NUTRITION AND MANAGEMENT MANUAL

TN Rex progeny

Topigs Norsvin
Global Nutrition and Female Reproduction Services
Updated: 01-02-2024

1. INTRODUCTION

Progress in Pigs. That is what Topigs Norsvin stands for. We are continuously improving our genetics to enable our clients to stay ahead. Our goal is to unlock the maximum potential of our genetics for all customers and to enable them to achieve the best possible performance results. Management and feeding are important to unlock this potential, therefore Global Nutrition and Female Reproduction Services provides advice and develops protocols, tools, and manuals. This manual can be used in professional pig production.

We want to thank Harper Adams University and the industry for contributing to this manual.

2. THE AIM OF THE MANUAL

The aim of this manual is to provide a feeding and management guide based on the nutritional requirements of the TN Rex progeny to achieve an optimum genetic performance, calculated in terms of daily gain and feed conversion. Daily gain is described as the sum of protein and fat deposition. The use of maximum genetic performance will result in optimal growth and a minimal feed conversion ratio. Maximum growth can be achieved only when the nutrients, specifically amino acids and energy, are supplied in the diet in the appropriate amount. Therefore, this manual focuses on optimal performance and not on the lowest feed costs.

The recommendations of the present manual are based on protein and fat deposition, which are influenced by factors like sex, age, feed intake, health status, and genetic line. In pig growth models, the deposition of protein and lipid mass is often used to describe compositional pig growth, and these can be estimated separately. The presented results are derived from our own Pig Growth Model® developed by Topigs Norsvin Research Center (TNRC, 2019) and from the analysis of field data in various environments. This manual can only be used for Topigs Norsvin genetics.

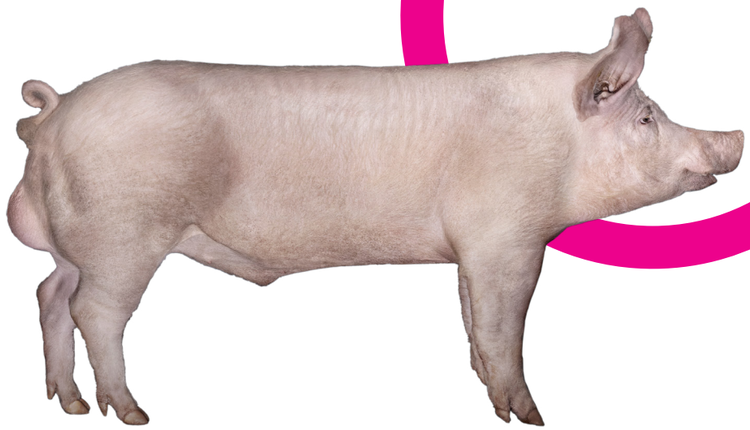
3. TYPOLOGY AND CHARACTERISTICS OF TN REX

The TN Rex is a crossbred terminal boar for markets where premiums are paid for carcasses with a high lean meat percentage. The robust TN Rex is specifically bred for hot climates. TN Rex offspring maintain excellent feed intake capacity during hot summers and are therefore able to achieve superior growth rates compared to purebred Piétrain boars.

The key strengths of TN Rex are:

- Competitive lean meat percentage
- Fast and efficient growth in hot conditions

TN Rex is robust and lean.
Compared with other Piétrain boars,
TN Rex finishers reach market weight
5 days sooner while using 5 kg less feed.



4. DAILY NUTRITIONAL REQUIREMENTS

4.1 Basic assumptions

TN Rex progeny are capable of high protein deposition and high growth rates. High performance is achieved with the right diets which cover the daily requirements of the animals. The daily requirements given in this manual are based on Pig Growth Model® (TNRC, 2019) and the validation data was collected in Topigs Norsvin nucleus and test farms.

The daily requirements in this manual are based on:

- Multi-phase feeding
- Castrates, gilts, and boars fed *ad libitum*
- Dry pelleted diet, with a dry matter of 88% (using pelleted feed improves the digestibility of the diet and the daily intake)
- Conventional/high health
- Sexes housed and fed separately

4.2 Daily nutritional requirements of TN Rex progeny

Due to relatively low feed intake in the starter/grower phase (or early finishing), and their high capacity for protein deposition, diet formulation and management strategies for TN Rex progeny should focus on increasing nutrient intake during this stage.

