Korean Journal Of Agricultural Science

pISSN : 2466-2402
eISSN : 2466-2410

ANIMAL

Efficacy of decreasing levels of tryptophan relative to lysine on the performance and meat quality of finishing pigs

Golam Sagir Ahammad, In Ho Kim*

Department of Animal Resource and Science, Dankook University, Cheonan 31116, Korea

*Corresponding author: inhokim@dankook.ac.kr

Abstract

We conducted this research to examine the reducing level of lysine : tryptophan ratios in the diet affected the performance and meat quality of finishing pigs. At the end of the experiment, 144 crossbred finishing pigs (Duroc × [Yorkshire × Landrace]) having an average body weight of 70.6 ± 3.9 kg were randomly assigned to four dietary treatments (9 replications, 4 pigs per pen). The pigs in the 4 treatments were fed diets with different lysine : tryptophan ratios, such as 1 : 0.175, 1 : 0.160, 1 : 0.145, and 1 : 0.130. In considering average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR), the ratio of tryptophan and lysine (Lys : Trp) did not show any significant effect ($p > 0.05$). Moreover, nutrient digestibility had no significant impact ($p > 0.05$). However, the decreasing level of tryptophan linearly decreased the back-fat thickness at overall period ($p = 0.038$) and reduced at week 5 ($p = 0.007$). Additionally, the lean meat percentage (LMP) showed a tendency to increase at initial (linear effect, $p = 0.097$) and increased at overall period (linear effect, $p = 0.045$). Therefore, we suggest that Lys : Trp ratio of 0.130 could enhance the meat quality in finishing pigs.

Keywords: finishing pig, lysine, meat quality, performance, tryptophan

Check for updates

OPEN ACCESS

Citation: Ahammad GS, Kim IH. 2024. Efficacy of decreasing levels of tryptophan relative to lysine on the performance and meat quality of finishing pigs. Korean Journal of Agricultural Science 51:1-8. https://doi.org/10.7744/kjoas.510101

Received: August 11, 2023
Revised: September 02, 2023
Accepted: September 27, 2023

Copyright: © 2024 Korean Journal of Agricultural Science

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction

Optimizing nutrient composition in pig diets is essential for maximizing growth performance and ensuring high-quality meat production (Rodrigues et al., 2022). Among the essential amino acids, tryptophan and lysine are of particular importance due to their role in protein synthesis and the overall growth of pigs (Lin et al., 1988; Liao et al., 2015). However, the conventional approach of formulating diets with balanced levels of tryptophan and lysine may not always be the most cost-effective or efficient strategy.

Recent research has explored the efficacy of tryptophan relative to lysine in finishing pig diets as a means to enhance performance and meat quality while minimizing feed costs (Ma et al., 2016). This strategy involves manipulating the amino acid ratio to better match the animal's specific nutrient requirements, thereby potentially improving nutrient utilization and growth efficiency.

The influence of tryptophan-to-lysine ratios on pig performance has gained considerable attention (Aftab, 2012). Tryptophan is a precursor for serotonin, a neurotransmitter that plays a crucial role in regulating feed intake and behavior (Zhang et al., 2007). By decreasing the level of tryptophan relative to lysine, it is hypothesized that feed intake can be modulated, potentially leading to improvements in growth performance. Additionally, tryptophan is known to interact with the immune system, and altering its ratio to lysine could have implications for immune function and overall health status of finishing pigs (Gao et al., 2018; Huang et al., 2021).

Meat quality is another important aspect that is influenced by the nutritional composition of pig diets (Ellis and McKeith, 1999). Amino acid ratios, including tryptophan and lysine, have been found to affect carcass traits, meat composition, and sensory attributes (Ma et al., 2020). Decreasing the relative level of tryptophan to lysine may impact the deposition of intramuscular fat, which is associated with marbling and tenderness (Tous et al., 2014). Understanding the effects of these dietary modifications on meat quality parameters is essential for producing pork products that meet consumer preferences and market demands.

Given the potential benefits and consequences associated with decreasing tryptophan levels relative to lysine, there is a need for a comprehensive evaluation of its efficacy on the performance and meat quality of finishing pigs. This research study aims to determine that the lysine and tryptophan (Lys : Trp) ratio would contribute to growth performance and meat quality in finishing pigs.

