THE PIG FEEDING AND NITROGEN ASSOCIATED GASEOUS EMISSIONS IN LATVIA

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Abstract
The research paper focuses on description of the pig (*Sus scrofa domestica*) farming tendencies in Latvia with the scope to give feeding characteristics in relation to emission outcome. In the recent years the concentration of pigs in farms with a herd size more than 10,000 has increased. With increase of the large farms the average feed consumption is more affected by one operator. Efficient utilization of nutrients content in feeding is crucial to meet environmental goals. It is one of the steps to achieve Nutrient Use Efficiency. There is relationship between crude protein and reduction of reactive nitrogen. Feed content not only affects excreted nitrogen, but also pH of manure and total ammoniacal nitrogen. It is complex abatement measure to quantify reduction of the emission because of impact of various environmental factors. In Latvia, the most common are sows cross breeds (Yorkshire × Landrace) and on January 1, 2019 the biggest group accounted was fattening pigs with average dry feed consumption per day from 0.33 kg (liveweight from 5 to 6 kg) up to 3.6 kg (liveweight from 80 to 120 kg) with crude protein value from 163.5 g to 155.3 g per 1 kg feed dry matter. Excreted nitrogen (N_{ex}) was calculated for these groups of pigs less than suggested values in guidelines for emission calculation. The highest calculated total NH_3 emission is from fattening pigs group with liveweight from 55 to 90 kg although the highest calculated N_{ex} is for lactating sows. NO_x also calculates as NO_2 and the highest value was 3.23 g per one lactating sow.
Key words: pig feed, nutrient content, reactive nitrogen, crude protein, manure management.

Introduction

The demand for food production altered the land-based cycle of nitrogen causing harm for human health, environment and economics. Improvement of nutrient use in animal production is one of the key actions to achieve Nutrient Use Efficiency. The negative effects of abundance of nitrogen not only affects water quality and biodiversity, but also decreases the air quality including increased global warming effect by more reactive gas than CO_2 – N_2O (Sutton *et al.*, 2013). Reduction of the emissions is in scope of the EU National Emission Ceiling Directive (Directive 2016/2284/EU). Traditionally the aim of pig (*Sus scrofa domestica*) breeder is to achieve high increase in liveweight of pigs and reproduction rates with minimum feed consumption and low feed costs. Excessively high levels of dry matter, protein, minerals and other nutrients in doses of pig feed increases water consumption, manure and urine output. Non-digested nutrients enter the ecosystem increasing environmental impact described previously.

As pigs are monogastrics, digestion of all nutrients takes place mainly in the endemic process. The main energy amount for pigs is protein, fat, starch and fibre. Minerals and vitamins are also important to ensure physiological processes. There are many researches investigating the effect of adaptation of feeding strategies to reduce nitrogen loss by manure. Sajeev *et al.* have published a meta-analysis discussing the potential of crude protein (CP) adjustment to meet the aim of ammonia (NH_3) reduction for cattle and pigs. Fourteen published works were used to determine the effect of reduction CP on NH_3 and total ammoniacal nitrogen (TAN). The conclusions show that there is a relationship between CP and NH_3. There is on average 11 ± 6% reduction of NH_3 per %-point of CP (Sajeev *et al.*, 2017). Canth *et al*. research includes experimental data on growing pig after reduce of CP level. Two way experiment where performed. Measurements made in metabolism cages and farm level (housing type – slatted floor compartment). Initial CP level was 16.5% and 14.5% which was reduced by 2% and 4% respectively. Reduced NH_3 emission was similar for both experiments with a little bit higher efficiency in farm level. About twice higher reduction level determined for 4% reduction of CP compared to 2% CP reduction. There was a positive effect on manure pH and TAN, which are also factors of reduced NH_3 emissions (Canh *et al*., 1998). The highest effect on NH_3 is described in the research by Portejoie *et al.* for barrows fresh slurry. Reduction of NH_3 emission was about 76% with much greater reduction of the CP because of high initial CP level (20%). The CP reduction was 8 CP % (Portejoie *et al*., 2004). The results of researches are various because of differences in methodology and impact of environmental factors. Reduction of NH_3 emission depends on lowering level of CP with coefficient of determination 0.53 (Sajeev *et al*., 2017). An alteration of CP is not the only way to impact NH_3 emissions from manure. Increasing the non – starch polysaccharides by 100 g can lower pH of the slurry by 0.12 units according to the research of Jha and Berrocoso (Jha & Berrocoso, 2016).