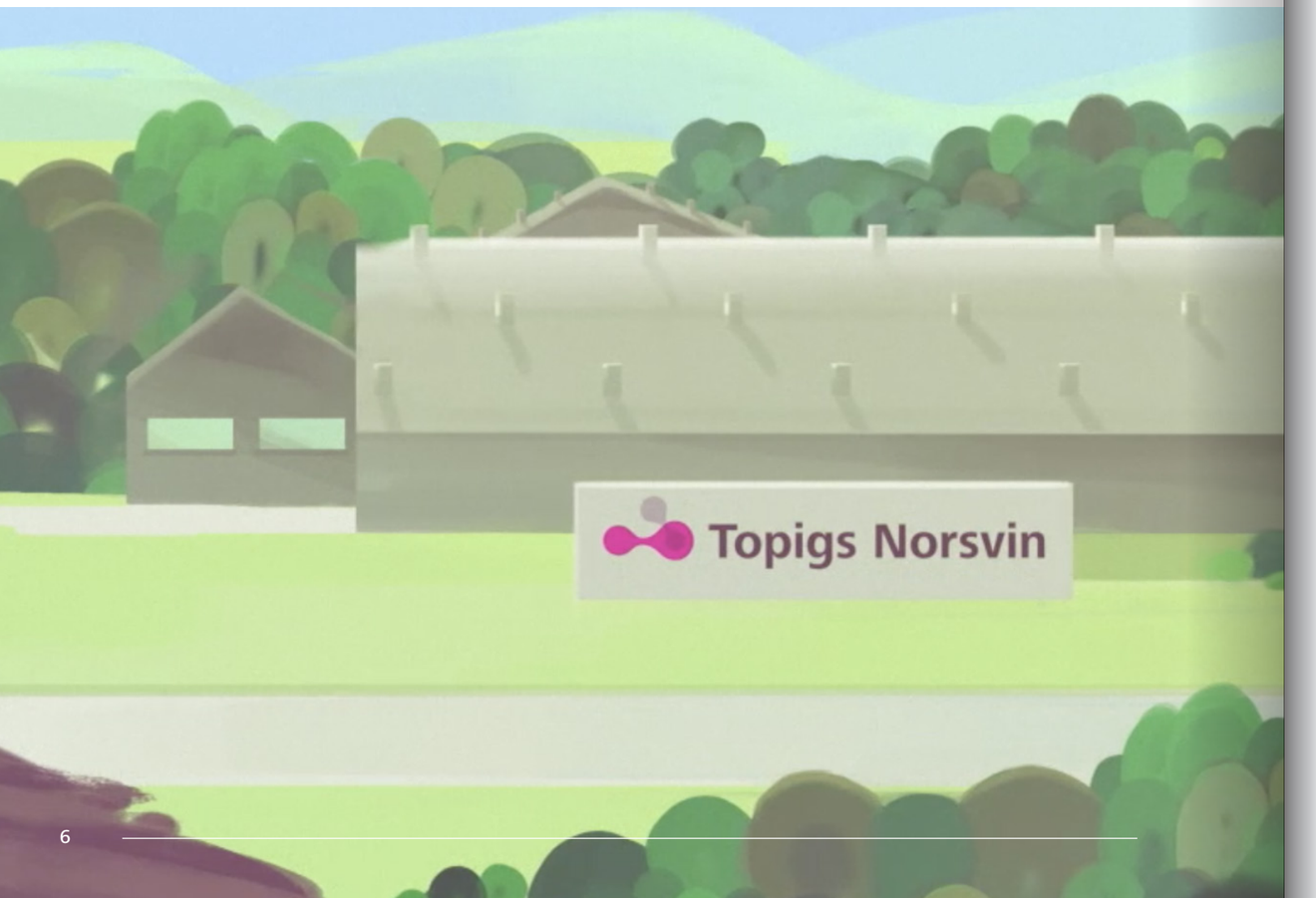


Table 1. Daily nutritional requirements and weight development curves of TN Rex progeny.

Days in	Castrates			Gilts			Boars		
	BW, kg	NE, MJ/day[1]	SID Lys, g/day[1]	BW, kg	NE, MJ/day[1]	SID Lys, g/day[1]	BW, kg	NE, MJ/day[1]	SID Lys, g/day[1]
1	25,0	11,3	13,7	25,0	10,9	13,5	25,0	10,4	13,1
8	30,1	12,9	14,9	29,9	12,4	14,6	30,1	11,4	14,3
15	35,7	14,6	16,0	35,4	13,9	15,8	35,7	13,2	15,6
22	41,8	16,3	17,2	41,3	15,6	16,9	41,8	14,9	16,9
29	48,4	18,1	18,3	47,6	17,2	18,0	48,4	16,8	18,2
36	55,3	19,9	19,3	54,3	18,8	19,0	55,4	18,6	19,4
43	62,6	21,6	20,2	61,4	20,4	19,9	62,8	20,3	20,5
50	70,2	23,3	20,9	68,7	21,9	20,7	70,5	22,0	21,5
57	78,0	24,9	21,4	76,3	23,4	21,3	78,4	23,6	22,4
64	85,9	26,4	21,8	84,0	24,7	21,7	86,5	25,1	23,0
71	93,9	27,7	21,9	91,8	25,9	21,9	94,7	26,4	23,5
78	102,0	28,9	21,7	99,7	27,0	21,9	103,1	27,5	23,8
85	110,1	29,9	21,4	107,5	28,0	21,7	111,4	28,5	23,9
92	118,1	30,8	20,8	115,3	28,7	21,2	119,6	29,2	23,7
99	126,0	31,5	20,1	123,0	29,4	20,6	127,8	29,8	23,4
106	133,8	32,1	19,1	130,6	29,9	19,8	135,9	30,2	22,9

[1] Net energy (NE) and standardized ileal digestible (SID) lysine requirements are expressed as the amount required per day to achieve optimal performance. Based on the TNRC Pig Growth Model® (2019).

5. FEEDING AND MANAGEMENT

5.1 Introduction

To achieve the highest performance possible, Topigs Norsvin provides the daily requirements for genetic potential. However, genetic potential is influenced by different environmental factors. In this chapter, we will describe the most important factors which may affect the performance during the finisher phase.

5.2 Feed intake: *ad libitum vs.* restricted feeding

The daily feed intake of a finisher will be the key determinant for the feed industry to design a proper feed program, which will give the farmer the highest economic return. Due to the variation in feed intake, Topigs Norsvin presents the requirements to their clients as net energy and standardized ileal digestible (SID) lysine per day, as given in this manual.

Feed intake can be affected by feed type and quality, management, health status, and housing. So, when pigs are fed *ad libitum*, the estimation of actual intake is also a reflection of their appetite under the prevailing conditions.

TN Rex progeny have a good feed intake capacity compared to other Piétrains, and they are still efficient from 75 kg body weight onwards. At a certain point during the finisher phase, there will be a shift towards lower protein deposition and higher fat deposition. Consequently, back fat thickness will slightly increase, and lean meat percentage will decrease. Due to TN Rex's genetic progress in feed efficiency and gain, there is less need to control the feed intake during the latter part of the finishing phase. However, controlling energy intake will lead to higher lean meat percentages but this can limit the maximum growth performance compared to *ad libitum* feed systems.

TIP
The actual feed consumed by pigs at various body weights (or over time) is required to estimate the optimal dietary levels in the diets.

5.3 Health conditions

The efficiency of nutrient utilization in pigs is optimized in high-health environments. A high-health status not only increases productivity and efficiency but also leads to an increased nutrient demand. When pigs are immunologically challenged, nutrients are diverted away from productive functions (i.e., lean tissue growth) towards the activated immune system. Therefore, under conventional health situations (most farms in the world), the immune system of the animal has to cope with all kinds of pathogens. This can have an influence on the amino acid profile requirements of the challenged animals, especially for methionine + cysteine, threonine, and tryptophan (Kampman-Van de Hoek, 2015).

Under Specific Pathogen Free (SPF) conditions, animals can increase their feed intake by 10-15%, reduce maintenance requirements by approximately 10%, and increase protein deposition capacity by around 25 g/d.

The following points need to be taken under consideration for SPF animals:
- SPF animals grow faster; therefore, they can reach higher protein deposition rates.
- The higher feed intake capacity in SPF animals is not reflected by an increased protein deposition level if SID lysine to energy ratio in the diet is limited.

- A balanced health situation in the herd is important to increase productivity and efficiency.
- Ensure a good colostrum intake of the piglets after birth (within 24 hours). This enables the immune system development.

5.4 Paylean® (Ractopamine)

Ractopamine-HCl is regulated by local legislation, please check the guidelines before using it. Ractopamine-HCl, is an adrenergic agonist and is labeled for use in swine diets during the final growth stages. Dietary inclusion has shown consistent improvement in pig growth performance and has led to its widespread use in the swine industry. When included int the feed, it promotes lean growth rather than fat deposition by redirecting nutrients away from the fat depots towards muscle development.

Fat tissue deposition requires more energy than lean growth, thus increasing lean tissue deposition leads to improved feed efficiency and a leaner carcass prior to market. Because of the increased protein accretion, pigs that are fed Ractopamine have an increased dietary amino acid requirement.

Besides the advantages of using Ractopamine, there are some attention points that should be considered. Topigs Norsvin recommends strictly following the nutritional guidelines of the manufacturer when using these additives.

