

EXCLUSIVE

Hybrid Rye



Hybrid Rye
Resource
efficient
—
Valuable for
gut health



CONTENTS

3 Rye not?

Crop Production Magazine & Steve Hart, Norfolk Free Range

6 Hybrid Rye provides Perthshire estate with a cheaper to grow, more reliable cereal crop

Colin Mitchell, Meikleour Estate

8 JSR looking to rye to benefit the pig and arable sides of the business

Pig World Magazine & Stephen Waite, JSR Farming

9 Rye-rich feed mixes can reduce CO2 emissions in pork production by more than 20%

Dr. Andreas von Felde, KWS

10 At 10t/ha hybrid rye out-does wheat

David Lord, Earls Hall Farm, Clacton on Sea

13 Hybrid rye is undergoing a modern renaissance!

Prof. Dr. Josef Kamphues, Institute for Animal Nutrition, Hanover, Germany

16 Rye improves gut health

Prof. Dr. Christian Visscher, Institute for Animal Nutrition, Hanover, Germany

18 Compound feed for pigs using rye – examples in practice

Prof. Dr. Josef Kamphues, Institute for Animal Nutrition, Hanover, Germany

22 Rye – my favourite pig feed!

Cord Penschorn, Bergen, Lower Saxony, Germany

6

A Perthshire Estate which has grown Hybrid Rye for the last four years has progressively expanded the area because the crop produces higher, more reliable returns than conventional winter cereals.



13

Hybrid rye is undergoing a modern renaissance in pig feeding, with opportunities to strengthen gut health, and carcass quality. The benefits are being realized by many pig farmers over standard wheat, maize or barley diets.

9

Among other provisions, the German government's climate protection plan stipulates reducing annual CO2 emissions in agriculture by 13 million tonnes by 2030.



18

How to include rye in compound feeds for pigs? Here are different examples.

Rye not?

Interest in hybrid rye for grain is growing in the UK, not just because of its agronomic merits but also because it adds diversity to the rotation. Recent research demonstrates rye's benefits as a feed grain for pigs, opening up an expanding market opportunity for growers.

For many growers 2020 is a year where rotations are coming under real scrutiny. Finding crops to help lengthen the rotation has been on the agenda for a while but with oilseed rape now struggling to hold its place on some farms and increasingly stubborn weather patterns to contend with, it's now a top priority.

WHY CONSIDER HYBRID RYE?

While a minor crop in the UK, rye has remained an important crop in Eastern Europe since it was first cultivated around 2,500 years ago and occupies approx five million ha worldwide. It has always been recognised for its drought tolerance and winter hardiness.

Rye was the first combinable cereal to be hybridized, with the first hybrids launched in the mid-1980s. Rye uses the modern CMS F1 technique, allowing breeders to systemise its seed production and modern hybrids use genetics originating from as far afield as Iran.

Owing to its relatively small global area, rye is not a species available from all cereal breeders. Despite this hybrid rye travels remarkably well, so it's common to see the same variety grown from Russia to Denmark and in Canada and the USA.

KWS in common with other breeders made the decision to focus on hybrids. Since the 1990s there has been significant yield gains over 'conventional' rye, with modern hybrids now delivering grain yields in excess of 12t/ha. The hybridisation of rye has firmly suppressed ergot, which has been a historic weakness of rye, because of the pollination traits this has brought to modern varieties.

WHY IS DEMAND GROWING?

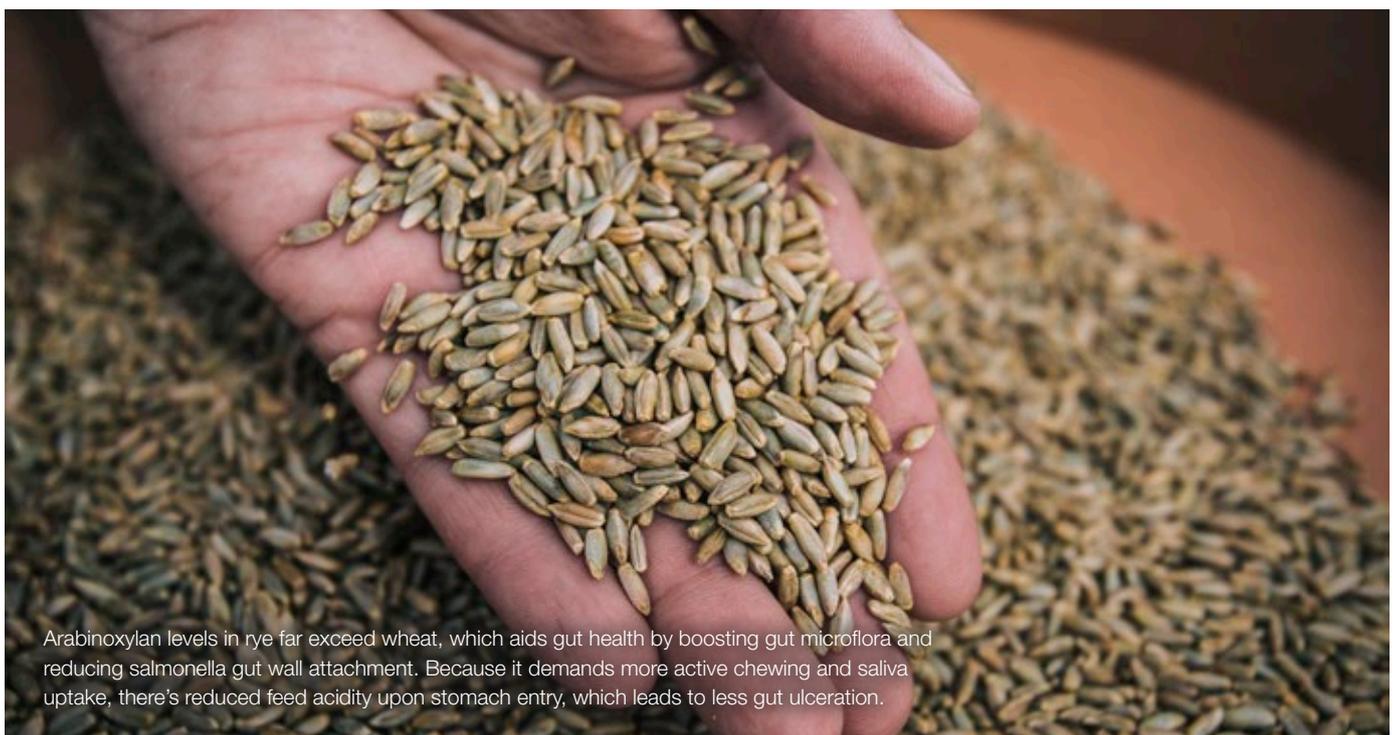
Artisan breads, specialist spirits and beers are growing markets that account for some of the increase in demand for rye grain. But the biggest growth area is in pig feed, where rye can be fed as pellets, or as wet or dry meal in home 'mill and mix' rations.

