EFFECT OF QUILLAJA SAPONINS ON HARMFUL GASES EMISSION FROM PIG FARMS

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Abstract

The aim of the study was to evaluate the effect of saponins from *Quillaja saponaria* in pig diet on CO_2, NH_3, N_2O and CH_4 emissions. Ten pigs of the Přeštice black-pied breed with an average weight at the beginning of the experiment of 16.89 ± 2.51 kg were included in the study. The experiment was finished at an average live weight of 32.65 ± 4.28 kg. The experimental diet was enriched with a preparation containing saponins from *Quillaja saponaria*. The dosage of the preparation was 0.5 kg/t of feed mixture. Saponins have a significant ability to inhibit the activity of the enzyme urease, which acts as a catalyst in the decomposition of nitrogenous substances into ammonia and other components. Inhibition of urease inhibits the production of ammonia in the intestines of non-ruminant animals, thereby significantly reducing the production of stable gases. The production of the gasses was calculated per kg of live weight of pigs. It was found that the inclusion of Quillaja saponins in pig feed reduces the emission of harmful gases in the stable.

Key Words: Pig; gas emissions; Quillaja saponaria; saponins

Emissions of harmful gases are a long-term problem in livestock farming. In pig farming, these gases are ammonia, carbon dioxide, methane and hydrogen sulfide. These gases are mainly released from pig feces and urine (Hossain et al., 2024). Currently, various methodologies are being promoted that contribute to improving the stable environment, animal health and improving productivity. The largest part of the measures is taken by technological measures in the stables, a manure removal system, manure storage, manure acidification, and air scrubbers are used. The production of harmful gases includes enzymatic, microbial and chemical reactions that convert feed mixture or organic materials into gases. Interest in developing suitable and effective methods for reducing gas emissions in pig farming is growing. One such approach is nutritional regulation, which involves manipulating the pig ration to reduce the production of gas-forming compounds in the large intestine (Rowland et al., 2018; Park et al., 2018).

A properly selected feeding strategy can reduce the production of greenhouse and stable gases in the farm. It is necessary to ensure a balanced composition of the feed ration according to the given animal category. The feed should contain the optimal amount of nutrients that are usable by the animal. Feeding interventions can include, for example, reducing the protein content in the feed ration, including usable forms of nitrogen, using emission-reducing substances directly in the pig ration, for example based on amino acids or plant active substances. The effect of these supplements is mostly associated with increased nutrient digestibility, increased performance, improved nutrient conversion, or increased stress resistance (Oh et al., 2021; Davani-Devari et al., 2019; Rowland et al., 2018; Yan et al., 2012)

Supplementation of saponins to pig feed, particularly Quillaja saponin (QS), may help reduce emissions of harmful gases such as ammonia and hydrogen sulfide, by potentially binding directly to these gases and inhibiting urease enzymes produced by harmful bacteria in the gut. While the impact on carbon dioxide and methane emissions may be less direct, some studies show a trend towards reduction, likely due to improved feed intake and growth, leading to lower CO_2 emissions per unit of body weight gain (Biswas and Kim, 2024; Dang et al., 2020).

Material and Methods

Ten pigs of the Přeštice Black and White breed with an average weight at the beginning of the experiment of 16.89 ± 2.51 kg were included in the study. The experiment was finished at an average live weight of 32.65 ± 4.28 kg.

The pigs were housed in a group pen with a total area of 9 m^2. The floor was concrete, solid, without slats, housing on litter, which was changed after each measurement of stable gas emissions. Feed and water intake was ensured ad libitum using a nipple drinker, feed was placed in the trough manually, unconsumed residues were removed and weighed every day to monitor feed consumption.

The experiment used a commercial feed mixture (Table 1), which was enriched with a preparation containing saponins from *Quillaja saponaria*. The dosage of the preparation was 0.5 kg/t of feed mixture.

The first phase of the experiment lasted 14 days and the animals were fed a commercial feed mixture without the addition of the preparation containing *Quillaja saponaria*, followed by the second phase, when the animals were presented with a feed mixture enriched with the above preparation.

To measure gas emissions in the air of the experimental stable, the LumaSense INNOVA 1412i gas monitor was used. The measurement interval was set to 30 min. For the measurement of emissions in manure, an automatic CO2 and CH4 and H2O analyzer LI-7810 from LI-COR (USA) with a Multiplexer LI-8250 and measuring chambers LI-8200-104 was used (Figure 1 and 2). NH3 emissions were determined as N-NH4 after sorption of NH3 in 3% boric acid and subsequent colorimetric determination with the SANplus SKALAR device. During the measurement, faeces samples were taken to determine the digestibility of nutrients. During both experiments, the temperature and relative humidity of the experimental barn were continuously measured with the Datalogger Comet S3120.