Material and Methods

The research protocol (DK-2-2104) for this work was approved by the Dankook University Animal Care and Use Committee in Cheonan, South Korea.

Animals and diets

A total of 144 crossbred finishing pigs (Duroc × [Yorkshire × Landrace], 17 weeks old) with an average body weight of 70.6 ± 3.9 kg were randomly distributed to four dietary treatment groups based on body weight (BW) and sex. Each treatment had nine replicate pens with four pigs (two barrows and two gilts) per pen. Different lysine : tryptophan ratios, such as 1 : 0.175, 1 : 0.160, 1 : 0.145, and 1 : 0.130, were fed to the pigs in the four treatments. The diets were formulated to meet or surpass the NRC (2012) nutrient requirements (Table 1). The temperature was thermostatically maintained at 25℃ during the experiment, while the humidity was controlled at 60%. All the pigs were kept in an environmentally maintained facility equipped with a barn with slatted plastic floor. To ensure that the animals had unlimited access to feed and water during the experiment, a one-sided feeder and nipple drinker were equipped.

Table 1. Composition of finishing pig diets as fed basis.

Item	TRT1	TRT2	TRT3	TRT4
Ingredients (%)				
Corn	69.505	58.15	59.82	60.79
Wheat	-	10	10	7.24
Soybean meal (SBM)	12	15.29	12	10.08
Sesame meal, mech	3	2	2	2
Dried distillers grains (DDGS), corn, USA	5	-	-	3
Palm kernel meal	2.97	10.03	11.43	11.94
Magnesium soluble (MGS), condensed molasses soluble (CMS), liquid	2	-	-	-
Animal fat (YG, cattle)	2.7	2.2	2.2	2.3
Limestone	1.08	1.08	1.09	1.1
Mono-dicalcium phosphate (MDCP)	0.1	-	-	-
Refined salt	0.3	0.3	0.3	0.3
DL-Methionine, 99%	0.05	0.04	0.07	0.07
Lysine, 50%	0.59	0.43	0.57	0.64
Threonine, 98.5%	0.09	0.04	0.08	0.1
Tryptophan, 20%	0.14	-	-	-
Vitamin-3000[y]	0.1	0.1	0.1	0.1
Mineral-3100[z]	0.1	0.1	0.1	0.1
Phytase-5000	0.015	0.02	0.02	0.02
Calculated value				
Net energy	2,450	2,450	2,450	2,450
Lysine	0.900	0.900	0.900	0.900
AID lysine	0.756	0.756	0.756	0.756
AID tryptophan	0.133	0.121	0.109	0.098
AID tryptophan/lysine	0.175	0.160	0.145	0.130
Crude protein	14.79	14.47	14.20	13.98
Calcium	0.67	0.69	0.69	0.69
Phosphorus	0.34	0.32	0.31	0.33

TRT1, lysine : tryptophan = 1 : 0.175; TRT2, lysine : tryptophan = 1 : 0.160; TRT3, lysine : tryptophan = 1 : 0.145; TRT4, lysine : tryptophan = 1 : 0.130; AID, apparent ileal digestibility; YG, yield grade; DL; dextro and levo.

[y] Provided per kilograms of diet: vitamin A, 13,000 IU; vitamin D3, 1,700 IU; vitamin E, 60 IU; vitamin K3, 5 mg; vitamin B1, 4.2 mg; vitamin B2, 19 mg; vitamin B6, 6.7 mg; vitamin B12, 0.05 mg; biotin, 0.34 mg; folic acid, 2.1 mg; niacin, 55 mg; D-calcium pantothenate, 45 mg.

[z] Provided per kg diet: Fe, 115 mg as ferrous sulfate; Cu, 70 mg as copper sulfate; Mn, 20 mg as manganese oxide; Zn, 60 mg as zinc oxide; I, 0.5 mg as potassium iodide; Se, 0.3 mg as sodium selenite.

Sampling and measurements

Growth performance

Each pig's average daily gain (ADG) was assessed at the beginning, week 5, and overall to determine its ADG. The feed consumption and residuals were recorded to measure the average daily feed intake (ADFI) and feed conversion ratio (FCR).