5.5 Vaccination against boar taint (Zoetis)

Immunization against gonadotropin-releasing hormone (GnRH) for controlling boar taint and sexual boar behaviour has been introduced and licensed globally as an animal welfare-friendly alternative to surgical castration. The first dose of the injection primes the pig's immune system but does not alter the testes functionality. The second dose stimulates the protective immune response resulting in a temporary inhibition of testicular development.

Until the second injection, the animal remains a boar. After the second immunization, the testicular hormone release is blocked (for about 10 weeks) inducing a physiological transition to a castrate-type animal.

After a 10- to 14-day transition period following the second injection, the average daily feed intake (ADFI) of the immunized animals increases dramatically. Because of the significant increase in ADFI that occurs starting two weeks after the second injection, feeder space and feed availability must be prioritized for these immunized animals.

This increase in feed consumption results in a significant increase in lipid deposition rate, and the overall feed conversion ratio (FCR) advantage of immunocastrates begins to decline (by 1,5 to 2,0% per week for each additional week after the second dose (Puls, 2013)). In addition, the immunized animals continue to be more efficient than physically castrated males up to at least 7 weeks after the second dose. At the same time, belly yield and bacon-slicing characteristics improve as the time after the second injection increases (Boler et al., 2012). Therefore, it will be imperative for each production system to balance live performance and carcass characteristic goals to maximize the profit potential from this technology.

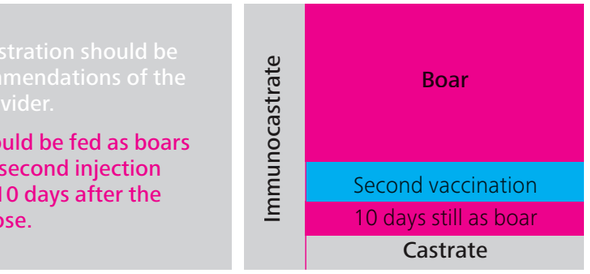
Nutritional guidance

To optimize average daily gain (ADG) and FCR, it is recommended that SID Lysine and other amino acid levels for boars immunized against boar taint are increased to the same requirement for non-immunized entire boars until 10 days after the second dose and to the same requirement for physically castrated animals from 10 days after the second dose to market. Energy density before and after the second immunization needs to be adapted in a way that animals do not limit themselves in intake and can be fed *ad libitum*.

How to feed immunocastrates:

Utilization of immunocastration should be done based on the recommendations of the solution provider.

The immunocastrates should be fed as boars until 10 days after the second injection and as castrates from 10 days after the second dose.



5.6 Pellet *vs.* mash feed

The eating behaviour and performance of pigs can also be influenced by the feed type (pellet *vs.* mash). Feeding pelleted diets has shown an increase in nutrient digestibility and an improvement of FCR between 5-8% in finishing pigs. Improvements in animal performance have also been attributed to decreased feed wastage and ingredient segregation in the feed bin or feeder, reduced selective feeding, less time and energy expended for feed intake, destruction of pathogens (i.e., enteropathogens), thermal modification of starch and protein, and improved palatability.

The improvements in FCR highly depend on pellet quality, pellet size, particle size, and its distribution after grinding. Another advantage of using pelleted diets is the opportunity to grind grains to smaller and/or different micron sizes and to use a higher percentage of alternative ingredients in the diets while still maintaining good feed flowability.

- Provide a gradual transition between different types of feed to improve feed intake.
- Ensure a good connection between different types of feed by using similar raw materials.

5.7 Hot climates

The environment can serve as a significant factor affecting both the voluntary feed intake level and the overall nutrient requirements of pigs. Temperature, probably more than any other environmental factor, explains most of the variation associated with differences in feed intake and performance among groups of pigs. Given the fact that animals tend to eat less when the temperature rises, feed intake capacity can be a limiting factor for optimal performance. Swine diet formulations should be adjusted to account for the variations in feed intake associated with environmental temperature changes.
Some alternatives can be used to optimize the performance in hot climates. Under heat stress, pigs reduce their feed intake to lower their heat production due to the thermal effect of feed (TEF). Nutritional solutions can mainly be described according to their ability to reduce dietary heat increment or to increase dietary nutrient density. The increase in crude protein supply is associated with a higher protein turnover which enhances heat production.

Tips to cope with hot climates:

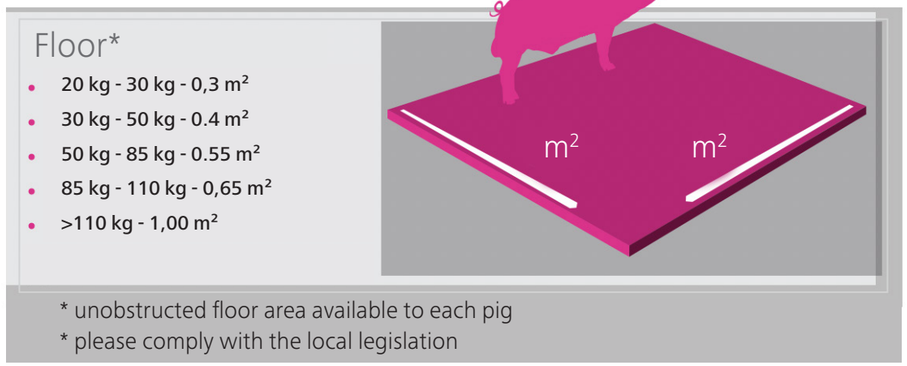
- Low crude protein diets. A practical solution is to partially replace crude protein with industrial amino acids to meet the protein requirement for optimal performance.
- Replace starch with fat to reduce TEF.
- Offer the feed during cooler phases of the day/night.
- Increase the number of daily feedings which will lower the energy needed for digestion (internal heat production).
- Ensure the availability of fresh and clean water. Water should be available *ad libitum*. Ensure a minimum flow rate of 1,5 litres of water per minute.

5.8 Stocking density

The stocking density is very important for the overall performance and the welfare of the herd. Not complying with the minimum stocking densities will affect overall performance.

High stocking density can lead to:

- Decreased ADG and feed conversion.
- An increase in agonistic behaviour between pigs due to crowding, especially if there is also a lack of resources such as feed, water and/or resting space.
- Less sociable pigs with damaging behaviour towards pen mates.
- Increased losses.
- Impaired locomotion.
- More dirty pens.



5.9 Rooting and enrichment material

Pigs are active and exploratory and will spend 70-80% of their active time rooting and investigating their surroundings. Lack of stimulation can lead to stereotypic and/or damaging behaviours such as belly nosing and tail, flank, or ear biting. These are not aggressive behaviours but they occur due to crowding and stimulus-poor environments. Therefore, we recommend that fattening pigs are provided with rooting material daily.

Enrichment materials should ideally be (Bracke et al., 2020):

- Accessible
- Chewable and deformable
- Investigable
- Have a prolonged interest for the pig
- Destructible
- Edible
- Digestible

Hay and straw are both optimal choices because they have all the characteristics to meet the pigs' needs (Ruis & Patt, 2020).

Regularly change the rooting and enrichment materials to keep the pig's interest.

