

This study was conducted to evaluate the effect of choline chloride alone and in combination with propylene glycol on the growth performance, meat quality and backfat in finishing pigs. A total of 90 crossbred [(Landrace× Yorkshire)× Duroc] pigs with an average initial body weight (BW) of 75.15± 1.94 kg were randomly distributed by BW and sex. This 8-week experiment consisted of 3 dietary treatments with 6 replications per treatment and 5 pigs per pen. The experiment included 3 treatments: CON, basic diet; TRT1, basic diet+0.05% choline chloride; TRT2, basic diet+0.05% biocholine P (chloride chloride and propylene glycol). Body weight was statistically higher ($P < 0.05$) in pigs fed TRT2 diet than the CON diet in week 8. During 4 to 8 weeks and overall, the average daily gain (ADG) was significant higher ($P < 0.05$) in the pigs fed TRT2 diet than the CON diet. Digestibility of nitrogen was significantly increased ($P < 0.05$) at week 4 and week 8, back fat was higher ($P < 0.05$) in week 6 and week 8 in pigs fed TRT2 diet than the CON diet. In conclusion, dietary TRT2 can increase the BW, ADG, nitrogen and backfat in finishing pigs.

Key words: Backfat, Choline chloride, Finishing pigs, Growth performance, Meat quality, Propylene glycol.

INTRODUCTION

Choline is an essential nutrient for the pig. It acts as an important methyl donor, a component of lecithin and acetylcholine in animals, which can prevent fat accumulation in liver, kidney and its tissue degeneration. Zeisel's studies (1990, 1993) poninted that choline deficiency can evoke slow growth rates associated with the development of fatty liver. Cooke *et al*. (2007) demonstrated the ability of dietary choline to prevent and alleviate hepatic lipid accumulation in cows with experimentally induced fatty liver. Chung *et al*. (2009) evaluated the supplementing choline as rumen-protected choline to improve hepatic lipid metabolism thereby improving feed intake and milk production in Holstein dairy cows in early lactation. Choline is known to improve growth and carcass characterises in poultry (Rath *et al*., 2017). Energy is a major cost component in diets for growing-finishing pigs. In the last many years, scientists have attempted to improve the energy status of pigs by supplementing lipids into maternal diets. Grummer *et al*. (1994) showed that addition of propylene glycol (PG) can increase the level of glucose. Cavender (2012) reported that PG, by short-term feeding tests with chicks and chickens, is a suitable source of energy. Yildiz and Erisir, (2016) reported that PG can reduce the negative energy balance in dairy cows. Thus, we hypothesized that a possible propylene glycol-choline interaction might has some postive effects on the pigs. Two nutritional supplements, reported that ruminally-protected choline and propylene glycol, have proven effective at preventing fatty liver (Grummer, 2008). Chung *et al*. (2009) reported that a combined effect of dietary PG and choline was not evident and beneficial. However, to our knowledge, no study was conducted to evaluate the effects of choline chloride alone and in combination with propylene glycol in pigs. The commercial biocholine products (biocholine P) used in this study were provided by KOFAVET SPECIAL INC., Korea. It is mainly blend of the guaranteed chloride chloride (the purity is 50%), and propylene glycol (a nonacidogenic dry product, NEL = 2.6 Mcal/kg, which was composed of 65% propylene glycol and 35% silicon dioxide as the carrier). The current study was designed to assess the efficacy of commercial biocholine P on growth performance, nutrient digestibility, meat quality, and backfat in finishing pigs.

MATERIALS AND METHODS

All animals received human care as outlined in the guide for the care and use of experimental animals (Dankook University, South Korea, Animal Care Committee).

Experimental Design, Animals, Housing, and Diets: A total of 90 crossbred [(Landrace×Yorkshire)×Duroc] pigs with an average initial body weight (BW) of 75.15±1.94 kg were randomly assigned by BW and sex according to a randomized complete block design. This 8-week experiment consisted of 3 dietary treatments with 6 replications per treatment and 5 pigs per pen (2 gilts and 3 barrows). Pigs were housed in an environmentally controlled facility and

*Corresponding author's e-mail: inhokim@dankook.ac.kr

room temperature was maintained at approximately 24°C. Each pen was equipped with a self-feeder and nipple drinker to allow *ad libitum* access to feed and water throughout the experiment. The experimental treatments included: i) CON, basic diet; ii) TRT1, basic diet+0.05% choline chloride; iii) TRT2, basic diet+0.05% biocholine P (chloride chloride and propylene glycol). All the diets were based on corn and soybean meal (Table 1). All diets were provided in mash form and formulated to meet the NRC (2012) recommen dations for all nutrients, regardless of treatment. Treatment additive was included in the diet by replacing the same amount of corn.