Nutrient digestibility

At the end of the study, the apparent total tract digestibility (ATTD) of nutrients was determined. To determine the digestibility of the nutrients, chromium oxide (Cr_2O_3, 0.25%), an indigestible marker, was introduced to the diet seven days before fecal collection. Rectal massage was performed to collect feces from at least 2 pigs (1 gilt and 1 barrow) in each pen and specimens were combined by pen put on the ice box, transported to the laboratory, and stored at -20°C. Samples from the feces and feed were placed in an oven at 70°C for 72 hours. Specimens were then crushed to pass through a 1-mm sieve and gathered. The method of the AOAC (2000) was used to analyze the dry matter (DM), nitrogen (N), and digestible energy (DE) of feed and feces samples. UV spectrophotometry (UV-1201, Shimadzu Corporation, Japan) was used to determine the presence of chromium in the specimens. Using a Parr 6100 bomb calorimeter (Parr Instrument Company, USA), the heat of combustion in the samples was measured to determine the amount of DE. The following formula was used to calculate the apparent total tract digestibility (ATTD).

ATTD of nutrients (%) = [1 − (Nf × Cd)/(Nd × Cf)] × 100, where Nf stands for nutrient concentration in excreta (% DM), Nd stands for nutrient concentration in diet (% DM), Cf stands for chromium concentration in excreta (% DM) and Cd stands for chromium concentration in diet (% DM).

Back fat thickness, lean meat percentage

The back fat thickness and lean percentage of all live pigs (n = 36 per treatment) were measured 5 cm from the right hand side of the midline from 3 different sites (shoulder, mid back, and loin at a position directly above the point of elbow, last rib, and last lumbar vertebra, respectively) before the commencement and at the end of week 4 and week 8 of the experiment using a real-time ultrasound instrument (Piglog 105, SFK Technology, Denmark). The mean value was taken and used for subsequent statistical analysis.

Statistical Analysis

General linear model approaches were used to evaluate the data in a completely randomized-block design (SAS Institute Inc., USA). Pen was used as an experimental unit. Standard errors of the mean were used to describe variation in data. The effects of the various Lys : Trp ratios in the diet were examined using linear and quadratic polynomial contrasts, with $p < 0.05$ denoting significance and $p < 0.10$ showing trends.

Results

The effect of decreasing the level of tryptophan in growth performance of finishing pig diet is described in Table 2. Reducing the level of tryptophan did not show any significant effects ($p > 0.05$) in ADG, ADFI, and FCR during the whole experimental period. Similarly, no differences were observed in the nutrient digestibility of DM, N, and DE in pigs (Table 3).

As shown in Table 4, the decreasing level of tryptophan linearly decreased the back-fat thickness at overall period ($p = 0.038$) and reduced at week 5 ($p = 0.007$). Also, the lean meat percentage (LMP) showed a tendency to linearly increase ($p = 0.097$) at initial and significantly increased at the end of the experiment ($p = 0.045$).

Table 2. The effect of tryptophan/lysine ratio on growth performance in finishing pigs.

Item	TRT1	TRT2	TRT3	TRT4	SEM	p-value	
						Linear	Quadratic
Initial							
ADG (g)	867	850	858	863	11	0.891	0.358
ADFI (g)	2,409	2,374	2,382	2,393	29	0.764	0.436
FCR	2.786	2.794	2.783	2.776	0.048	0.869	0.886
Week 5							
ADG (g)	936	926	928	932	12	0.804	0.437
ADFI (g)	3,015	2,969	2,978	2,992	35	0.717	0.406
FCR	3.222	3.207	3.212	3.215	0.049	0.956	0.980
Overall							
ADG (g)	901	888	893	897	10	0.810	0.328
ADFI (g)	2,636	2,618	2,606	2,597	20	0.613	0.209
FCR	2.928	2.925	2.922	2.920	0.038	0.890	0.938

TRT1, lysine : tryptophan = 1 : 0.175; TRT2, lysine : tryptophan = 1 : 0.160; TRT3, lysine : tryptophan = 1 : 0.145; TRT4, lysine : tryptophan = 1 : 0.130; ADG, average daily gain; ADFI, average daily feed intake; FCR, feed conversion ratio; SEM, standard error of means.