The following indicators were monitored as part of the experiment:

- live weight of experimental pigs at the beginning anf at the end of the experiment (kg)
- live weight of experimental pigs at the transition to the experimental feed mixture (kg)
- average daily weight gain in the first and second phases of the experiment (g/day)
- feed consumption (kg)
- feed conversion (kg/kg)
- digestibility of nutrients by indicator method (natural indicator - ash insoluble in 4M hydrochloric acid),
- CO_2, CH_4 and NH_3 emissions in manure and in the air of the experimental barn
- production of gases per kg live weight of experimental pigs

Figure 1. LI-COR LI-7810 Automatic CO2, CH4 and H2O Analyzer with LI-8250 Multiplexer

Figure 2. LI-8200-104 measuring chambers

Table 1. Composition of the basic feed mixture

Components	**% in feed mixture**
Barley	41.20
Wheat	17.50
Wheat bran	3.00
Selvico grain	25.00
Fish meal	2.60
Dried poultry blood	4.50
Molkolac	1.00
Fish oil	0.43
Premix, min. substances, vitamins, org. acids	4.77
Nutrient content - calculation	
Dry matter (g)	874.10
N-substances (g)	179.54
Lysine (g)	12.15
Fiber (g)	39.63
ME (MJ)	13.47

Results and Discussion

The production traits of the experiment are presented in the following tables 2 and 3. Average live weight gain in the first phase of the experiment was 431.79 ± 66.39 g/day, in the second phase 647.67 ± 76.64 g/day. Feed conversion ratio was lower in phase 2, when pigs were fed a mixture with added saponins (1.94 kg/kg vs. 1.85 kg/kg). Digestibility of fat and N-substances was higher in phase 2.

CO_2 emissions determined in manure and subsequently converted to kg live weight of pigs are shown in graphs 1 and 2. The nitrogen content of manure is illustrated in Graph 3. Total CO_2 emissions increased in the first and second weeks of measurement up to the level of 231.49 µmol/m2/s, then there was a decrease and the CO_2 level was almost constant. After conversion to kg live weight of pig, a decrease in CO_2 emissions is evident (graph 2).

Table 2. Growth parameters of pigs

Parameter	
Average live weight at the beginning of the experiment (kg)	16.89 ± 2.51
Average live weight at the transition to the experimental feed mixture (kg)	22.94 ± 3.24
Average live weight at the end of the experiment (kg)	32.65 ± 4.28
Average daily live weight gain – phase 1	431.79 ± 66.39
Average daily live weight gain – phase 2	647.67 ± 76.64
Feed conversion – phase 1	1.94
Feed conversion – phase 2	1.85

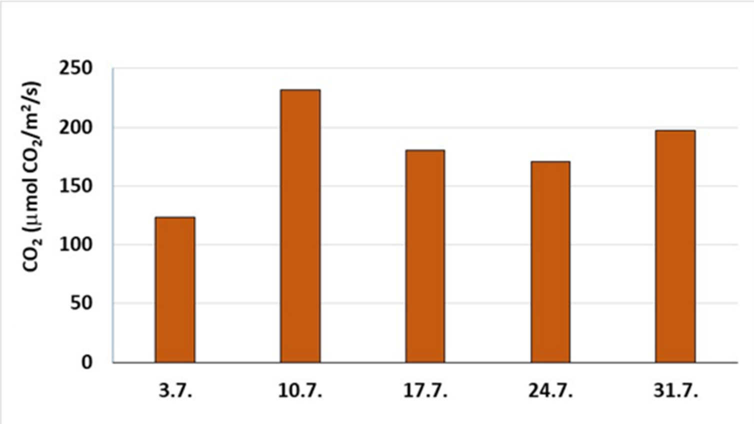
Phase 1: From the beginning of the experiment to the change in feed ration (first 14 days)
Phase 2: from the change of feed ration to the end of the experiment (next 14 days)

Table 3. Digestibility of fat and N-substances (%) determined by the indicator method