Rye grain is high in dietary fibre so promotes satiety, gut health and calm behaviour. This is especially important in finishers and sows as it leads to less tail biting and fighting over feed. As part of a finisher ration, rye can be included in the ration at up to 70%.

Although the benefits of rye are now being recognised by the pig industry, there are constraints. About 50% of UK finishers are fed on pellets and compounders are currently only set up for wheat, barley, and imported maize. The remaining 50% is mill and mix where rations are far more adaptable, and this is where rye uptake is likely to be faster.

WHY GROW HYBRID RYE?

Yield and marketing options aside, hybrid rye has a host of agronomic qualities that make it an attractive crop to grow in the UK. It's much more drought tolerant than other cereals, using 25% less water/ha than winter



Arabinoxylan levels in rye far exceed wheat, which aids gut health by boosting gut microflora and reducing salmonella gut wall attachment. Because it demands more active chewing and saliva uptake, there's reduced feed acidity upon stomach entry, which leads to less gut ulceration.



◁ To push grain yield, breeders have worked to increase the harvest index (or grains/ear) and have combined this with progressively shortening straw height and increasing internode strength.

wheat. That makes it ideal for free-draining, sandy or acidic soils of moderate fertility, as well as in regions where annual rainfall is less than 650mm.

Using its Land Information System, (LandIS), Cranfield University has taken these criteria and identified a total land area of approx. 300,000 ha most likely to suffer high soil moisture deficits during the late spring.

WHAT ABOUT AGRONOMY?

Hybrid rye suits drilling in Sept, so fits into the rotation well and has the potential to help spread workload, with harvest generally falling after winter barley.

Agronomically grain rye has similar phosphate and potash requirements to all winter cereals, but nitrogen inputs are far lower at 120-150kgN/ha – 45% less than required for a second wheat.

KWS recommend a seed rate of 175-200 seeds/m² for Sept drilling, which is the optimum time, increasing to 220-250 seeds/m² going into Oct. Hybrid rye looks fairly spartan during the winter but in the spring its vigour kicks in, producing up to 20 tillers/plant. Because of its prolific spring growth, hybrid rye offers good blackgrass suppression; shading it so that maturity is delayed and less seed is shed – 60% of which has been found to be unviable.

But as ears become heavier, the need to counter lodging risk means PGRs, such as prohexadione and trinexapac-ethyl, play a vital role.

WHAT ARE ITS OTHER BENEFITS?

In spite of modern hybrids being shorter and stiffer strawed, it's a tall crop and produces 30% more straw than barley or wheat, providing additional income. Rye straw is a useful commodity and is low in dust, making it especially suitable as a bedding material. Rye straw also provides pigs with a 'novel stimuli' and provides them with 'occupation' to relieve boredom and aggression in between feeding times.



Under the UK's new Agricultural Bill and the upcoming ELMS scheme, farmers are likely to be rewarded for lowering their emissions but will ideally aim to deliver this without comprising yields. With a 45% reduction in nitrogen requirement compared with a second wheat and a significant saving on herbicide and fungicide inputs, hybrid rye could help achieve this.



◀ Former Pig Farmer of the Year, Steve Hart.

RYE PROMOTES WELL-BEING

Former Pig Farmer of the Year, Steve Hart, gained the accolade because of the high welfare standards implemented at Norfolk Free Range.

It was the welfare benefits of feeding rye that prompted his interest and he's been undertaking an assessment of how it could benefit the pigs on his farms.

Steve has 12 breeding units, housing 10,000 sows, and a further 30 farms which take his 80,000 growers to finish, of which 16,000 are housed indoors on straw and the vast majority are reared outdoors.

All the indoor pigs are fed on meal made from raw materials grown on the farm's 1,100ha of arable land, which includes rye.

"Our nutritionist was keen to explore the well-being effects from inclusion of rye in the diet and to determine whether there were any negative effects nutritionally. We've found rye can successfully replace wheat in the ration and has a calming effect on the pigs," explains Steve.

Rye has a higher fibre and fructan content than other types of grains. Its complex carbohydrates degrade slowly and evenly in the small intestine to form glucose, which leads to lower and more even blood sugar levels which result in longer satiety.

"Most fructans are digested in the hindgut so rye also stays in the hind gut for longer, filling the colon, so more water and nutrients are absorbed which leads to firmer dung. The pigs feel more comfortable so there are less problems with aggression."