Table 3. The effect of tryptophan/lysine ratio on nutrient digestibility in finishing pigs.

Item	TRT1	TRT2	TRT3	TRT4	SEM	p-value	
						Linear	Quadratic
Week 5							
Dry matter	74.24	73.73	73.82	74.06	0.46	0.901	0.734
Nitrogen	72.59	72.13	72.39	72.43	0.64	0.948	0.871
Digestible energy	72.70	72.13	72.28	72.45	0.47	0.905	0.719
Finish							
Dry matter	70.55	70.10	70.17	70.35	0.91	0.985	0.343
Nitrogen	66.70	66.35	66.50	66.53	1.17	0.997	0.444
Digestible energy	69.34	68.78	68.92	69.11	1.02	0.982	0.441

TRT1, lysine : tryptophan = 1 : 0.175; TRT2, lysine : tryptophan = 1 : 0.160; TRT3, lysine : tryptophan = 1 : 0.145; TRT4, lysine : tryptophan = 1 : 0.130; SEM, standard error of means.

Table 4. The effect of tryptophan/lysine ratio on Back-fat thickness and lean meat percentage (LMP) in finishing pigs.

Item	TRT1	TRT2	TRT3	TRT4	SEM	p-value	
						Linear	Quadratic
Initial							
Backfat thickness (mm)	12.6	12.4	12.4	12.5	0.1	0.667	0.105
Lean meat percentage (%)	57.7	57.8	57.9	58.0	0.1	0.097	0.971
Week 5							
Backfat thickness (mm)	15.7	15.6	15.5	15.4	0.1	0.007	0.668
Lean meat percentage (%)	54.4	54.7	54.7	54.4	0.1	0.716	0.104
Finish							
Backfat thickness (mm)	18.3	18.2	18.1	18.0	0.1	0.038	0.444
Lean meat percentage (%)	51.3	51.4	51.7	51.8	0.2	0.045	0.917

TRT1, lysine : tryptophan = 1 : 0.175; TRT2, lysine : tryptophan = 1 : 0.160; TRT3, lysine : tryptophan = 1 : 0.145; TRT4, lysine : tryptophan = 1 : 0.130; SEM, standard error of means.

Discussion

The objective of the present study was to determine the effects of decreasing levels of dietary apparent ileal digestibility (AID) Lys : Trp ratio in finishing pig diets on their performance and carcass quality. Several previous studies have reported varying optimal Lys : Trp ratios. For instance, a study by Liu et al. (2019) using a broken-line model showed that the optimum AID Lys : Trp ratios for maximal weight gain and minimal feed conversion were 0.171, 0.183, and 0.184, respectively in finishing pigs weighing 20 to 50, 50 to 80, and 80 to 110 kg at the start of the experiment when fed low crude protein diets ad libitum. In another study, Gonçalves et al. (2018) reported that the estimated AID Lys : Trp ratio for 30 to 125 kg gilts ranged from a minimum of 0.169 for maximum FCR to 0.235 for maximum ADG, using a linear-plateau model. A study by Zhang et al. (2012) conducted on growing pigs observed AID Lys : Trp ratio optimums ranging from 0.197 to 0.236, where the AID Lys : Trp ratio needed to maximize ADG was at least 0.220 for 0.250 to 50 kg pigs. Xie et al. (2014) observed that estimates of the optimum AID Trp to Lys ratios were 0.203, 0.197, and 0.214 for weight gain, and feed conversion ratio, respectively, using a broken-line model. However, results from the present study have shown that the ratio of lysine and tryptophan (1 : 0.175, 1 : 0.160, 1 : 0.145, and 1 : 0.130) did not show any significant effect on ADG, ADFI, and FCR in finishing pigs. The inconsistent result showed due to difference in Lys : Trp ratio, different body weights, age of the animal, and different breeds used in the study.