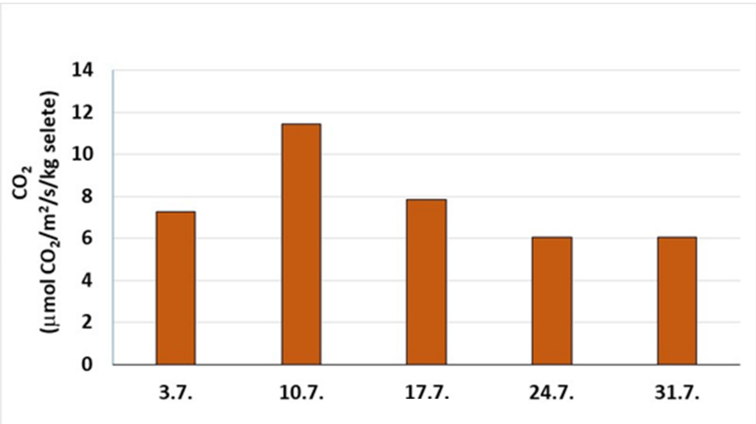
	Phase 1	Phase 2
Fat	78.19	91.36
N-substances	76.04	90.50

Phase 1: From the beginning of the experiment to the change of feed ration (first 14 days)
Phase 2: from the change of feed ration to the end of the experiment (next 14 days)

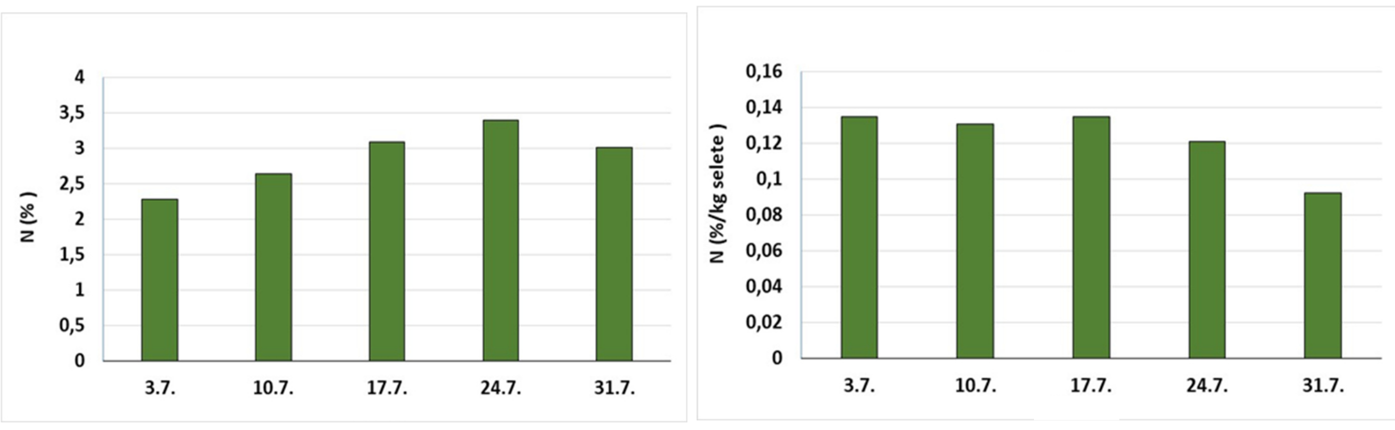
Graph 1. CO_2 emissions in pig manure



Graph 2. CO_2 emissions in manure converted to live weight of pigs



Graph 3. Nitrogen content of manure (total and converted to kg live weight of pigs)