5.10 Liquid feeding

Working with liquid feeding systems requires certain precautions. For each type of diet, there is an ideal dilution, which depends on the ingredients used and how they were included. There can be decomposition into sub-products which do not have proper time to be incorporated into the liquid diet, and losses of vitamins and essential nutrients can also occur. When considering the type of grain to be included in the feed, it is important to consider the chemical composition and the effects that the raw materials can have on digestibility. Therefore, Topigs Norsvin advises regular laboratory analyses of the feed to guarantee that the pigs are not fed diets that can limit their performance and/or affect the carcass quality negatively.

- Regularly test the dry matter content of the liquid feed.
- Pigs like to eat together at the same time, a long trough fulfills this need.
- Ensure that feed is divided over the whole trough length so all pigs can eat together.
- Check frequently the hygiene of the feed and feed system.

5.11 Split sex feeding

In general, gilts will consume less feed and are about 4% more efficient in converting feed to body weight gain during the finishing period compared to castrates. To offset the reduction in feed intake, diets for gilts need to contain higher nutrient levels (i.e., protein or amino acids) to achieve adequate daily intakes of these nutrients. Boars are even more efficient than gilts.
The differences in feed intake, together with the differences in performance and carcass parameters, provide the basis for split-sex feeding.

5.12 The advantages of using fibres

Extra added fibre in the form of soy hulls and wheat middlings or others like oat hulls, sunflower meal, and beet pulp can help to increase satiety, improve digestion, and limit the negative impact of rapid hindgut fermentation in older finishing pigs. It is also important to use different types of fibres: fermentable and insoluble. The right combination is essential for good results.

Inclusion examples:

- Adding 2% soy hulls in the diets up to 70 kg live weight and then increasing the inclusion up to 3-5% in the finishing phase.
- Adding 3-5% wheat middlings in the diets from 25 kg up to 70 kg live weight. In the finishing phase, this can be increased to 5-10% when needed.

5.13 Temperature and ventilation

Ensure proper ventilation rates in the rooms to support feed intake. High-performing animals have an increased body heat production and if stocking densities are too high this will affect the temperature in the pen. From research, it is known that at higher temperatures the density of pigs per m^2 should be decreased as this is also correlated with the behaviour of animals in terms of lying pattern and activity (Spoolder et al., 2012). Depending on the farm and the systems used, the temperature should be adjusted to keep the animals in their comfort zone.

- Prevent drafts in the room to avoid stress in the pigs.
- Maximum air velocity changes with the size and weight of the pig and the temperature of the incoming air.
- Clean floors will keep ammonia levels low.

5.14 Water

Water is an essential nutrient and is required in large quantities by swine. Water is required for tissue maintenance, body growth, thermoregulation, mineral homeostasis, excretion of metabolites and antinutritional substances, achievement of satiety, and behavioural purposes. Water requirements depend on temperature, health status, diet, and age (body weight). Water should always be freely available, and easily accessible for all pigs in a group. A low water intake could lead to dehydration, reduced feed intake, increased stress, more urinary tract infections, and a lower tolerance for disease. Poor water access and quality are also considered risk factors for tail biting occurrences and prolapses.

Water management

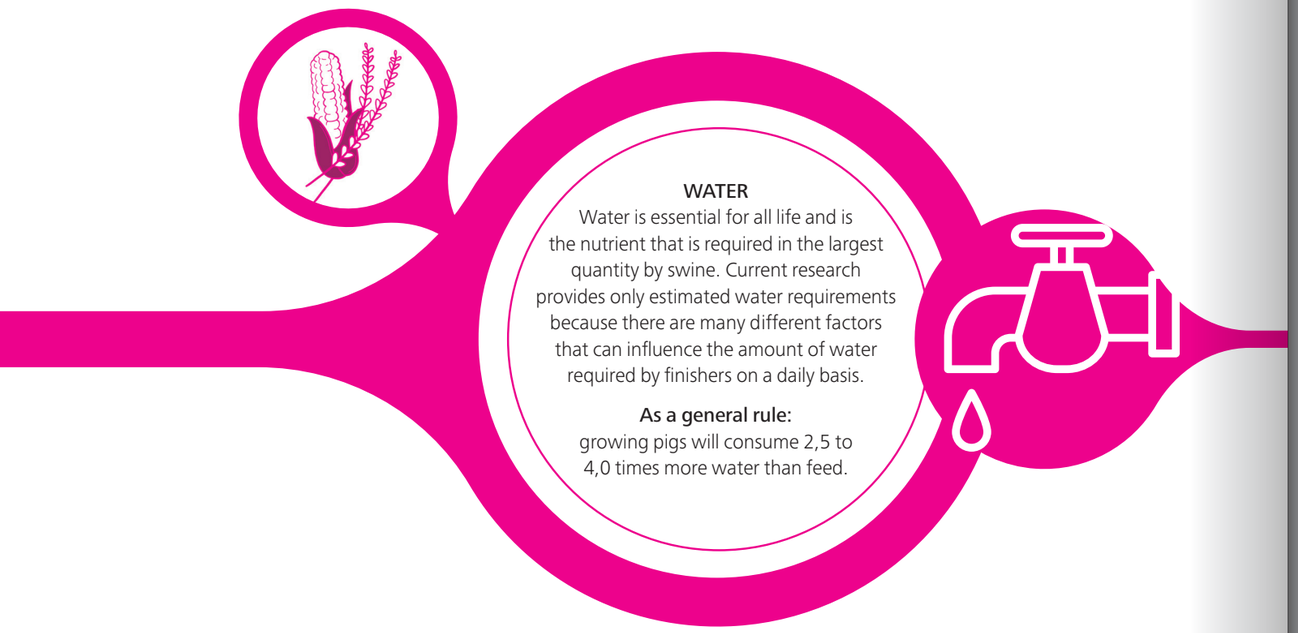
Regardless of whether you have a liquid feed system or a dry feed system, water should always be freely accessible 24 hours a day. Water nipples should be placed at a height appropriate for the age and size of the pigs, preferably using the shoulder of the smallest pig to determine the height. Drinkers should also be placed with enough space between them so that more pigs can drink simultaneously. If one pig can block access to another drinker while using a different drinker, the drinkers are placed too close together. To avoid competition, always ensure that the number of water access points coheres with the number of pigs in the pen. We recommend having 1 drinker for 10 pigs. Always check the national legislation for your country.

Water volume and pressure

Water volume and pressure will influence the water consumption of pigs because pigs usually drink right after they eat, and they will not stand around drinking for a long period. So, if the water pressure is too low, they will most likely consume less than they require. On the other hand, the water flow rate has also an influence on water consumption. Therefore, make sure that the right drinker with the right yield (>1,0 litre per minute (Brede, 2006)) is used.

Water quality

The provided water should be of good quality: clean, clear, and fresh. The bacteriological and chemical guidelines for drinking water quality need to be checked locally concerning quality standards at least once a year.