Sampling, and measurements: Individual pig BW and feed consumption were monitored daily in this experiments to determine the average daily gain (ADG), average daily feed intake (ADFI) and gain:feed ratio (G/F). The coefficient of apparent total tract digestibility of dry matter and nitrogen was determined using chromic oxide (0.20%) as an inert indicator. Pigs were fed diets mixed with chromic oxide from d 22 to 28 and d 50 to 56. Fresh fecal grab samples were collected from 2 pigs (1 gilt and 1 barrow) per pen (d 28 and 56) for nutrient digestibility. Fecal and feed samples were kept in a freezer at –20°C until being analyzed. Prior to chemical analysis, the fecal samples were dried for 72 h at 70°C and finally ground to a size sufficient to pass through a 1-mm screen. All feed and fecal samples were analyzed for dry matter and nitrogen in accordance with the procedures outlined by the AOAC (2000). Chromium was analyzed using UV absorption spectrophotometry (Shimadzu, UV-1201, Shimadzu, Kyoto, Japan) in accordance with the method described by Williams, *et al*. (1962). The digestibility was calculated according to the following formula:

$$CATTD = [1- \{(Nf\times Cd)/(Nd\times Cf)\}]$$

Where Nf = nutrient concentration in feces (% DM), Nd = nutrient concentration in diets (% DM), Cf = chrome concentration in feces (% DM), and Cd = chrome concentration in diets (% DM).

At the end of the experiment, pigs were slaughtered by exsanguination after electrical stunning at a local commercial slaughter house and were treated with conventional procedures. After chilling at 2°C for at least 24 h, a piece of the right loin sample was removed between the 10th and 11th ribs. Before the meat quality evaluation was performed, meat samples were thawed at ambient temperature. The color measurement of lightness (L*), redness (a*) and yellowness (b*) values was determined by Minolta CR410 chroma meter (Konica Minolta Sensing, Inc., Osaka, Japan). Sensory evaluation (color, marbling and firmness scores) was evaluated according to NPPC (1991). At the same time, duplicate pH values of each sample were measured by a pH meter (Pittsburgh, PA, USA). The water holding capacity (WHC) was measured according to the methods of Kauffman *et al*. (1986). In brief, 0.2 g sample was pressed at 3000 psi for 3 min on 125-mm-diameter filter paper. The areas of the pressed sample and expressed moisture were delineated and then determined with a digitizing area-line sensor (MT-10S; M.T. Precision Co. Ltd., Tokyo, Japan). A ratio of water to meat areas was calculated, giving a measure of WHC (the smaller ratio indicates the higher WHC). Longissimus muscle area (LMA) was measured by tracing the longissimus muscle surface at the 10th rib, which also used the aforementioned digitizing line sensor. Drip loss was measured by using approximately 2 g of meat sample according to the plastic bag method, which was described by Honikel (1998). The last rib back fat thickness (measured on the mid line of the split carcass) for each pig was adjusted (using regression analysis) to the average final BW before being pooled using the equation proposed by the National Pork Producers Council (NPPC, 2000).

Statistical analysis: All data were subjected to the statistical analysis as a randomized complete block design using the SAS (SAS Inst. Inc., Cary, NC). Performance, digestibility, and meat quality were analyzed by pen. Variability in the data was expressed as the pooled SEM. Significant

Table 1: Experimental diet composition

Items	Diet
Ingredients (%)	
Corn	68.60
Soybean meal	16.97
Wheat	6.00
Tallow	2.20
Molasses	3.50
Lysine (78%)	0.28
Methionine (99%)	0.01
Dicalcium phosphate	1.25
Limestone	0.59
Salt	0.30
Vitamin premix[1]	0.20
Mineral premix[2]	0.10
Chemical composition (%)	
CP	13.99
Ca	0.60
P	0.53
Met	0.23
Met+Cys	0.28
Choline	0.99
Calculated level unit	
ME (kcal/kg)	3,308
Choline, %	0.99

[1]Provided per kilogram of diet: 20,000 IU of vitamin A; 4,000 IU of vitamin D3; 80 IU of vitamin E; 16 mg of vitamin K3; 4 mg of thiamine; 20 mg of riboflavin; 6 mg of pyridoxine; 0.08 mg of vitamin B12; 120 mg of niacin; 50 mg of Ca-pantothenate; 2 mg of folic acid; and 0.08 mg of biotin.