One of the objectives in switching to a rye-based diet for the indoor pigs was to reduce the need for tail docking, a measure taken to reduce tail biting. Steve is hopeful this will be the case but says it's still too early to draw firm conclusions.

Nutritionally there doesn't appear to be a drawback from feeding rye, he notes. "Liveweight gains are very similar to a wheat-based ration and its lower protein and starch content (approx. 2%) appears to be offset by the other benefits it offers."

This season the rye in the ground is looking good where other crops are suffering from the drought, notes Steve. Agronomically, he believes it has the potential to be more profitable than a second wheat and adds some diversity to the rotation. Steve is still exploring where rye fits best in his farming enterprise and intends to try some on his heavier fenland this autumn to see how it compares with the performance on the lighter land.

"The pig market for rye now needs to gain a critical mass so that there's enough demand from pig farmers for mainstream compounders to switch ingredients. They don't have the bin space for another raw bulk material but with less wheat in the ground this year, it could just be the opportunity rye needs for them to give it a go."

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TOP TIPS - HYBRID RYE

Consider rotational income – and where grain rye could benefit yield performance the most

Consider soil type – rye is well suited to light and acidic soil, but not heavy clays due to the risk of slug damage

Plan to drill early – keep seed rates around 175 - 200 seeds/m² and focus on PGRs for root anchorage and internode strength

Hybrid Rye provides Perthshire estate with a cheaper to grow, more reliable cereal crop

A Perthshire Estate which has grown hybrid rye for the last four years has progressively expanded the area because the crop produces higher, more reliable returns than conventional winter cereals.

There are many reasons to favour hybrid rye over winter wheat or winter barley at the Meikleour Estate 12 miles north of Perth, says the business's manager Colin Mitchell.

"When I came here 12 years ago there were significant areas of oilseed rape and spring barley, which was a risky crop to grow because it struggled to achieve 5t/ha and was uneconomic," he recalls.

"Winter wheat can also be a challenge on the estate's mainly light, sandy gravel soils because yields vary considerably from season to season, making it difficult to budget accurately.

"One of hybrid rye's great benefits is that it does not suffer from the extremes of yield to which wheat is prone and that makes for much more predictable, reliable performance."

Over the last four seasons, hybrid winter rye has been much more consistent, averaging 8.4t/ha compared to 8.3t/ha for winter wheat, he explains.

"But that does not paint a true picture, as a poor crop of rye could yield 7.5t/ha but wheat could be down to 6t/ha, so the risk is much, much greater. Rye also requires significantly fewer inputs than winter wheat, so the growing costs are over £100/ha less.

"A key factor is that the nitrogen requirement is only 150kg/ha, compared with 200 – 220 kg/ha for winter wheat, which not only reduces inputs costs but is also important because the estate is in a nitrate vulnerable zone.

"Rye also requires fewer, cheaper, fungicides and its carbon footprint is relatively low, an important consideration for many end-users these days.

"We grew our first crop of hybrid rye for silage for the 2015 harvest after trials data from Scottish Agronomy Ltd suggested that it might be a better proposition than winter wheat on our light soils."

That year, 12ha were drilled on some very dry, gravelly land where the best-ever yield had been 6.5t/ha from winter oats, Colin Mitchell points out.

"Even though we were very much at the experimental stage during that first season the rye came in at 7.7t/ha and all of it sold to a local anaerobic digestion plant.

"The success of that initial crop persuaded me to increase the area the following season and the 25ha went for human consumption. I ramped up production slowly to 100ha for the 2019 harvest and the crop averaged 10t/ha, which was unheard of over such a large area."

GETTING THE MOST OUT OF HYBRID RYE

Following wheat and oats, Meikleour Estates' crop of KWS Edmondo was drilled 2.5cm deep at 250 seeds/m² using a 6m Lemken power harrow-drill combination operating directly on land which had been ploughed 20cm deep.

Although no seedbed fertiliser was applied, the crop emerged quickly and subsequently received an application of Liberator (Bayer) herbicide for early control of grass weeds and broad-leaved weeds, together with manganese sulphate. Colin Mitchell explains.

"Rye develops so vigorously in the spring that it easily outcompetes most weeds. In February, we applied 30 per cent of the total nitrogen and sulphur, together with another application of manganese sulphate,

plus magnesium, manganese, a low dose of epoxiconazole and a full dose of Moddus (Syngenta) at GS30.

"At GS31, Tracker (BASF) broad-spectrum fungicide was applied to help control eyespot, together with Chlormequat and another dose of Moddus, followed by trace elements.

"The remainder of the nitrogen and sulphur was applied before the end of March, together with variable-rate potash, but no phosphate as levels were quite high from the chicken litter which went on before the land was ploughed.

A final dose of epoxiconazole was applied at flag leaf emergence, along with 0.5l/ha of PGR (Cerone/NuFarm), he adds.

"We finished drilling the rye on 3 October, about 10 days later than normal due to the adverse weather, but the crop came through the winter looking good. Also it is shorter than usual which will make it easier to combine.

"At harvest, the grain is normally about 17%-20% moisture and the extra volume of rye straw reduces the forward speed of our 9.1m New Holland 9070 combine by about one-third, although the grain is easier to separate out than winter wheat or winter barley.

Last harvest was complicated because the weather turned showery in August and on the lighter land the rye and winter wheat matured at the same time, he explains.

"Because of the volume of straw, we had to combine rye early in the day when it was driest and leave winter wheat later in the afternoon and evening. The rye averaged 9.1% protein with a bushel weight of 72kg/hl, slightly below the 78 – 79 kg/hl of previous seasons.



“Root crops are our main cash generator, so it is important to conserve straw from cereals to cover carrots over winter to protect them from the cold. We cover them in straw during October and November at the rate of 50t/ha, equivalent to 100 500kg Hesston bales.