6. LITERATURE LIST

Bikker, P., & Blok, M. C. (2017). *Phosphorus and calcium requirements of growing pigs and sows* (No. 59). Wageningen Livestock Research.

Boler, D. D., Killefer, J., Meeuwse, D. M., King, V. L., McKeith, F. K., & Dilger, A. C. (2012). Effects of slaughter time post-second injection on carcass cutting yields and bacon characteristics of immunologically castrated male pigs. *Journal of Animal Science*, 90(1), 334-344.

Bracke, M. B. M., Ruis, M. A. W., Patt, A., & Pedersen, L. J. (2020). Signs of enrichment use: indicator to assess the risks for tail biting in pigs.

Brede W. (2006). Produktions- und Bauberatung.

Kampman-Van de Hoek, E. (2015). *Impact of health status on amino acid requirements of growing pigs: towards feeding strategies for farms differing in health status* (Doctoral dissertation, Wageningen University).

Lee, S. A., Lagos, L. V., & Stein, H. H. (2019). Digestible calcium and digestible phosphorus in swine diets: the CFM de LANGE lecture in pig nutrition. In Proceedings of the London Swine Conference, 26-27 March 2019, London, Ontario, Canada (pp. 63-72). London Swine Conference.

Merriman, L. A., & Stein, H. H. (2016). Particle size of calcium carbonate does not affect apparent and standardized total tract digestibility of calcium, retention of calcium, or growth performance of growing pigs. Journal of animal science, 94(9), 3844-3850.

National Research Council (NRC). (2012). Nutrient requirements of swine.

Puls, C. L. (2013). *Growth performance and carcass characteristics of immunologically-castrated barrows in comparison to intact males, physically-castrated barrows, and gilts.* University of Illinois at Urbana-Champaign.

Ruis, M. A. W., & Patt, A. G. (2020). Suitability of enrichment materials: indicator to assess the risks for tail biting in pigs, indicator factsheet.

Schaafsma, G. (1981). The influence of dietary calcium and phosphorus on bone metabolism (Doctoral dissertation, Schaafsma).

Spoolder, H. A., Aarnink, A. A., Vermeer, H. M., van Riel, J., & Edwards, S. A. (2012). Effect of increasing temperature on space requirements of group housed finishing pigs. *Applied Animal Behaviour Science*, 138(3-4), 229-239.

Topigs Norsvin Research Center (TNRC). (2019). Pig Growth Model®. *Topigs Norsvin.*

Van der Peet-Schwering, C. M. C., & Bikker, P. (2018). Amino acid requirement of growing and finishing pigs. *Amino acid requirement of growing and finishing pigs.*

Van Riet et al. (2013). Impact of nutrition on lameness and claw health in sows.

Yang, P., & Ma, Y. (2021). Recent advances of vitamin D in immune, reproduction, performance for pig: a review. Animal Health Research Reviews, 1-11.

7. APPENDIX

1. Example of diet calculations for Wheat-Barley markets

Corn-Soy and Wheat-Barley are the two main feed markets in the world. Pigs fed well-balanced Wheat-Barley-based diets can perform as well as those fed Corn-Soy diets. The minimum reachable energy levels when using these two different feed sources are what differentiates these two markets. Therefore, the feed schedules and calculations will be different for these two markets. Nevertheless, the daily nutrient requirements of TN Rex progeny are the same.

Table 2. Nutritional requirements (g/kg) for TN Rex progeny in Wheat-Barley markets, based on a 5-phase feeding program.

Sex	Body weight (kg)	Starter	Grower 1	Grower 2	Finisher	Final
		25 - 35	35 - 55	55 - 75	75 - 100	100 - 130
Castrates	**Avg Daily Feed Intake, kg/day[1]**	1,3	1,8	2,3	2,8	3,1
	NE, MJ/kg [2, 3]	10,0	9,9	9,8	9,7	9,7
	ME, Mcal/kg [2, 3]	3,20	3,17	3,13	3,10	3,10
	SID Lys, g/kg [2]	11,5	10,1	9,0	7,8	6,8
	SID Lys/NE, g/MJ	1,15	1,03	0,91	0,81	0,69
	Ca, g/kg [4]	8,8	8,5	7,4	6,7	6,1
	Digestible P, g/kg [5]	3,3	3,1	2,8	2,5	2,3
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7
Gilts	**Avg Daily Feed Intake, kg/day[1]**	1,2	1,7	2,2	2,6	2,9
	NE, MJ/kg [2, 3]	10,1	10,0	9,9	9,8	9,7
	ME, Mcal/kg [2, 3]	3,23	3,20	3,17	3,13	3,10
	SID Lys, g/kg [2]	11,9	10,6	9,4	8,4	7,4
	SID Lys/NE, g/MJ	1,18	1,06	0,96	0,86	0,76
	Ca, g/kg [4]	9,0	8,8	7,8	7,1	6,1
	Digestible P, g/kg [5]	3,4	3,2	2,9	2,6	2,3
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7
Boars	**Avg Daily Feed Intake, kg/day[1]**	1,2	1,6	2,1	2,6	2,9
	NE, MJ/kg [2, 3]	10,1	10,0	9,9	9,8	9,8
	ME, Mcal/kg [2, 3]	3,23	3,20	3,17	3,13	3,13
	SID Lys, g/kg [2]	12,5	11,2	9,9	8,9	8,1
	SID Lys/NE, g/MJ	1,25	1,12	1,01	0,91	0,83
	Ca, g/kg [4]	9,2	9,0	8,1	7,2	6,7
	Digestible P, g/kg [5]	3,5	3,3	3,0	2,7	2,5
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7

[1] Average daily feed intake was used to calculate the nutrients per kg feed.
[2] Net energy (MJ/kg), Metabolizable energy (Mcal/kg) and SID Lysine (g/kg) are calculated based on the ADFI (kg/d).
[3] NE = ME X 0,74 (The conversion factor could be different for each country); MJ = Mcal X 4,184.
[4] The level of total calcium (g/kg) is focussed on bone quality, the level can be slightly adjusted if the objective is optimal gut health.
[5] The level of digestible phosphorous (g/kg) is expressed as STTD-P (standard total tract digestibility) and is calculated by dividing daily requirements by the daily feed intake of the animals. We recommend the utilization of phytase to reduce phosphorous excretions and environmental impact. Our levels are adapted from the research work of Bikker & Blok (2017) from Wageningen University & Research and CVB (Appendix 6).

2. Example of diet calculations for Corn-Soy markets

Corn-Soy and Wheat-Barley are the two main feed markets in the world. Pigs fed well-balanced Corn-Soy-based diets can perform as well as those fed Wheat-Barley diets. The minimum reachable energy levels when using these two different feed sources are what differentiates these two markets. Therefore, the feed schedules and calculations will be different for these two markets. Nevertheless, the daily nutrient requirements of TN Rex progeny are the same.