[2]Provided per kilogram diet: 140 mg of Cu (as copper sulfate); 179 mg of Zn (as zinc oxide); 12.5 mg of Mn (as manganese oxide); 0.5 mg of I (as KI); 0.25 mg of Co (as $Co_2O_3\cdot 7H_2O$); and 0.4 mg of Se (as $Na_2SeO_3\cdot 5H_2O$).

differences in the mean values among dietary treatments were analyzed by repeated measures and Tukey's tests using the GLM procedure. The level of statistical significance was set at $P < 0.05$ (Wasserstein and Lazar, 2016).

RESULTS AND DISCUSSION

Growth performance and nutrient digestibility: In this study, in week 8 the BW of pigs fed TRT2 diet were significantly higher ($P<0.05$) than pigs fed CON diet (Table 2). Similar results were reported by Cook and Easter (1991) who pointed out the main signs of choline deficiency in pigs, as in many other species, are impairment of growth rate; Cavender (2012) found that PG can be an energy source for poultry; Fouladi *et al*. (2008) shown that interaction effects of canola oil and choline chloride supplement could affected live BW in broilers. These results may explain the reason of improvement in BW in pigs fed TRT2 indicating propylene glycol served as an energy source for finishing pigs. The other possible reason for increased BW may be due to the increase in backfat thickness. In the current study, during 4-8 weeks and overall, the ADG of pigs fed TRT2 diet were significantly higher ($P < 0.05$) than the CON diet (Table 2). Smith *et al*. (1995) found that the ADFI of pigs fed the diet with added choline were higher than the CON diet, which is related to the current results.

In the current study, the nitrogen digestibility of pigs fed TRT2 diet was higher ($P < 0.05$) than CON diet (Table 2). Shingfield *et al*. (2002) found that dietary PG inclusion had no effect on dry matter, but tended to decrease apparent nitrogen digestibility in cows. Chibisa *et al*. (2008) found that supplementing pre- and postpartum diets with PG tended to increase apparent dry matter, but had no effect on nitrogen in transition dairy cows. In the present study, there were also no significant effects on dry matter and energy, while contrary results found in week 4 pigs fed TRT2 diet had higher nitrogen digestibility than CON diet ($P < 0.05$). The reason why nitrogen digestibility had a significant diffe rence might due to the added propylene glycol in TRT2 diet. Nielsen and Ingvartsen, (2004) summarized that PG decreases amino acid requirements for gluconeogenesis, and that the spared amino acids would be limiting for increased protein synthesis in the mammary gland, meanwhile, an in crease in the energy content of the feed may stimulate an incr ease in protein percentage. Other reasons might due to the cow are the ruminant animals, and the pigs are the monogastric ani mals; different add measure of choline chloride, propylene gly col, etc.

Meat quality and backfat: In the present study, marbling of pigs fed TRT1 diet was significantly higher than the CON

Table 2: Effect of choline chloride alone or in combination with propylene glycol on growth performance in finishing pigs1.

Items	CON	TRT1	TRT2	SEM[2]	*P*-Value
Growth performance (Body weight, kg)					
Initial	74.95	75.02	75.23	0.21	0.84
wk 4	95.80	96.38	96.87	0.31	0.22
wk 8	118.00^{b}	119.39^{ab}	120.13^{a}	0.46	0.02
0-4 wk					
ADG, g	771	762	744	9.69	0.16
ADFI, g	2466	2216	2198	28.61	0.51
G/F	0.356	0.359	0.368	0.004	0.08
4-8 wk					
ADG, g	793^{b}	820^{a}	830^{a}	7.49	0.01
ADFI, g	2780	2828	2810	19.26	0.25
G/F	0.282	0.286	0.293	0.003	0.06
Overall					
ADG, g	769^{b}	792^{ab}	802^{a}	8.15	0.02
ADFI, g	2326	2373	2359	12.12	0.06
G/F	0.330	0.334	0.340	0.003	0.09
Nutrient digestibility					
wk 4					
Dry matter	75.73	77.79	78.41	1.16	0.12
Nitrogen	68.03^{b}	71.49^{ab}	73.37^{a}	1.21	0.02
Gross Energy	69.91	72.37	72.78	1.34	0.29
wk 8					
Dry matter	71.97	73.32	74.88	0.85	0.08
Nitrogen	71.19^{b}	72.27^{ab}	74.14^{a}	0.78	0.05
Gross Energy	72.42	73.37	74.57	0.86	0.24

[1]Abbreviation: CON, basic diet; TRT1, CON + 0.05% choline chloride; TRT2, CON + 0.05% Biocholine P (chloride chloride and propylene glycol).

[2]Standard error of means.

[a,b]Means in the same row with different superscript differ significantly ($P<0.05$).