The aim of the study is to estimate the current effect of feeding strategies of Latvian pig production, its tendencies and estimate impact on greenhouse gasses (GHG) and ammonia emissions for the purpose to assess options to optimize feed composition for reduction of gaseous emissions.

Materials and Methods

Statistical data of the number of pigs in Latvia are based on data collection of the Agricultural Data Centre (Agricultural data centre, 2019). Pig numbers are represented in groups according to the herd size. Surveys about pig feeding on pig holdings with more than 1000 pigs have been carried out in cooperation with the Latvian Association of Pig Growers (n=5) during 2015-2018. Recipes have also been obtained from main pig feed producers (n=5). For analyses average data is used and represents the major tendency of pig feeding strategies. Emission in relevance to reactive nitrogen is evaluated theoretically.

The main factor that influences excreted nitrogen (N_{ex}) is the diet of the livestock. Input – output measurements or balance method was used for estimating N_{ex} by pigs assuming that the amounts of N_{ex} in faeces and urine is equal to the total amounts of feed N consumed minus the amounts of N in the pigs product. Equation (1) was used to calculate annual N excretion rate.

$$N_{ex} = N_{intake} \cdot (1 - N_{retention}),$$
kg N animal^{-1} year^{-1} (1)

The annual total nitrogen intake per pigs is calculated by Equation 2. Values fraction of annual N intake that is retained by pigs ($N_{retention}$) for the study is adopted from in-depth analyses of country reports on nitrogen excretion factors of livestock (Šebek *et al*., 2014).

$$N_{intake} = \frac{GE}{18.45} \cdot \left(\frac{CP}{6.25}\right),$$
kg N animal^{-1} year^{-1} (2)

In Equation (2) gross energy intake of the animal (GE, MJ animal^{-1} day^{-1}), conversion factor for dietary GE per kg of dry matter (18.45 MJ kg^{-1}) are used. This value is relatively constant across a wide range of forage and grain-based feeds commonly consumed by livestock. CP in diet (%) and conversion from kg of dietary protein to kg of dietary N, kg feed protein (kg N)$^{-1}$ – 6.25 are also used in Equation 2.

Equation 3 was used to calculate gross energy intake by pigs using energy intake for maintenance and growth of pigs (ME, MJ animal^{-1} day^{-1}) and digestible energy of gross energy of pigs (DE, %).

$$GE = \frac{ME}{DE},$$ MJ animal^{-1} day^{-1} (3)

Intergovernmental Panel on Climate Change Guidelines methodology 2006 and emission factors were used to estimate N_2O emissions from manure management of pigs (Intergovernmental …, 2006). Feed digestibility was obtained from the catalogue of forage digestibility and chemical analysis study under 2009-2014 EEA Grants Programme National Climate Policy and financial support for the project 'Agricultural sector GHG emissions calculation methods and data analysis with the modelling tool development, integrating climate change' (Degola, Trūpa, & Aplociņa, 2016). Ammonia emissions are calculated using European Monitoring and Evaluation Programme and European Environment Agency Guidebook 2016 Tier 2 approach. Emission coefficients used are default (European Environmental Agency, 2016).

It is assumed for calculations that pigs are housed all year with slurry manure management system. Emissions are calculated for one animal unit per defined pig group per year.

Results and Discussion

When the term protein is used in pig production, we immediately understand that it is a protein that is complete, or that in which essential amino acids are in certain ratio, so that animals achieve positive yields. Pigs have 5 major essential amino acids - lysine, methionine + cysteine, threonine, tryptophan and valine. Each amino acid performs a specific function, so it is important to control their contents and ratio. In practice, when drawing up feed doses for fattening pigs the following amino acid ratios are used:

- lysine – 1.00;
- methionine + cysteine – 0.56;
- threonine – 0.63;
- tryptophan – 0.18;
- valine – 0.58.

In pig feeding, it is important to respect not only the ratio of amino acids, but also their ratio to the maintenance energy (ME). This is important because if there is no adequate energy supply, protein use will not be efficient and overall metabolic processes may be disrupted. In practice, it is important to control the energy to lysine ratio (Table 1).