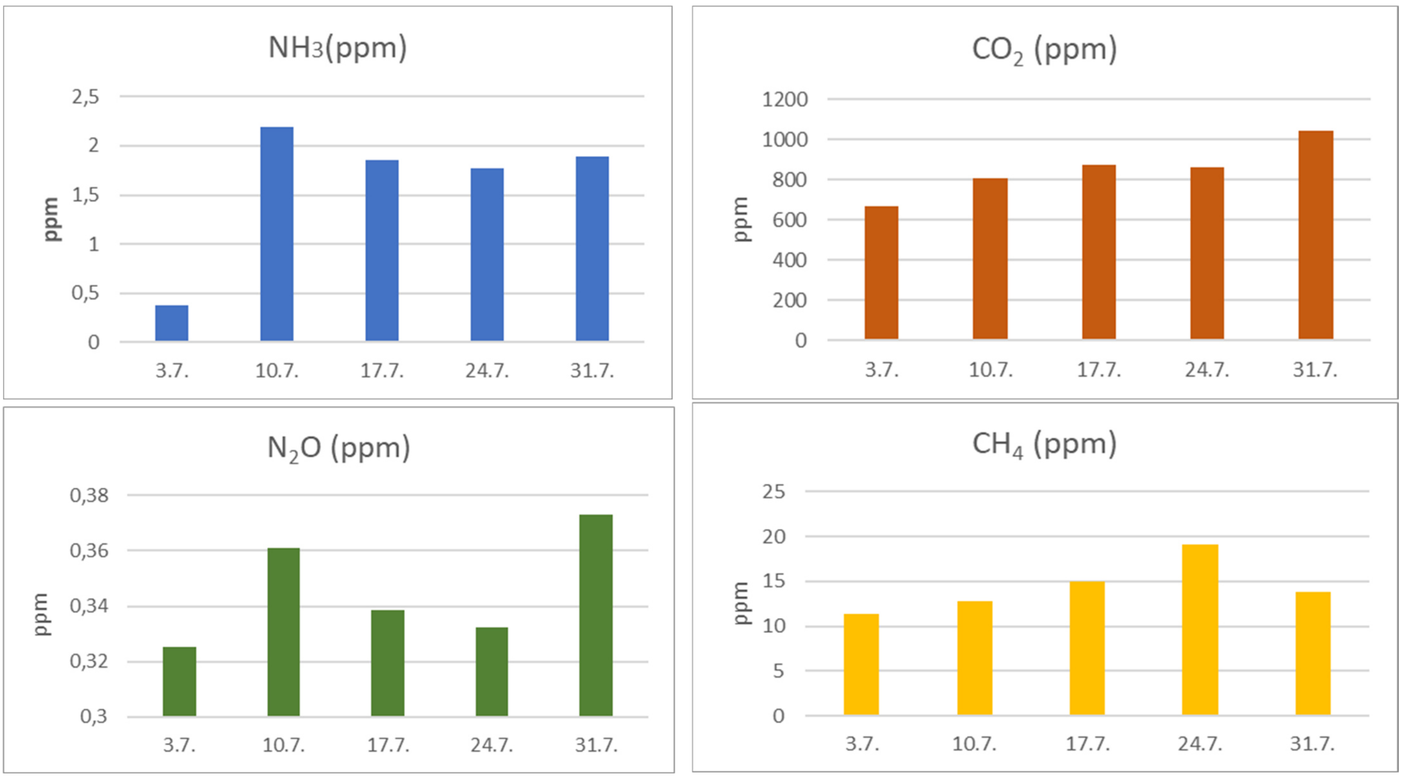


Gas emissions in the air of the experimental stable are illustrated in the following graphs 4 and 5. NH_3 emissions increased in the second week of measurement, then decreased slightly and remained at a constant level. Total CO_2 emissions increased slightly throughout the measurement period. The N_2O level fluctuated throughout the experiment, with the highest levels in the second and last weeks of measurement. CH_4 emissions increased until the penultimate week, and then a decrease in emissions was observed in the last week of measurement. After converting gas emissions per kg of live weight, their decrease was found after the addition of saponins to the pig feed ration. NH_3 emissions decreased evenly from 0.105 ppm to 0.058 ppm from the second week. A slight decrease in CO_2 levels in the air was also found from the second week of the experiment. The N_2O level converted to kg of live weight of experimental pigs decreased from the first week of measurement (0.018 ppm) until the end of the experiment (0.011 ppm). CH_4 emissions decreased significantly only in the last week of the experiment; in the previous weeks their level was at a constant level.