Table 3: Effect of choline chloride alone or in combination with propylene glycol on meat quality and backfat in finishing pigs1.

Items	CON	TRT1	TRT2	SEM2	*P*-Value
Meat color					
L*	58.53	57.53	56.95	0.50	0.15
a*	15.96	16.17	16.02	0.19	0.74
b*	6.48	6.66	6.43	0.08	0.20
Sensory evaluation					
Color	3.41	3.56	3.60	0.08	0.28
Firmness	2.69	2.63	2.56	0.13	0.79
Marbling	2.22[b]	2.38[a]	2.31[ab]	0.04	0.05
Cooking loss, %	33.05	32.16	31.71	1.40	0.79
Drip loss, %					
d1	7.51	7.33	7.25	0.52	0.93
d3	14.08	13.91	13.78	0.80	0.96
d5	19.86	19.68	19.56	1.37	0.98
d7	25.01	24.65	24.46	0.72	0.86
pH	5.61	5.58	5.57	0.03	0.85
Longissimus muscle area, cm2	66.76	67.45	67.72	0.47	0.33
Water holding capacity, %	54.86	55.63	56.16	0.85	0.58
Backfat thickness, mm					
Initial	13.4	13.4	13.3	0.17	0.80
wk 2	14.8	15.0	15.1	0.17	0.53
wk 4	16.6	17.0	17.3	0.20	0.08
wk 6	18.4[b]	18.9[ab]	19.3[a]	0.15	0.01
wk 8	21.1[b]	21.7[a]	21.8[a]	0.11	0.001

[1]Abbreviation: CON, basic diet; TRT1, CON + 0.05% choline chloride; TRT2, CON + 0.05% Biocholine P (chloride chloride and propylene glycol).

[2]Standard error of means.

[a,b]Means in the same row with different superscript differ significantly (P<0.05).

diet; meanwhile, marbling of pigs fed TRT2 diet was higher than the CON diet, and TRT2 was only 2.94% lower than TRT1 (Table 3). Thus, we probably consider that the biocholine P had the same influence on marbling as choline chloride, and it had positive effects on marbling in finishing pigs. In the current study, pigs had higher (P < 0.05) backfat when fed TRT2 diet than pigs fed the CON diet (Table 3). Faucitano *et al*. (2004) reported that marbling score and intramuscular fat content had the positive correlation. Thus, we considered that the increased marbling was due to the incease of backfat thinkness. Smith *et al*. (1995) found that no differences were detected for any of the backfat measurements or percent lean or muscle between choline diet and CON diet. While in this experiment, pigs had higher backfat when fed a diet containing PG than pigs fed the CON diet. Typically, the consumption of diets with high energy levels or fat tend to increase backfat thickness (Pettigrew and Moser 1991). In the current study, in week 6 and week 8, the backfat thickness of pigs fed TRT2 diet were the highest among all the dietary treatments (Table 3). It was hypothesize that it is because PG as a kind of energy substances added to the diet, then it illustrates that biocholine P is superior to choline chloride alone in some degree. From this view, we considered that PG can be used as energy source for pigs, while biocholine P did not influence the carcass characteristics of finishing pigs, therefore, in combination with the results of our experiment.

CONCLUSION

The results of the current study indicate that dietary supplementation of choline chloride alone can increase the ADG, marbling and backfat thickness in finishing pigs. The dietary supplementation of choline chloride in combination with propylene glycol can increase the BW, ADG, total tract digestibility of nitrogen, and backfat thickness in finishing pigs.

ACKNOWLEDGEMENT

This research was supported by a grant from the Bio-industry Technology Development Program (315021-04) through the Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries (iPET) and KRIBB Research Initiative Program, Republic of Korea.

REFERENCES

AOAC, (2000). Official Methods of Analysis of AOAC International Methods (934.01). AOAC International, Arlington, VA, USA. Cavender, F. L. (2012). Glycols. *Patty's Toxicology.* **4:** 595-640.

Chibisa, G.E., Gozho, G.N., Van Kessel, A.G., Olkowski, A.A., Mutsvangwa, T. (2008). Effects of peripartum propylene glycol supplementation on nitrogen metabolism, body composition, and gene expression for the major protein degradation pathways in skeletal muscle in dairy cowsathways in skeletal muscle in dairy cows. *Journal of Dairy Science*. **91**: 3512-3527.

Cook, D.A., and Easter, R.A. (1991). The Water-Soluble Vitamins. *In: Swine Nutritiou (Miller, EX., Ullrey, D.E., Lewis, A.J., Eds), Butterworth-Heinemann*. 235-266.