Table 3. Nutritional requirements (g/kg) for TN Rex progeny in Corn-Soy markets, based on a 5-phase feeding program.

Sex	Body weight (kg)	Starter	Grower 1	Grower 2	Finisher	Final
		25 - 35	35 - 55	55 - 75	75 - 100	100 - 130
Castrates	**Avg Daily Feed Intake, kg/day[1]**	1,3	1,7	2,2	2,7	3,0
	NE, MJ/kg [2, 3]	10,2	10,1	10,0	9,9	9,9
	ME, Mcal/kg [2, 3]	3,26	3,23	3,20	3,17	3,17
	SID Lys, g/kg [2]	11,7	10,4	9,1	8,0	6,9
	SID Lys/NE, g/MJ	1,15	1,03	0,91	0,81	0,69
	Ca, g/kg [4]	8,9	8,8	7,7	6,9	6,3
	Digestible P, g/kg [5]	3,3	3,2	2,9	2,6	2,4
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7
Gilts	**Avg Daily Feed Intake, kg/day[1]**	1,2	1,6	2,1	2,6	2,9
	NE, MJ/kg [2, 3]	10,3	10,2	10,1	10,0	9,9
	ME, Mcal/kg [2, 3]	3,29	3,26	3,23	3,20	3,17
	SID Lys, g/kg [2]	12,1	10,8	9,6	8,6	7,5
	SID Lys/NE, g/MJ	1,18	1,06	0,96	0,86	0,76
	Ca, g/kg [4]	9,2	9,0	8,0	7,2	6,2
	Digestible P, g/kg [5]	3,4	3,3	3,0	2,7	2,3
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7
Boars	**Avg Daily Feed Intake, kg/day[1]**	1,1	1,6	2,1	2,5	2,9
	NE, MJ/kg [2, 3]	10,3	10,2	10,1	10,0	9,9
	ME, Mcal/kg [2, 3]	3,29	3,26	3,23	3,20	3,17
	SID Lys, g/kg [2]	12,8	11,4	10,2	9,2	8,3
	SID Lys/NE, g/MJ	1,25	1,12	1,01	0,92	0,83
	Ca, g/kg [4]	9,3	9,1	8,3	7,4	6,9
	Digestible P, g/kg [5]	3,5	3,4	3,1	2,8	2,5
	Ratio Ca/dP	2,7	2,7	2,7	2,7	2,7

[1] Average daily feed intake was used to calculate the nutrients per kg feed.
[2] Net energy (MJ/kg), Metabolizable energy (Mcal/kg) and SID Lysine (g/kg) are calculated based on the ADFI (kg/d).
[3] NE = ME X 0,74 (The conversion factor could be different for each country); MJ = Mcal X 4,184.
[4] The level of calcium (g/kg) is focussed on bone quality, the level can be slightly adjusted if the objective is optimal gut health.
[5] The level of digestible phosphorous (g/kg) is expressed as STTD-P (standard total tract digestibility) and is calculated by dividing daily requirements by the daily feed intake of the animals. We recommend the utilization of phytase to reduce phosphorous excretions and environmental impact. Our levels are adapted from the research work of Bikker & Blok (2017) from Wageningen University & Research and CVB (Appendix 6).

3. Recommendations for essential amino acid ratios

Lysine is the first limiting amino acid in swine diets. It is common practice to first define the adequate lysine level in the diet and then derive the required level of other essential amino acids from lysine based on an ideal protein ratio, thus giving a balanced protein diet. A balanced protein diet contains sufficient levels of each essential amino acid to meet the biological needs of the animal while minimizing the amounts of excess amino acids. The latest review by Peet-Schwering & Bikker (2018) has defined the ideal balance of amino acids for each phase of production based on the concept of Ideal Protein. This serves as the basis for Topigs Norsvin's recommendations. Feed ingredients have different amino acid digestibility coefficients. Therefore, when formulating more complex diets, it is recommended that standardized ileal digestible (SID) values are used in the formulation process.

Table 4. Topigs Norsvin recommendations adapted from Van der Peet-Schwering & Bikker (2018) for essential SID amino acids other than SID Lysine in starter, grower, and finisher pig diets (expressed as % of SID Lysine) for current and future growing and finishing pigs.

Amino Acids[1]	Starter diet	Grower diet	Finisher diet	Variation[5]
Lysine	100	100	100	-
Met+Cys[2]	60	61	62	58-63
Tryptophan[3]	21	20	20	17-23
Threonine	66	67	68	61-74
Valine	68	67	67	64-72
Isoleucine	53	53	53	50-54
Leucine	100	100	100	100-102
Histidine	32	32	32	32-32
Phenylalanine+Tyrosine[4]	95	95	95	94-100

[1] The amino acid profiles are based on the daily gain of the future growing and finishing pigs is 10% higher than the daily gain of the current growing and finishing pigs and is realized by a 10% higher feed intake or a 10% improved feed conversion ratio;
[2] A minimum ratio of methionine to methionine+cystine of 55% is advised;
[3] Recommendations in diets without blood products (non-excess level of leucine);
[4] A minimum SID phenylalanine to lysine of 54% and a maximum SID tyrosine to lysine ratio of 40% to support maximal growth is advised.
[5] The boundaries given in the column "Variation" can be used e.g. stage of production, health status, behaviour etc.

4. Standardized ileal digestible (SID) *vs.* apparent ileal digestible (AID) lysine

The terminology used to describe the bioavailability and ileal digestibility of amino acids in pig feed ingredients is explained in this appendix. Ileal digestibility values may be expressed as apparent ileal digestibility (AID), standardized ileal digestibility (SID), or true ileal digestibility (TID). These terms are used to specify how ileal endogenous AA losses are reflected in digestibility values. Ileal endogenous AA losses may be separated into basal losses, which are not influenced by feed ingredient composition, and specific losses, which are induced by feed ingredient characteristics such as levels and types of fibre and anti-nutritional factors. Values for AID are established when the total ileal outflow of AA (i.e., the sum of endogenous losses and non-digested dietary AA) is related to dietary AA intake. A concern with the use of AID values is that these are not additive in mixtures of feed ingredients. This concern may be overcome by correcting AID values for defined basal endogenous losses of AA, which yields SID values. Furthermore, if the AID values are corrected for basal and specific endogenous losses, then values for TID are calculated. However, reliable procedures to routinely measure specific endogenous losses are not yet available. It is suggested that SID values should be used for feed formulation, at least until more information on TID values becomes available.