“Last season we averaged 12 hesston bales per hectare, compared with seven from the winter wheat, which at £25 per bale means that the rye is worth an additional £125/ha.

“The other benefit that we have found is that rye straw does not break down as quickly as winter wheat or winter barley, so we might be able to reduce the application rate going forward, although protecting the crop remains our prime consideration.”

Rye has now replaced quite a chunk of the feed barley, second wheats and spring cereals which used to be grown, he says.

“All our current rye production goes for malting and distilling which is an industry where producers are always looking for an edge in terms of flavour and increasing their product’s consumer appeal.

“If markets continue to develop I would be quite comfortable with increasing the area of rye to 200ha, although that may take time to achieve.”



△ Business manager Colin Mitchell says, “Hybrid rye is significantly better than winter cereals in that respect as its straw yield is 50% to 100% higher.”

JSR looking to rye to benefit the pig and arable sides of the business

As part of its continual search for new and innovative opportunities to improve performance, the JSR Group has examined whether expanding its crop production to include rye would benefit both the pig and arable sides of the business.

Alongside its pig breeding operation, JSR runs more than 9,000 acres of crop production around the company's base in East Yorkshire, which is largely a mix of barley, wheat, oilseed rape, beans, peas and seed potatoes.

Having seen the success of rye production on the continent, Charles Parker, JSR Farms' arable managing director, was keen to explore whether these results could be replicated in the UK.

"We work with a number of partner organisations around the world and had heard first hand of the results farms were seeing after introducing hybrid rye to the crop rotation," he said.

"It produces good yields across a variety of soil types and has lower production costs than many other cereals, with savings made on nitrogen and fungicide. It also has a good drought resistance, which until lately has been very useful! Due to the integrated nature of our business, we had to be convinced that it would work well for our pig business as well."

To put the cereal to the test, Harbro designed and mixed a ration, including rye, that was fed to a recent batch of 2,000 JSR 9T x Tempo animals, with the level of rye included in the diet increasing as the pigs grew.

Stephen Waite, JSR's managing director of pigs & genetics, said: "As a business we're committed to improving the efficiency as well as sustainability of our operations, while promoting the highest standards of animal welfare.

"With industry results having shown a potential for improved gut health, which in turn leads to improved health, behaviour and performance, we were keen to test the cereal for ourselves and were pleased with the results.

"Rye now features as a permanent addition to our rotation and we're excited to see how pigs at other stages of the production cycle perform on it."



△ Stephen Waite, JSR's managing director of pigs & genetics.

The following results were recorded:

Weaning Weight	9.3kg
Wean-Finish Growth	823g/day
Wean-Finish FCR	2.21
Weight In	24.3kg
Average Dead Weight	91.8kg
Average Live Weight	120.1kg
Average P2	11.7mm
Finishing Growth	990g/day
Finishing FCR	2.33

Source: JSR, Harbro



Rye-rich feed mixes can reduce CO2 emissions in pork production by more than 20%

Among other provisions, the German government's climate protection plan stipulates reducing annual CO2 emissions in agriculture by 13 million tonnes by 2030.

In implementing this, animal feed could play an important role. Just by using regional, rye-rich feed containing some amount of rapeseed, annual CO2 emissions in pork production can be lowered by more than 20%. These are the results of the "6-R-Konzept"¹ ("6-R Concept"), a project KWS is heavily involved in as an industry partner.

Earlier studies have shown Hybrid rye can reduce CO2 emissions by up to 80 kilograms per tonne of yield in comparison with wheat.

Rye needs significantly less fertilizer than wheat, demands substantially less water and generally enjoys very good plant health.

Now the "6-R-Konzept" has provided scientific evidence that rye-rich feed mixes

can decrease CO2 emissions in pork production by more than 20%. "If all pig farming operations in Germany - and that's more than 18,000 farms with more than 17 million pigs - switched to a new feed concept, the agricultural industry would produce about 6.5 million tonnes less of CO2 each year," says Dr. Andreas von Felde, who heads global product management for animal feed at KWS.

The savings on CO2 emissions are not only through new feed concepts and the advantages from hybrid rye described above, but also from the ability to produce animal feed locally, thereby eliminating long transport distances. Imported wheat is now often added to feed, just like imported

soy products for supplying protein. That, of course, negatively impacts the carbon footprint. In contrast, hybrid rye can be grown regionally in sufficient quantities, and domestic protein crops can replace soy.

"The old type of cereal rye, which is indigenous to our latitudes, had in the past been increasingly displaced by wheat," von Felde says. "But little by little the enormous potential hybrid rye offers in many different areas is being recognized again - and we're happy about that."

Published by KWS SAAT SE



At 10t/ha hybrid rye out-does wheat

Interest in hybrid rye grain is soaring thanks to the emergence of rye as a whisky with serious appeal and recognition that it is more than just a good source of fibre for inclusion in pig rations.



David Lord grows hybrid rye at Earls Hall Farm, Clacton on Sea.

This demand has seen it move from 'another AD crop', to a mainstream cereal. It is its performance on farm however, that is capturing the interest of growers.

Annoyed by the under-performance of winter malting barley, David Lord decided to investigate hybrid rye after a discussion with a neighbour. It's now four years later and the area grown has expanded to 40 hectares as demand has increased.

"I was looking for a crop to fit the light land rotation of potatoes, wheat, peas/onions, and wheat.

Rye had good drought tolerance and the straw is useful for the cattle enterprise though we are careful to follow it with potatoes to replace the phosphate taken off (with the straw) and control the volunteers"

It was the low water requirement that appealed in the first instance. At 300 litres per tonne of grain produced, its moisture needs are typically 25% lower than that of wheat or barley.