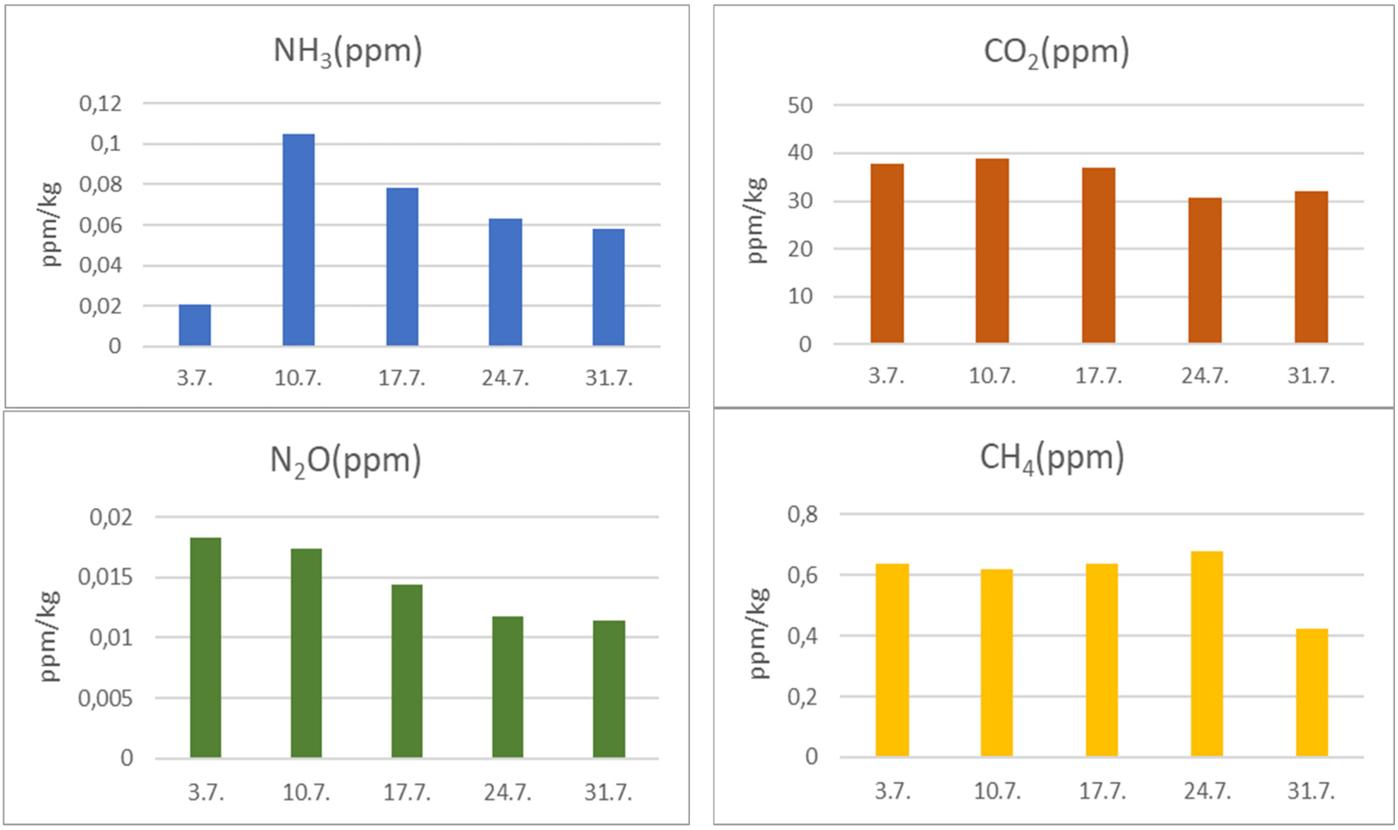
The pharmacological effects of QS have been extensively studied and include strengthening biological membranes, lowering serum cholesterol levels, and influencing ammonia production (Francis et al., 2002). As a natural glycosidic compound, QS has a number of effects on the gastrointestinal tract, including digestion and nutrient absorption, which are closely related to the bioactivity of saponins (del Hierro et al., 2018).

The inclusion of QS in the diet of weaned pigs at a concentration of 125 mg/kg resulted in improved feed intake and conversion rates, as observed in a study by Václavková and Bečková (2008). Another study found that supplementing the diet of growing pigs with 200 mg/kg of QS resulted in improved growth, reduced levels of infectious microbes, and a more favorable barn atmosphere due to reduced fecal gas emissions (Dang and Kim, 2021). Permylmaceutical fatty acids containing QS can improve performance by increasing nutrient intake, improving growth efficiency due to better palatability, and reducing ammonia emissions from pig farms (Bartos et al., 2016). Dang and Kim (2020) reported that adding 400 mg/kg QS to the feed ration of finishing pigs improved meat quality and fecal gas emissions without affecting growth efficiency and nutrient retention.

Graph 4. Gas emissions measured in the stable



Graph 5. Gas emissions measured in the stable – conversion to kg of live weight of pigs



Conclusion

The effect of saponins from *Quillaja saponaria* in pig diet on CO_2, NH_3, N_2O and CH_4 emissions in pig manure and in stable air was evaluated in the study. The production of the gasses were measured as a total amount and calculated per kg of live weight of pigs. The total amount of gasses increased during the experiment but after calculation to kg of live weight was found that the inclusion of Quillaja saponins in pig feed reduces the emission of harmful gases in the stable.