5. Vitamin and mineral recommendations

Table 5. Vitamin recommendations

Vitamins	Units	25 – 45 kg		45 – 75 kg		75 kg - End	
		Min	Max	Min	Max	Min	Max
Fat soluble vitamins							
VIT. A	i.u	6500	10000	6500	10000	5000	7500
VIT. D3	i.u	1800	2000	1800	2000	1500	2000
VIT. E	i.u	80	150	80	150	60	150
VIT. K3	mg	2	3	2	3	2	3
Water soluble vitamins							
VIT. B1 (Thiamine)	mg	2	3	2	3	2	3
VIT. B2 (Riboflavin)	mg	7	10	7	10	5	8
VIT. B3 (Nicotinic acid)	mg	20	40	20	40	20	30
VIT. B5 (Pantothenic acid)	mg	25	45	25	45	25	45
VIT. B6 (Pyridoxine)	mg	2	4	2	4	2	3
VIT. B12 (Cobalamin)	mcg	30	50	30	50	20	40
VIT. B9 (Folic acid)	mg	1,0	1,5	1,0	1,5	0,5	1,0
VIT. B7 (Biotin)	mg	0,05		0,05		0,05	
Vitamin C	mg	+	300	+	200	+	100
Choline (Betaine)	mg	150	300	150	300	100	200

Notes:
- Comply with the local legislation given per country.
- Vitamin requirements are based on the latest recommendations and were derived from various sources.
- Use a minimum of 50% vitamin D in the form of 25(OH)D3 or 1,25(OH)2D3 as recommended by Global Nutrition Services.
- The levels can be adjusted depending on the objectives (i.e., meat quality, heat stress, etc.).

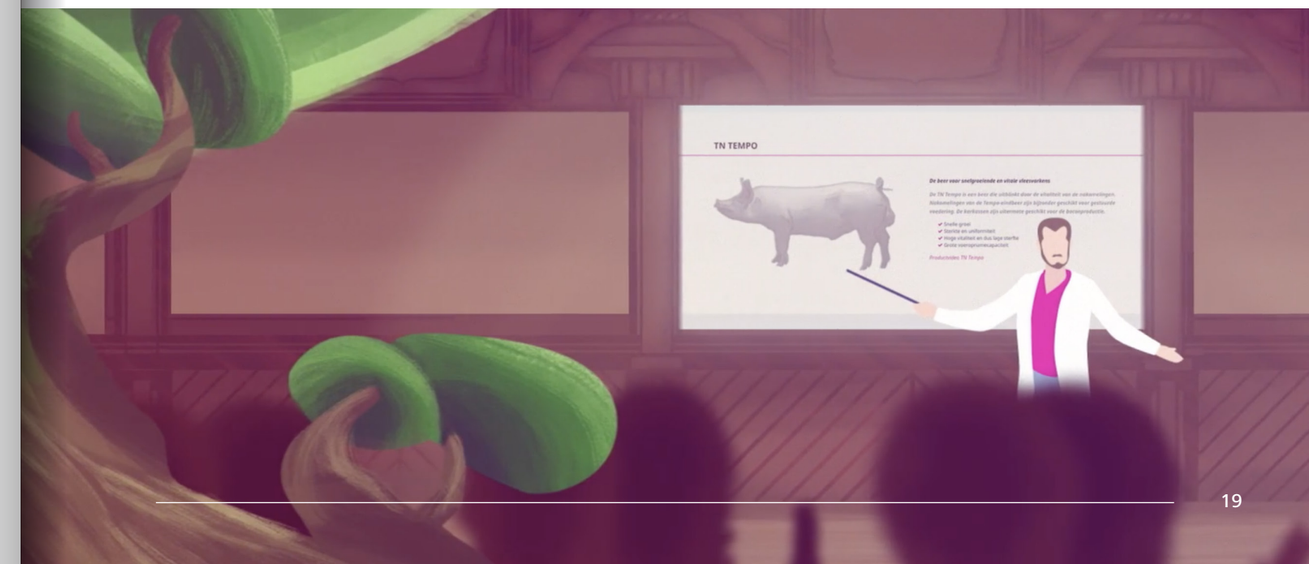


Table 6. Mineral recommendations

Vitamins	Units	25 – 45 kg		45 – 75 kg		75 kg - End	
		Min	Max	Min	Max	Min	Max
Macro minerals							
Na	%	0,25	0,30	0,20	0,30	0,20	0,30
K	%		1,1		1,3		1,3
Cl	%	0,15		0,15		0,15	
Mg	%	0,20	0,30	0,20	0,40	0,20	0,40
dEB (Na+K-Cl)	meq	200	240	200	240	190	240
Trace minerals							
I	ppm	1	2	1	2	1	2
Se	ppm	0,4	0,5	0,3	0,5	0,3	0,5
Cu	ppm	25		25		25	
Zn	ppm	120		120		100	
Mn	ppm	75		75		50	

Notes:
- Comply with the local legislation given per country.
- Mineral requirements are based on the latest recommendations and were derived from various sources.
- The levels can be adjusted depending on the objectives (i.e., meat quality, heat stress, etc.).
- Use a minimum of 50% of selenium from an organic source as recommended by Global Nutrition Services because organic selenium has higher tissue accumulation and is beneficial to the antioxidant status of the pigs (Reinoso-Maset et al., 2023).

6. Calcium and phosphorus

Optimal bone development is the key to ensure good leg quality in TN Rex progeny. Therefore, proper nutrition during all stages is highly important. The right levels of calcium (Ca) and phosphorus (P), and even more importantly, the ratio between these minerals are crucial in all diets.

Ca and P are the most essential minerals for proper bone and skeleton development and for claw quality. In detail, 99% of Ca is present in the skeleton and only 1% of this Ca is transferred into Ca that circulates in the body and soft tissues (Schaafsma, 1981). It is also known from Van Riet et al. (2013) that Ca has an impact on horn production and consequently claw quality: insufficient dietary Ca levels might lead to weaker claws.

P is essential for bone development and plays a key role in metabolic processes such as the formation of cellular membranes and it is vital for enzymatic systems involved in protein and carbohydrate metabolism. To optimize growth performance and minimize nutrient excretion, the inclusion of dietary Ca and P needs to be adequate. There are different ways to express Ca and P levels. An example is given for P:

- Total P: all P that is present in an ingredient, including non-available P (which is mostly bound to phytic acid).
- Available P: shows relative bioavailability, this may overestimate the real amount of P that is utilized (available P = total P – P bound in phytic acid).
- Digestible P:
  - Apparent total tract digestibility (ATTD) P: this includes basal endogenous P losses.
  - Standardized total tract digestibility (STTD) P: is corrected for basal endogenous P losses. Endogenous substances are for example bile, mucus, digestive enzymes, and epithelial cells.

The metabolism of Ca is linked to that of P which means that they are antagonists of each other. An oversupply of dietary Ca can negatively affect the digestibility of P. Furthermore, an oversupply of dietary Ca reduces feed intake and ADG. The negative effect of excess Ca on growth performance is mitigated by increasing dietary P above the requirement.

- Total Ca: the Ca level in this manual is presented as the sum of analyzed Ca and Ca released from phytase.
- Topigs Norsvin advises contacting the phytase suppliers for matrix values of Ca released by phytase to ensure proper bone development.