We budget for yields of about 8.5t/ha, but it often exceeds this - in good years 10t/ha or more. As our contract pays us the same as feed wheat, it often produces a better gross margin because it is cheaper to grow," he says.

It has since become an established crop and his 350-400 tonnes annual production is sold locally to a specialist food ingredients business.

"It does better than wheat on the same ground and is earlier to mature, but later than oilseed rape, so helps ensure a smooth harvest," he says.

Sowing is much the same as any other cereal. David will either drill it conventionally after cultivations, or direct into stubble depending on the workload at the time, the field and the weed burden.

"It's certainly easy to grow. We sow it in early October, normally apply two fungicides, though it has had only one in 2019, as mildew and brown rust are the main disease pressures, and a single application of Chloromequat to

keep it from lodging. About 150 kg N/ha is applied in two splits and that's it.

"It matures evenly which makes combining easy and stores better in bins as it doesn't heap that well. This suits the customer as they can take it as and when they need it," he says.

Ergot is the curse of rye, but since moving to a fully hybrid variety this has become less of a concern.

"We moved to KWS Bono a few years ago partly for the higher yield potential, but also because the higher quantities of pollen these PollenPlus varieties produce means there is a far lower risk of ergot infection occurring," he says.

"It's not completely risk-free, but with milling wheat on the farm too we need to be proactive and PollenPlus varieties have helped greatly."



NEW HOLLAND



Hybrid rye is undergoing a modern renaissance!

Hybrid rye is undergoing a modern renaissance in pig feeding, with opportunities to strengthen gut health, and carcass quality. The benefits are being realized by many pig farmers over standard wheat, maize or barley diets.

AUTHOR

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RYE CHARACTERIZED BY A HIGH LYSINE CONTENT

Today wheat and barley are the standard cereals used for compound feed.

However, rye has been catching up recently because of the changing climate conditions, drought, and loss of agro-chemicals. Once more the cultivation of rye is catching the farmer's attention!

Due to its relatively high root mass, rye has a better dry resistance than other cereals. This is an advantage especially for farms on sandy and less fertile soils. In recent years, breeders have produced modern day hybrid rye, making it fit for the future.

The risk of ergot contamination has been significantly reduced by new hybrid varieties, thus, rye is acceptable for feeding pigs now.

AMINO ACID PROFILE; RYE FITS PERFECTLY

But what are the benefits of rye? The energy level about 15.0 MJ/ME per kg DM (dry matter) is only slightly lower than in wheat (15.5 MJ/ME per kg DM). Rye, with its averagely 115g crude protein per kg DM, has less protein than wheat (135g per kg DM on average). But this reduced crude protein level is what makes rye so interesting for modern

diet formulations.

Furthermore, rye also has advantages regarding its amino acid profile. As shown in table 1 rye protein has more lysine than all other cereals (including corn). Only the protein of oats has a slightly higher lysine content. Compared to wheat, rye protein has approx. 30 % more lysine which is the first limited amino acid for pigs.

There are different measurements about the prececal digestibility of rye's lysine. According to the DLG (German Agricultural Association) the ileal digestibility is about 80% and the digestibility of barley varies at 73%. Other sources declare 62% digestibility of rye and 67% of barley. Regarding methionine, cystine and threonine the values of rye are comparable with wheat and barley.

Only tryptophan figures are significantly lower. But this is hardly important in pig feeding. Only corn has a lower contents. If necessary, the deficit could be balanced by added amino acids or by using DDGS.

SUMMARY:

- Rye is an important ingredient for feeding pigs, its use is increasing across Europe and North America
- The advantages of rye are its high dietary fibre content and favourable amino acid profile
- Rye is very high in native phytase
- Rye is high in dietary fibre which acts as a substrate for microorganisms in the hind gut (colon), and helps to raise the production of short chain fatty acids (SCFAs)

- SCFAs lead to the formation of butyrate which further promotes intestinal health

RYE – HIGH IN NSP'S WHICH PROMOTE GUT HEALTH

Rye's starch content is about 645g per kg DM. By comparison wheat is around 10% higher in starch. But cereal grains contain more than just starch. In this context the Non-Starch-Polysaccharides (NSP) are worth noting.

The specific feature of NSP is that they cannot be digested by the host's own enzymes of the animal, but only by the gastrointestinal flora in the hind gut.

Compared to wheat and barley, rye has a lot of NSP - especially arabino-xylans and fructans. The hind gut fermentation of both arabino-xylans and fructan helps to promote the formation of butyrate by the hind gut flora.

Concerning crude fibre, rye is on a relatively low level. The content of 18g per kg DM is even lower than in wheat (21g per kg DM). The reason is rye and wheat are naked cereals – the grains are non-hulled.

RYE – UNIQUE PHYTASE LEVELS

Rye is the cereal with the highest phytase activity. Thus phosphorus metabolism is optimized. Recent studies showed the phytase activity was at 4,177 units/kg - as you can see in table 2. This has a lot of advantages in terms of the environment because less dietary mineral phosphorus is needed. Triticale and wheat only have values half as high and in barley they are notably lower.