The tryptophan-lysine ratio is considered important for digestibility in finishing pig diets due to its role in supporting efficient growth, nutrient utilization, and overall health in pigs. Lys : Trp ratios are both essential amino acids required by pigs for protein synthesis (Lin et al., 1988). A balanced tryptophan-lysine ratio can positively influence gut health and digestion (Gao et al., 2020). Tryptophan is associated with the production of important gut hormones that regulate feed intake and gastrointestinal motility (Roager and Licht, 2018). This can impact the pig's ability to digest and absorb nutrients effectively. However, in the present study, decreasing the AID Lys : Trp ratio in the finishing diet did not show any significant effect on DM digestibility, N, and energy digestibility. The digestibility of nutrients is not solely dependent on the Trp to Lys ratio. Digestibility is influenced by a complex interplay of various nutrients. While the tryptophan-lysine ratio is important for specific physiological functions, other nutrients like fiber, fat, and various amino acids also play crucial roles in digestion (Xu et al., 2021; Lee et al., 2022). The absence of a negative effect on digestibility might indicate that other nutrients in the diet were already well-balanced, compensating for any potential influence of the tryptophan-lysine ratio.

Normally, a pig deposits proportionally fatter and less muscle as it approaches its mature body size and weight. For heavier pigs (130 kg), Smit et al. (2018) showed reduced lean yields (59 - 61%). However, the present study showed that the back-fat thickness tended to decrease at week 5, and back-fat thickness decreased at the end of the experiment, whereas LMP linearly tended to increase initially and increased at the end of the experiment with decreasing trp-lys ratio in the finishing diet. Tryptophan, as a precursor of serotonin, influences feed intake and appetite regulation. A reduction in the Lys : Trp ratio may have contributed to a decrease in serotonin production, which, in turn, could have led to a decrease in feed intake and subsequently reduced fat deposition (Yabut et al., 2019). This aligns with studies suggesting that tryptophan depletion can modulate lipid metabolism and adipose tissue accumulation (Osawa et al., 2011). The current study showed that ADFI reduced numerically, for this reason, backfat thickness was reduced. Furthermore, lysine, as a key amino acid for protein synthesis and muscle development, can influence lean tissue accretion (Liao et al., 2015). A lower Lys : Trp ratio might have facilitated an increased availability of lysine relative to tryptophan, enhancing protein synthesis and lean muscle deposition. This could explain the observed increase in lean meat percentage.

Conclusion

Even though the Trp to Lys ratio did not influence ADG, FCR, or ADFI, it had a notable effect on back-fat thickness and LMP. Our findings indicate that a Trp : Lys ratio as low as 0.13 had a significant impact on these particular aspects.

Conflict of Interests

No potential conflict of interest relevant to this article was reported.

Authors Information

Golam Sagir Ahammad, https://orcid.org/0000-0002-4182-7763
In Ho Kim, https://orcid.org/0000-0001-6652-2504

References

Aftab U. 2012. Dietary amino acid optima: An economic appraisal. Journal of Applied Poultry Research 21:738-743.

AOAC (Association of Official Analytical Chemists). 2000. Official methods of analysis, 17th Edition. AOAC, Washington, D.C., USA.

Ellis M, McKeith F. 1999. Nutritional influences on pork quality. National Pork Producers Council, Urbandale, IA, USA.

Gao J, Xu K, Liu H, Liu G, Bai M, Peng C, Li T, Yin Y. 2018. Impact of the gut microbiota on intestinal immunity mediated by tryptophan metabolism. Frontiers in Cellular and Infection Microbiology 8:13.

Gao K, Mu CL, Farzi A, Zhu WY. 2020. Tryptophan metabolism: A link between the gut microbiota and brain. Advances in Nutrition 11:709-723.

Gonçalves MAD, Tokach MD, Bello NM, Touchette KJ, Goodband RD, DeRouchey JM, Woodworth JC, Dritz SS. 2018. Dose-response evaluation of the standardized ileal digestible tryptophan: lysine ratio to maximize growth performance of growing-finishing gilts under commercial conditions. Animal 12:1380-1387. DOI:10.1017/S1751731117002968.

Huang D, Maulu S, Ren M, Liang H, Ge X, Ji K, Yu H. 2021. Dietary lysine levels improved antioxidant capacity and immunity via the TOR and p38 MAPK signaling pathways in grass carp, Ctenopharyngodon idellus fry. Frontiers in Immunology 12:635015.