Table 1

Maintenance energy / lysine ratio for fattening pigs

Animal liveweight, kg	10 – 30	30 – 60	60 – 90	90 – 120
Lysine: ME	0.93	0.80	0.64	0.52
Digestible lysine: ME	0.82	0.70	0.55	0.44

In practice, the following amount of fat in the feed dose is maintained:

- 2.0 – 2.6% for pregnant sows;
- 3.5 – 4.5% for lactating sows;

Table 2

Change in number of pigs by herd size

Pig holding groups	Number of pigs by year							
	2011	2012	2013	2014	2015	2016	2017	2018
1 – 9	6,122	3,794	3,560	7,205	7,171	9,174	11,798	10,539
10 – 50	14,628	11,710	11,925	10,729	9,330	10,074	10,695	9,554
51 – 100	7,334	5,865	5,797	5,041	4,367	3,484	3,762	3,108
101 – 500	17,894	14,465	10,134	7,429	6,714	9,798	6,198	6,121
501 – 1,000	12,876	5,664	6,841	9,439	9,066	6,097	5,148	3,737
1,001 – 5,000	46,692	57,495	43,032	58,809	55,247	36,020	36,642	33,884
5,001 – 10,000	66,533	60,170	48,721	48,186	69,455	48,781	52,490	52,095
> 10,000	158,685	151,318	181,239	171,989	167,507	204,266	203,997	202,465

- 7.0 – 10.0% for suckling piglets;
- 5.0 – 6.0% for separated piglets;
- 3.0 – 4.0% for fattening pigs up to 30 kg;
- 2.5 – 3.0% for fattening pigs (30 – 60 kg);
- 2.0 – 2.5% for fattening pigs (60 – 115 kg).

A significant energy source in pig nutrition is starch. The main source of starch is the cereals included in the feed dose. In the Baltic region, the main used cereals are barley, wheat and triticale. The starch in pig feed on average is between 40% and 55%. The level of starch in feed is determined by the proportion of cereals and, as it will be higher, the higher the level of starch. The soybeans contain a large amount of protein required in the pig feed dose, but in the pig feed production practice, the fat and protein components are added separately. It is convenient for diversification of feed to meet the required protein and fat levels according to each age group of pigs.

It is also important for pig health and good digestive tract function to control the amount of neutral detergent fibres (NDF) in feed. Crude fibre makes animals feel sate, they are peaceful, stress level, aggression and cannibalism is decreased. This is particularly important for groups of pregnant sows and for the final fattening period, when NDF should be planed 13.0 – 14.5%. Crude fibres are mainly contained in compound shells of feed materials. A high percentage of NDF is in feed with high concentration of barley, rapeseed and dried beet grasses in feed.

The total number of pigs in Latvia on July 1, 2018 was 321,748. The number of pigs in Latvia is fluctuating, affected by the economic situation in Latvia and Europe, diseases, feed costs and other conditions.

There is a tendency to increase of small pigs holdings (1 – 9 pigs) by 2018, while the number of pigs in those holdings is small, approximately 3.2% of the total number of pigs (Table 2). In Latvia, 90% of total number of pigs is concentrated in large holdings, with more than 1,000 pigs in the herd (Table 2). These holdings are modern and use diversified feeding strategies with balanced protein, vitamin, mineral and other additives content.

In Latvia, the most common are cross breeds (Yorkshire×Landrace) – 44.3% and Landrace – 35.4% sows according to Agricultural data centre pig recording data (Figure 1).

Pig catering on these holdings is complete and provides pigs with all the necessary nutrients. Growers

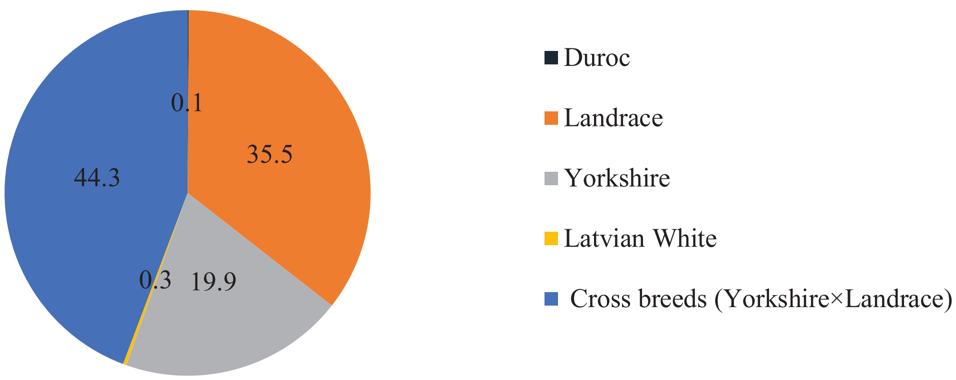

Figure 1. Distribution of sow breeds according to Agricultural data centre pig recording (%).