TABLE 1: AMINO ACID CONTENT OF CEREAL GRAINS¹⁾

	LYSINE	METHIONINE	CYSTINE	THREONINE	TRYPTOPHAN
Corn (Maize)	2.98	2.06	2.23	3.65	0.75
Barley	3.49	1.57	2.09	3.39	1.23
Wheat	2.72	1.47	2.21	2.86	1.15
Rye	3.59	1.52	2.10	3.23	1.02
Oats	4.22	1.74	2.93	3.55	1.41

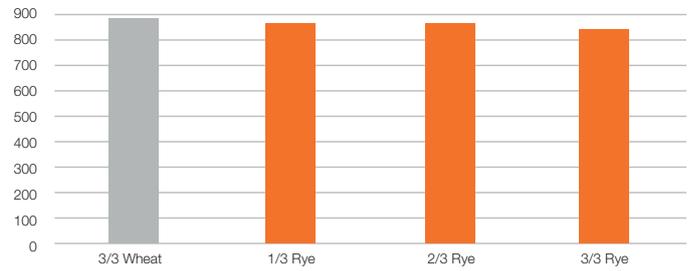
¹⁾ g per 100 g crude protein; according to Rodehutschord et al. 2016

TABLE 2: RYE – ITS UNIQUE HIGH PHYTASE ACTIVITY

CEREAL GRAINS	PHYTASE ACTIVITY (U/KG) ¹
Corn	143
Barley	693
Wheat	1,850
Triticale	2,154
Rye	4,177

¹u/kg = units/kg; source: Rodehutschord et al. 2016
Rye has top values in phytase activity.

FIGURE 1: HIGH DAILY WEIGHT GAINS FEEDING RYE



Source: Wilke 2020 (thesis)

RYE IS TASTY FOR PIGS!

If a cereal is qualified for pig feeding its nutritive value also depends on its palatability.

When a pig does not like its feed all benefits have no purpose. Regarding palatability, modern hybrid rye varieties with good ergot resistance i.e. zero ergot contamination are ideal. Pig producers need to keep an eye on this potential hazard when purchasing any cereal. According to recent Canadian tests an ergot content of more than 2g per kg in finisher’s diet significantly reduced performance.

Trials with shares of rye up to 69% in piglet starter feed did not have any negative impact on DM-intake. It also did not matter, whether the diet was offered dry or liquid resp. as mash or pelleted. The bitter substances problem seems to be solved as well. Today’s rye varieties do not result in palatability problems.

The question was, whether relatively high shares in the diet are possible for all age groups. Recent trials showed a rye ratio of almost 70% in compound feed for weaned piglets and grower diets is possible. Animals between 16 and 40 kg body weight had the highest feed intake with 1,224g and a feed conversion ratio of 1.62 : 1 which is excellent. The daily weight gains were very good as well. Piglets fed with two-thirds of rye in the compound feed reached daily gains of 865g (see figure 1). Thus, rye is well digestible in the gastrointestinal tract and the DM content in feces varied at desired levels.

Feeding trials show pigs reach very good daily weight gains with increasing shares of rye in the diet

Attention: Piglets between 10 and 15 kg bodyweight should not be fed with more than 25% rye in the compound feed. One reason is the hind gut which is still developing at this age. Similar effects are also

shown in diets with wheat or barley. Thus, the recommendation for rye should not be more than 50% in mixtures for piglets with a weight up to 20kg.

FAVOURING DIGESTION IN THE HIND GUT

The digestibility of rye in the small intestine is lower than of wheat or barley. Table 3 shows the amounts of DM absorbed in the small intestine is 625g using rye. From 1kg rye only 625g is digested in the small intestine. From barley the value is about 668g and about 745g from wheat – these values are significantly higher than rye.

But the lower small intestine digestibility of rye has advantages because significantly more fermentable substances will enter the hind gut – in trials 375g DM. If you compare the mass of feces, rye constituents are very efficiently digested.

Rye leads to increased availability of



◁ Feeding rye had no negative impact on the feed intake in recent studies.

TABLE 3: BY FEEDING RYE A HUGE AMOUNT OF DRY MATTER IS REACHING THE HIND GUT

1 KG OF...	...ABSORBED IN THE SMALL INTESTINE (DM, G)	...REACHING THE HIND GUT (DM, G)	FECAL EXCRETION (DM, G)
Wheat	745	255	110
Barley	668	332	176
Rye	625	375	128

Source: Stein et al. 2019; Kamphues et al. 2019

nutrients in the hind gut, where the intestinal flora utilizes these substrates, thus pigs have benefits from the elevated levels of volatile fatty acids.

The pig's hind gut is not an "unnecessary attachment" of the over 20m long small intestine but an important part of the overall GIT (Gastro Intestinal Tract). The more intestinal flora supplied the more functional the hind gut becomes.

These intestinal flora are then able to fend off or eliminate infective agents, such as salmonella. In this regard rye has considerable advantages compared to wheat and barley. Considering the digestibility of rye only 77% of the protein is digested in the small intestine - in wheat it is roughly 90%. Also more starch will reach the hind gut compared to wheat.

It is important to note that as a consequence of feeding a high share of rye, significantly more organic fermentable substances are available in the hind gut. The higher amount originates directly from NSP's (arabino-xylans / fructans) but also of the crude protein and the rye grain's starch.

BUTYRATE STRENGTHS THE INTESTINAL MUCOSA - THE FIRST LINE OF DEFENCE

The hind gut's microorganisms produce acetic acid, propionic acid and butyric acid (see figure 2). Butyric acid leads to the formation of butyrate, that has a lot of benefits;

- Butyrate is the preferred source of energy for the cells in the intestinal tract
- Butyrate helps regulate the functions of the intestinal wall. It contributes to maturation and regeneration of cells.
- Butyrate has preventive effects on infectious agents like salmonella
- Butyrate supports the exchange between the GIT flora, and the intestinal wall
- Butyrate also has positive effects beyond the intestine wall. E.g. raising blood sugar levels. This may have positive effects on satiety, activities and the social behaviour of pigs. However further studies are necessary.

RYE ENSURES MEAT QUALITY – THANKS TO ITS LOWER CRUDE FAT CONTENT

Feeding rye has positive effects on meat quality. Rye has the lowest fat content at only 18g crude fat per kg DM.

For comparison, wheat is 20g per kg DM and barley 26g per kg DM.