6.1 Maximizing bone ash *vs.* maximizing growth

The ratio between STTD-Ca and STTD-P appears to be more important than the dietary Ca and P levels (Lee, Lagos & Stein, 2019). A higher level and ratio of Ca and P improves ash content in bones, thus bone ash is an indicator of bone strength and development. Bone ash is the residue left after heating of bones at high temperatures. From the literature, it is known that if maximizing bone ash is the goal instead of maximizing growth performance, then the ratio STTD-Ca:STTD-P needs to be larger (Lee, Lagos & Stein, 2019).

Bikker & Blok (2017) reported Ca:STTD-P and STTD-Ca:STTD-P ratios for growing pigs which lead to a Ca:STTD-P ratio of 2,7-2,8 (Table 7).

Table 7. Ca:STTD-P and STTD-Ca:STTD-P ratios for growing pigs, adapted from Bikker & Blok, (2017).

Animal category	Ca:STTD-P	STTD-Ca:STTD-P
Growing pigs, 25-45 kg (55-99 lbs)	2,7	1,6
Growing pigs, 45-70 kg (99-154 lbs)	2,7	1,6
Growing pigs, 70-120 kg (154-265 lbs)	2,8	1,7

6.2 The use of phytase in pig diets

Phytase is a digestive enzyme that breaks down the phytate and releases phosphorus in a usable form to the animal. Phytase can be used to reduce environmental impact by limiting phosphorous excretion in several countries and it can also be used to improve feed efficiency. As phytase releases more phosphorus in the diet, it influences the Ca:STTD-P ratio and the mineral content. The contribution of phytase to the total mineral content of the diet should be carefully evaluated as it might lead to an overestimation or underestimation. As such, we should be careful of the influence of phytase on the levels of Ca, STTD-P and ratio between those as undesired problems can appear.

6.3 Vitamin D importance

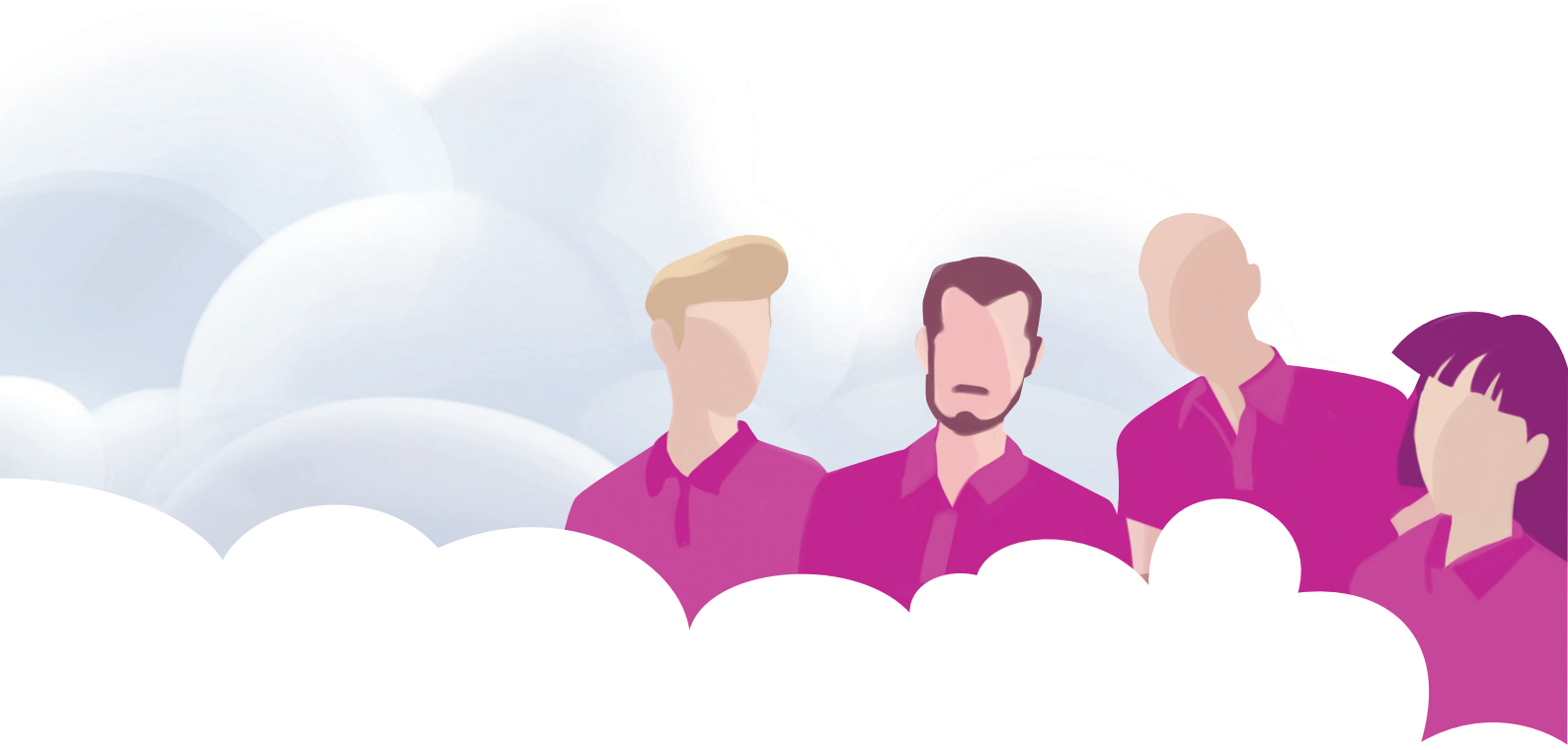
Vitamin D is important when it comes to leg quality as it stimulates the absorption of Ca and P from the intestine (Yang & Ma, 2021). Most of the time the diets are supplemented with vitamin D in the form of cholecalciferol (vitamin D3) which is then converted by the liver into 25(OH)D3 and subsequently converted by the kidneys into 1,25(OH)2D3.
Leg quality can be improved by adding the maximum amount of vitamin D allowed by legislation and by replacing partially (50%) or up to 100% of vitamin D3 with commercial forms of (25(OH)D3).

6.4 Particle size of calcium

A decrease in particle size of feed ingredients is associated with higher nutrient digestibility. Calcium carbonate ($CaCO_3$) can be included in pig diets at a diverse range of particle sizes related to the different pig categories without affecting the Ca or P digestibility, retention, and growth performance of weaned pigs. In general, it is advised to use particle sizes of $CaCO_3$ ranging from 0,2 – 1,1 mm in pig diets (Merriman & Stein, 2016).

6.5 Advice Global Nutrition and Female Reproduction Services

Global Nutrition and Female Reproduction Services utilises total Ca and STTD-P (usually referred to as digestible P) levels when guidance is offered to our clients. We provide and support the usage of total Ca and not STTD-Ca since there is a lack of digestibility data on Ca in feed ingredients (NRC, 2012). We focus on the ratio Ca to STTD-P with a minimum level of STTD-P to support bone development while minimizing impact on the environment. The ratios given in Table 7 are used as global advice and to establish our recommendations for finishers.



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