Cooke, R.F., Del Rio, N.S., Caraviello, D.Z., Bertics, S.J., Ramos, M.H., Grummer, R.R. (2007). Supplemental choline for prevention and alleviation of fatty liver in dairy cattle. *Journal of Dairy Science*. **90**: 2413-2418.

Chung, Y.H., Brown, N.E., Martinez, C.M., Cassidy, T.W., Varga, G.A. (2009). Effects of rumen-protected choline and dry propylene glycol on feed intake and blood parameters for Holstein dairy cows in early lactation. *Journal of Dairy Science*. **92**: 2729-36.

Faucitano, L., Rivest, J., Daigle, J.P., Lévesque, J., Gariepy, C. (2004). Distribution of intramuscular fat content and marbling within the longissimus muscle of pigs. *Canadian Journal of Animal Science*. **84**: 57-61.

Fouladi, P., Nobar, R.S.D., Ahmadzade, A. (2008). Effect of choline chloride supplement and canola oil on the performance and feed efficiency in the broiler chickens. *Research Journal of Poultry Science*. **3**: 58-62.

Grummer, R.R. (2008). Nutritional and management strategies for the prevention of fatty liver in dairy cattle. *The Veterinary Journal*, **176**:10-20.

Grummer, R.R., Winkler, J.C., Bertics, S.J., Studer, V.A. (1994). Effect of propylene glycol dosage during feed restriction on metabolites in blood of prepartum Holstein heifers. *Journal of Dairy Science*. **77**: 3618-3623.

Honikel, K.O. (1998). Reference methods for the assessment of physical characteristics of meat. *Meat Science*. **49**: 447-457.

Kauffman, R.G., Eikelenboom, G., Van der Wal, P.G., Merkus, G., Zaar, M. (1986). The use of filter paper to estimate drip loss of porcine musculature. *Meat Science*. **18**: 191-200.

Nielsen, N.I., and Ingvartsen, K.L. (2004). Propylene glycol for dairy cows: A review of the metabolism of propylene glycol and its effects on physiological parameters, feed intake, milk production and risk of ketosis. *Animal Feed Science and Technology*. **115**:191-213

NPPC. (1991). Procedures to Evaluate Market Hogs. Natl. Pork Producers Counc., Des Moines, IA.

NPPC. (2000). Pork composition and quality assessment procedures. In: National (Ed. E. P. Berg). Pork Producers Council. Des Monies, IA. 1-38.

NRC. (2012). Nutrient requirements of swine, 11^{th} edn. Natl. Acad. Press, Washington, DC.

Pettigrew, J.E., and Moser, R.L. (1991). Fat in swine nutrition. *In: Swine Nutritiou (Miller, EX., Ullrey, D.E., Lewis, A.J., Eds), Butterworth-Heinemann*, 133-145.

Rath, R., Mishra, S., Panigrahi, B., Singh, V., Tewari, H., Tewari, H. (2017). Effect dietary choline supplementation on egg quality and serum biochemical profile in White Pekin Ducks. *Indian Journal of Animal Research*. **51**: 847-850.

Shingfield, K.J., Jaakkola, S., Huhtanen, P. (2002). Effect of forage conservation method, concentrate level and propylene glycol on diet digestibility, rumen fermentation, blood metabolite concentrations and nutrient utilisation of dairy cows. *Animal Feed Science and Technology*. **97**: 1-21.

Smith, J.W., Richert, B.T., Owen, K.Q., Bergstrom, J.R., Blum, S.A., Nelssen, J.L., Goodband, R.D., Tokach, M.D. (1995). The effects of supplementing growing finishing swine diets with betaine and (or) choline on growth and carcass characteristics. *Kansas State University Swine Day. (1994). Report of Progress*. **717**: 162-164.

Wasserstein, R.L., and Lazar, N.A. (2016). The ASA's statement on p-values: context, process, and purpose. *The American Statistician*. **70**: 129-133.

Williams, C.H., David, D.J., Iismaa, O. (1962). The determination of chromic oxide in faeces samples by atomic absorption spectrophotometry. *The Journal of Agricultural Science*. **59**: 381-385.

Yildiz A, and Erisir Z. (2016). Effect of propylene glycol on fertility of postpartum dairy cows experiencing seasonal heat stress. *Indian Journal of Animal Research*. **50**: 27-30.

Zeisel, S.H. (1990). Choline deficiency. *Journal of Nutritional Biochemistry*. **1**: 332-349.

Zeisel, S.H. (1993). Choline phospholipids: signal transduction and carcinogenesis. *The FASEB Journal*. **7**: 551-557.