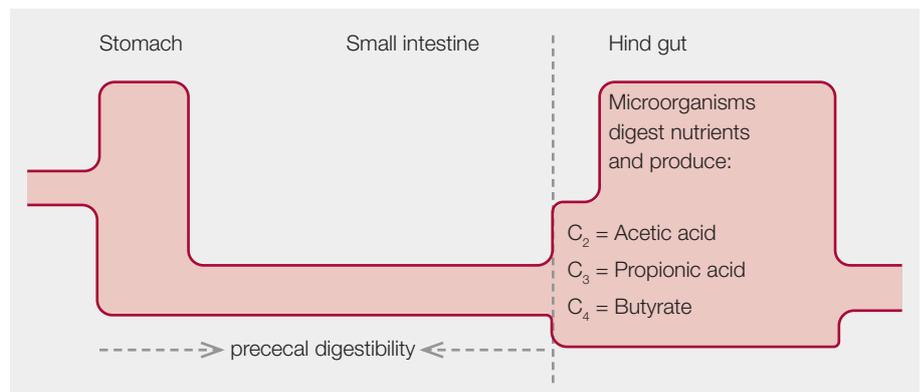
Due to the lower crude fat content from rye grain, the intake of unsaturated fatty acids are reduced, which has a positive impact on carcass quality and the lean meat ratio.

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△ Rye feeding helps carcass quality, including bacon (firmness).

FIGURE 2: RYE FAVOURS BUTYRATE FORMATION IN THE HIND GUT



△ By feeding rye intestinal micororganisms utilize specific nutrients, such as fructans and arabino-xylans in the hind gut and produce a lot of butyrate.

Rye improves gut health

Rye is not only an ideal feed for finishing pigs, it also improves and protects animal health. The advantages of rye are especially clear in the hind gut.

AUTHOR

Prof. Dr. Christian Visscher, Institute for Animal Nutrition, University of Veterinary Medicine Hannover, Foundation, Hanover, Germany

An important target in modern pig feeding is to keep the gastrointestinal-tract healthy and to offer an easily digestible diet. Farmers and nutritionists are already well aware of this.

Compound feed has to be well balanced. Aside from wheat and barley, rye is also an eminently suitable feeding component.

RYE BENEFITS – AT A GLANCE

- Rye feeding is a pre-cursor for hind gut health, helping intestinal mucosa to develop
- Rye has a high dietary fibre content, leading to natural butyrate formation through the digestion of arabinoxylan
- Butyrate in the hind gut helps naturally reduce salmonella
- Trials to reduce boar taint by feeding rye are underway. Initial results are promising

RYE NURTURES THE GUT WALL

Compared to other cereals, rye has a high content of specific dietary fibres which are not digested in the small intestine. Instead they are partly or totally decomposed and metabolized by microorganisms in the hind gut.

Specifically, these dietary fibres are classed as Non-Starch-Polysaccharides (NSPs) which include arabinoxylans, fructans, beta glucans as well as cellulose.

Recent studies show, the NSP content of rye is about 20 %. The ratio is around 7-12 % arabino-xylans, 3-6 % fructans & cellulose, and 1-3 % beta glucans and lignins.

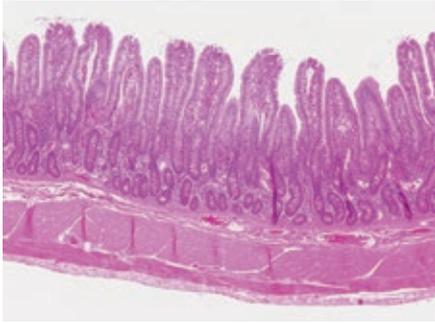
During degradation of the dietary fibres, several beneficial substances are produced. These substances are important for keeping the gut mucous membrane healthy by boosting faecal flora.

The degradation of arabino-xylans and fructan in the caecum as well as the degradation of insoluble arabino-xylans and cellulose within other zones of the hind gut,

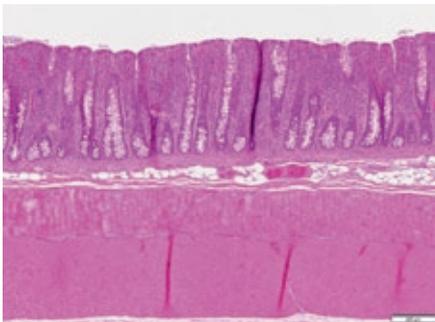


Feeding rye has positive effects on gut health.

Pictures: Carola Ellner, Institute for Animal Nutrition, FU Berlin



△ Cross-section of a healthy small intestinal wall. The mucosa with intestinal villi is clearly recognizable.



△ The hind gut wall (intestinal mucosa) is nourished by butyrate from the hind gut.

assists in the production of butyrate.

Butyrate is the favoured energy source of enterocytes (superficial cells in the small intestine) which are responsible for the resorption of nutrients. Butyrate also supports the growth of gut cells. Several studies show positive effects on the immunity of older pigs, reducing antibacterial factors in the intestine.

FEEDING RYE HELPS TACKLE SALMONELLA

Rye can also boost the defence against salmonella. Ideally, a high share of rye in the compound feed leads to more butyrate – in the caecum and the entry of the hind gut. The higher butyrate helps inhibit the dispersal of salmonella.

A study over several years shows reduced OD (Optical Density) salmonella values by feeding rye.

A large-scale farm field study shows the clear effect on salmonella reduction. Initially the share of rye has been increased in three stages: 20 % in the starter diet, 25 % in the grower diet and 40 % rye with 25 % barley in the finisher diet.

Salmonella levels were measured using the ELISA test method via OD (optical density) antibody values.

In the first evaluation of the field study, between 2016 and 2018, 2,770 individual values were considered in total.