Table 3

Average feed nutrient content in 1 kg of feed dry matter

Nutrients	Pregnant sows	Lactating sows	Piglets, 8 – 15 kg	Pigs, 15 – 30 kg	Pigs, 30-60 kg	Pigs, 55 – 90 kg
Maintenance energy, MJ	12.4	13.3	13.5	12.9	12.8	12.8
Crude protein, g	133.2	150.2	163.5	179.3	165.3	155.3
Digestible protein (%)	74.9	81.4	84.4	82.3	80.6	79.5
Starch, g	470.0	457.3	454.9	429.5	454.4	471.5
Fat, g	24.9	44.3	35.6	27.6	22.9	22.9
Lysine, g	7.1	9.8	13.7	12.8	11.1	9.9
Digestible lysine, g	5.8	8.8	12.6	11.6	9.7	8.6
Digestible met.+ Cist., g	4.3	6.0	7.2	7.4	5.3	5.0
Digestible met., g	2.0	2.8	3.5	3.6	2.6	2.4
Digestible threonine, g	3.9	5.5	8.0	7.4	6.0	5.5
Digestible tryptophan, g	1.1	1.8	2.0	1.9	1.7	1.6
Digestible valine ,g	4.6	4.6	5.0	4.7	4.5	4.8
Ca, g	6.6	7.8	8.2	7.8	6.9	6.2
P, g	4.8	4.9	5.0	5.5	4.8	4.7
Digestible P, g	2.1	2.5	2.7	2.8	2.1	2.1
Crude fibres, g	41.2	32.4	26.4	34.7	36.1	36.4
Neutral detergent fibre, g	150.0	120.0	80.0	100.0	140.0	145.0

cooperate with foreign counterparts and consultation firms. Different additives are used to balance feed. The average content of nutrients in feed for groups of different liveweights is shown in Table 3. Average CP for all pig groups is 157.8 g per kg of feed or 15.8%. The highest CP content is on average 17.9% and it is typical for pigs in growing period with liveweight 15 – 30 kg.

There are completed feed producers for pigs as 'LRS Musa'. Feed materials: wheat (*Triticum*), barley (*Hordeum vulgare*), triticale (*Triticosecale*), maize (*Zea mays*), pea (*Pisum*) bran, rye (*Secale*) bran, soya bean (*Glycine max*), rapeseed (*Brassica napus*), dried sugar beet (*Beta vulgaris*) chips, sunflower (*Helianthus annuus*) cake, sugar beet molasses, plant oil, minerals, amino acid and vitamin additives,

Table 4

Average daily consumption of dry matter and total protein of feed per pig

Group of pigs	Feed dry matter, kg	Crude protein in dry matter, g
Lactating sows (liveweight from 180 up to 300 kg)	1.53 + 0.41 per piglet (6.0 – 8 kg)	901 – 1,202
Sows after lactation, in 30 – 35 day period (liveweight from 180 up to 280 kg)	2.70 – 3.15	360 – 420
Pregnant sows (liveweight from 180 up to 200 kg):		
pregnancy period 0 – 35 days	1.80 – 2.25	240 – 300
pregnancy period 30 – 85 days	2.25 – 2.70	300 – 360
pregnancy period 85 – 115 days	3.10 – 3.60	413 – 480
Fattening pigs		
liveweight from 5 up to 6 kg	0.33	54
liveweight from 10 up to 18 kg	0.94	169
liveweight from 30 up to 60 kg	1.25	207
liveweight from 60 up to 80 kg	2.70	420
liveweight from 80 up to 120 kg	2.70 – 3.60	440 – 587

Table 5

Breakdown of pig number per group according to Agricultural Data centre pig recordings for January 1, 2019

Pig group	Pig number	% of total pig number
Total pig number	302,800	100.0
Sows	22,398	7.4
Boars	431	0.1
Fattening pigs	138,763	45.8
Piglets	45,609	15.1
Weaning piglets	82,946	27.3
Gilts	4,627	1.6
Growing pigs	8,026	2.7

mycotoxins binders. In feed recipes of these producers cereal amount are at 66 – 85% and soya, sunflower sprouts or rapeseed from 5 – 18%, depending on the demand of specific age group of pigs. Other feed companies also produce complete feed for pigs, such as ‘Dobeles Dzirnavnieks’, ‘Straume’, ‘Baltic Feed’ and other. However, the largest proportion of big holdings prepare feed themselves, using their own grown or purchased grains, rapeseed, soya and sunflower sprouts or cakes, bran, vegetable oil. Mineral, vitamin and amino acid additives are used for feed material on the demand of specific age group of pigs.