References

BARTOŠ P, DOLAN A, SMUTNÝ L, ŠÍSTKOVÁ M, CELJAK I, ŠOCH M, HAVELKA Z. 2016. Effects of phytogenic feed additives on growth performance and on ammonia and greenhouse gases emissions in growing-finishing pigs. Anim Feed Sci Technol. 212:143–148. doi: 10.1016/j.anifeedsci.2015.11.003

BISWAS S. and I.H. KIM. 2024. Assessment of Quillaja saponin as a feed supplement in maize-soybean-oilseed rape meal-based diet for enhanced growing pig performance. J. Anim. Feed Sci., 33, 2, 193–199, https://doi.org/10.22358/jafs/171702/2023

DANG D.X., KIM I.H. 2020. Effects of dietary supplementation of Quillaja saponin on growth performance, nutrient digestibility, fecal gas emissions, and meat quality in finishing pigs. J. Appl. Anim. Res. 48, 397–401, https://doi.org/10.1080/09712119.2020.1813739

DANG D.X., KIM I.H. 2021. Effects of Quillaja saponin supplementation on growth performance, nutrient digestibility, fecal microbiota, and fecal gas emission in growing pigs. Can. J. Anim. Sci. 101, 667–673, https://doi.org/10.1139/cjas-2020-0185

DAVANI-DAVARI D, NEGAHDARIPOUR M, KARIMZADEH I, SEIFAN M, MOHKAM M, MASOUMI SJ, et al. 2019. Prebiotics: definition, types, sources, mechanisms, and clinical applications. Foods., 8:92. https://doi.org/10.3390/foods8030092

HOSSAIN MM, HWANG HS, PANG M, CHOI MK, KIM IH. 2024. Effect of dietary Achyranthes japonica extract on growth performance of growing pigs and absorption rate of quercetin in blood. J Anim Sci Technol., 66:103-14. https://doi.org/10.5187/jast.2023.e23

ILSLEY SE, MILLER HM, GREATHEAD HMR, KAMEL C. 2003. Plant extracts as supplements for lactating sows: effects on piglet performance, sow food intake and diet digestibility. Anim Sci. 77:247–254. doi: 10.1017/S1357729800058987

ILSLEY SE, MILLER HM, KAMEL C. 2005. Effects of dietary quillaja saponin and curcumin on the performance and immune status of weaned piglets. J Anim Sci. 83:82–88. doi: 10.2527/2005.83182x

MUNIYAPPAN M., BAEK D.H., KIM I.H. 2022. Effects of dietary supplementation of quillaja saponin or fructooligosaccharide and a mixture of both on the growth performance, nutrient utilisation, faecal microbial and faecal noxious gas emissions in growing pigs. Ital. J. Anim. Sci. 21, 1489–1497, https://doi.org/10.1080/1828051X.2022.2093656

OH JK, VASQUEZ R, KIM SH, HWANG IC, SONG JH, PARK JH, et al. 2021. Multispecies probiotics alter fecal short-chain fatty acids and lactate levels in weaned pigs by modulating gut microbiota. J Anim Sci Technol., 63:1142-58. https://doi.org/10.5187/jast.2021.e94

PARK JH, KIM IH. 2018. Effects of a protease and essential oils on growth performance, blood cell profiles, nutrient retention, ileal microbiota, excreta gas emission, and breast meat quality in broiler chicks. Poult Sci., 97:2854-60. https://doi.org/10.3382/ps/pey151

ROWLAND I, GIBSON G, HEINKEN A, SCOTT K, SWANN J, THIELE I, et al. 2018. Gut microbiota functions: metabolism of nutrients and other food components. Eur J Nutr., 57:1-24. https://doi.org/10.1007/s00394-017-1445-8

VACLAVKOVA E, BECKOVA R. 2008. Effect of herbal extract on growth parameters of weaned piglets. Res Pig Breed, 2:36–38.

WANG B, TU Y, ZHAO SP, HAO YH, LIU JX, LIU FH, XIONG BH, JIANG LS. 2017. Effect of tea saponins on milk performance, milk fatty acids, and immune function in dairy cow. J Dairy Sci. 100:8043–8052. doi: 10.3168/jds.2016-12425

YAN L, KIM IH. 2012. Effect of eugenol and cinnamaldehyde on the growth performance, nutrient digestibility, blood characteristics, fecal microbial shedding and fecal noxious gas content in growing pigs. Asian-Australas J Anim Sci., 25:1178-83. https://doi.org/10.5713/ajas.2012.12111

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