Lee GI, Hedemann MS, Jørgensen H, Bach Knudsen KE. 2022. Influence of dietary fibre on nutrient digestibility and energy utilisation in growing pigs fed diets varying in soluble and insoluble fibres from co-products. Animal 16:100511.

Liao SF, Wang T, Regmi N. 2015. Lysine nutrition in swine and the related monogastric animals: Muscle protein biosynthesis and beyond. SpringerPlus 4:147.

Lin FD, Smith TK, Bayley HS. 1988. A role for tryptophan in regulation of protein synthesis in porcine muscle. Journal of Nutrition 118:445-449.

Liu JB, Yan HL, Cao SC, Liu J, Li ZX, Zhang HF. 2019. The response of performance in grower and finisher pigs to diets formulated to different tryptophan to lysine ratios. Livestock Science 222:25-30.

Ma W, Zhu J, Zeng X, Liu X, Thacker P, Qiao S. 2016. Estimation of the optimum standardized ileal digestible total sulfur amino acid to lysine ratio in late finishing gilts fed low protein diets supplemented with crystalline amino acids. Animal Science Journal 87:76-83.

Ma X, Yu M, Liu Z, Deng D, Cui Y, Tian Z, Wang G. 2020. Effect of amino acids and their derivatives on meat quality of finishing pigs. Journal of Food Science and Technology 57:404-412.

NRC (National Research Council). 2012. Nutrient requirements of swine, 11th rev. edition. National Academy Press, Washington, D.C., USA.

Osawa Y, Kanamori H, Seki E, Hoshi M, Ohtaki H, Yasuda Y, Ito H, Suetsugu A, Nagaki M, Moriwaki H, et al. 2011. L-tryptophan-mediated enhancement of susceptibility to nonalcoholic fatty liver disease is dependent on the mammalian target of rapamycin. Journal of Biological Chemistry 286:34800-34808.

Roager HM, Licht TR. 2018. Microbial tryptophan catabolites in health and disease. Nature Communications 9:3294.

Rodrigues LA, Koo B, Nyachoti M, Columbus DA. 2022. Formulating diets for improved health status of pigs: Current knowledge and perspectives. Animals 12:2877.

Smit MN, Landero JL, Young MG, Beltranena E. 2018. Effects of feeding canola meal or soy expeller at two dietary net energy levels on growth performance, dressing and carcass characteristics of barrows and gilts. Animal Feed Science and Technology. 235:166-176. DOI:10.1016/j.anifeedsci.2017.11.013.

Tous N, Lizardo R, Vilà B, Gispert M, Font-i-Furnols M, Esteve-Garcia E. 2014. Effect of reducing dietary protein and lysine on growth performance, carcass characteristics, intramuscular fat, and fatty acid profile of finishing barrows. Journal of Animal Science 92:129-140.

Xie CY, Zhang GJ, Zhang FR, Zhang SH, Zeng XF, Thacker PA, Qiao SY. 2014. Estimation of the optimal ratio of standardized ileal digestible tryptophan to lysine for finishing barrows fed low protein diets supplemented with crystalline amino acids. Czech Journal of Animal Science 59:26-34.

Xu E, Chen C, Fu J, Zhu L, Shu J, Jin M, Wang Y, Zong X. 2021. Dietary fatty acids in gut health: Absorption, metabolism and function. Animal Nutrition 7:1337-1344.

Yabut JM, Crane JD, Green AE, Keating DJ, Khan WI, Steinberg GR. 2019. Emerging roles for serotonin in regulating metabolism: New implications for an ancient molecule. Endocrine Reviews 40:1092-1107.

Zhang GJ, Song QL, Xie CY, Chu LC, Thacker PA, Htoo JK, Qiao SY. 2012. Estimation of the ideal standardized ileal digestible tryptophan to lysine ratio for growing pigs fed low crude protein diets supplemented with crystalline amino acids. Livestock Science 149:260-266.

Zhang H, Yin J, Li D, Zhou X, Li X. 2007. Tryptophan enhances ghrelin expression and secretion associated with increased food intake and weight gain in weanling pigs. Domestic Animal Endocrinology 33:47-61.