The feed consumption has been calculated (Table 4) for the dry feeding, which may also be diluted with water. It is complete, assuming that the dry matter in feed is 88%. Daily the highest consumption of CP is for lactating sows and finishing pigs (80 – 120 kg) because of high consumption of the feed.

In accordance with Agricultural data centre pig recordings for January 1, 2019 the biggest group is fattening pigs (45.8%) and weaning piglets – 27.3% (Table 5).

Pigs on small holdings from 1 to 9 pigs in the herd may consume higher quantities of feed, as the feed may sometimes be unbalanced by nutrient (not only forage, but also scraps of food, root crops and other compounds are used as feed materials). As a general rule, pigs are kept for their own consumption and do not affect the average use of feed in Latvia.

Calculated emission according to N_{ex} is summarized in Table 6. The highest total NH_3 emissions (12.81 kg) are from lactating sow with piglets due to highest N_{ex}. The same is for other nitrogen gaseous emissions (N_2O, NO_x). Calculated N_{ex} meet the requirements defined by Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs (European Commission, 2017). Values of N_{ex} in BAT are given for two groups: sows with piglets (till 25 kg) and fattening pigs (25 – 105 kg).

Comparing changes of pig feeding in the time scale, there is a decrease in the nitrogen emissions. According to pig feeding norms (Latvietis, 1998), calculated N_{ex} for a pregnant sow is 15.98 kg animal^{-1} year^{-1}. That is by 19% less than calculated N_{ex} and

Table 6

Emissions affected by nutrient content of pig feed

Pollutants	Pig groups					
	Pregnant sow	Lactating sow with piglets	Pig, 8 – 15 kg	Pig, 15 – 30 kg	Pig, 30 – 60 kg	Pig, 55 – 90 kg
N_{ex}, kg	12.91	28.04	2.08	5.19	6.38	14.72
N_{ex}, kg (European Commission, 2017)	21.00 – 32.00			7.00 – 13.10		
NH_3 (housing), kg	2.41	5.24	0.50	1.24	1.52	3.50
NH_3 (storage), kg	1.26	2.75	0.19	0.47	0.58	1.34
NH_3 (application), kg	2.22	4.82	0.46	1.14	1.40	3.23
Total NH_3, kg	5.89	12.81	1.15	2.85	3.50	8.07
NO_x (as NO_2), g	2.44	5.31	0.37	0.91	1.12	2.58
N_2O, g	101.42	220.34	16.35	40.80	50.12	115.63

emissions of NH_3, NO_x, N_2O according to represented data in this paper. The CP difference for a pregnant sow is about 0.7 CP%. There is greater difference (35% of reduction) for lactating sows with piglets with reduced CP by 3.5 CP%.

Calculated data shows that there is a need to revise used N_{ex} because of increasing impact of big pig holding share in pig production structure. For this moment in Latvia's Informative Inventory Report 1990 – 2017 (Skrebele *et al*., 2019) used N_{ex} is 14 kg head^{-1} year^{-1} for fattening pig, so in comparison with calculated data the weighted average should be lower. The same tendencies can be seen in other countries inventories, for example, Estonia where N_{ex} is 10.6 kg head^{-1} year^{-1} (Kohv *et al*., 2019). Decreased N_{ex} would decrease nitrogen associated gaseous emissions.

Development of feeding plans with decreased CP is an acceptable way to reduce pig production impact on environment because lower emissions can be reached. The lowest bar defined by BAT is still not reached in all farms in the country. There is still a possibility to reduce total with nitrogen associated gaseous emissions by pig feed planning.

Conclusions

More pigs in Latvia are concentrated in big holdings (>10,000). These pig producers use varied feed recipes and according to the used average data of feed composition calculated N_{ex} meet the requirements defined by European Commission. Low excreted nitrogen results in lower emissions of NH_3, N_2O and NO_x. Lactating sows emits highest emissions due to enclosure of piglets to calculation. Calculated excreted nitrogen values according to research of pig feeding and consequently N_2O end NH_3 emissions are less than calculated by using assumptions of the pig feeding norms published in 1998. That shows that there is a positive trend to reduce emissions by feed planning for pigs with reduced crude protein.

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