◁ Boar taint problems may be reduced by feeding rye. More experimental studies are necessary.

Comprising 1,481 meat juice samples (% OD average 19.97) and 1,289 blood samples (% OD average 21.01).

As demonstrated in figure 1 the values decreased continuously the longer the study lasted.

This means, rye-based feeding led to a reduction of salmonella antibody (OD) values. These results are significant. The target now is to offer the rye-based compound feed for sows. For further serologically reduction of salmonella, the complete production cycle has to be considered. Epidemiological analysis repeatedly confirms this outcome.

DOES RYE FEEDING INHIBIT BOAR TAIN?

Current studies in cooperation with the “Viehvermarktung Walsrode”^{*} analyses, if the use of rye-based feed compounds can help against boar taint. Previous results are promising.

^{*}Viehvermarktung Walsrode is a large independent pork abattoir in Lower Saxony, Germany.

The theory is, by feeding rye more butyrate arises, therefore, compound feed with a high share of rye has positive effects for fattening boars, and reducing taint.

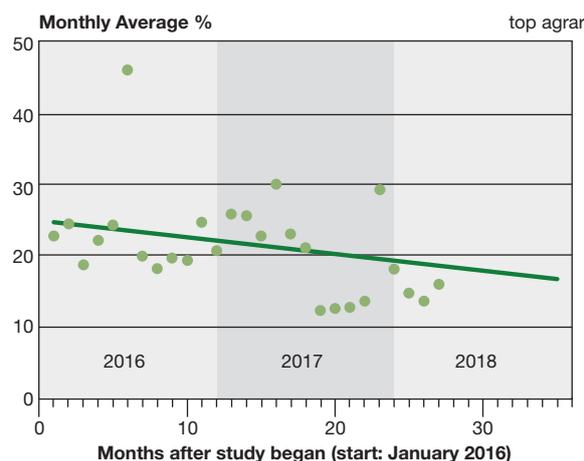
Boar taint mainly arises from the build up of androstenone and skatol. Both of which are produced from the degradation of the amino-acid tryptophan in the intestine. Skatol production can be significantly influenced by the feeding strategy. Among others, this has been confirmed by trials with potato starch.

By using 20 % crude potato starch in the compound feed the skatol content of the fatty tissue was significantly reduced. By using 5 to 10 % inulin in the compound feed similar results were shown. Inulin also happens to contain fructans similarly to those in rye.

The effects are based on carbohydrates (e.g. resistant starch) not digested in the small intestine but in the hind gut. For this reason the intestinal mucosa is again supplied with butyrate and less epithelial cells die off. In-turn less tryptophan is wasted (by the necrotic cells) and accordingly, less skatol arises.

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FIGURE 1: DECREASING SALMONELLA OD VALUES WHEN FEEDING RYE



◁ Source: Institute for Animal Nutrition, University of Veterinary Medicine Hannover, Foundation.

Compound feed for pigs using rye - examples in practice

How to include rye in compound feeds for pigs? Here are different examples.



AUTHOR

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Rye is applicable as a feed at all production stages in pig farming. This includes pregnant and lactating sows as well as rearing piglets and finisher pigs.

It is vital there is no ergot contamination in the compound feed, this is especially critical for sows. The maximum ergot level

is 1g / Kg in the rye grain sample. This value should not be exceeded in the final diet. Ergot can otherwise impair feed intake and reduce the sows fertility and milk formation.

PIGLETS: START WITH DIETS CONTAINING UP TO 10 % RYE

Only a limited number of study's have being published concerning rye in compound feed for rearing piglets. To be on the safe side, after weaning a maximum of 5 to 10 % rye should be included in the diet. 2-3 weeks after weaning the share of rye can be

increased up to 25 %. From a body weight of 18-20 kg significantly higher shares of rye are possible without any undesired effects regarding intake, performance and feces quality.

Two important aspects regarding the production compound feed, using rye have to be considered: At first, the feed structure (particle size) is an important factor. This is significantly altered when replacing barley with rye for example. If necessary, the crude fibre content can be adjusted when using classically whole (non-hulled) rye grain.



△ The stomach entrance as it should be - the mucosa is smooth, shiny and translucent.



△ A stomach entrance with severe ulceration due to excessively fine grinding of feed.

Crude fibre sources such as DDGS, oat bran or a certain share of sunflower grain may be added.

Furthermore, any cereal grain should not be ground too finely. In practice, around 10% of the total cereal inclusion is processed in a roller mill. This crushes and breaks the grain up instead of producing a “powder”. The remaining cereal fraction can be ground by a hammer mill with a 3 mm sieve.

SUMMARY

- Rye is very suitable for feeding pregnant and lactating sows and fattening pigs
- Rye inclusion up to 70 % in finisher diets

is possible, for rearing piglets this should be limited to 25 %

- The grinding intensity should not be excessively fine

SUFFICIENT COARSE PARTICLES SHOULD BE PRESENT IN THE FINAL FEED!

Compound feed must contain a well-balanced mix of grain sizes, especially coarse particles left after grinding. Fine particle sizes less than 0.2 mm should not exceed 35 % of the finished feed. (Using a wet screen analysis). This is well known to benefit gut health and prevent gastric

ulcers. Additionally, a rather greasy feces consistency can only be avoided by a sufficiently structured coarse feed.

Finally, when using rye in compound feed the share of dried sugarbeet pulp or similar components must be limited. When mixing 50% rye and 20% dried sugarbeet pulp the feces can quickly become sticky. Sufficient undigestible and hard coarse particles must be included. Due to such substances, the feces shows “breaking points” and drops easier through the slatted floor. With a high share of dried sugarbeet pulp the feces will obstruct the slats.



◁ A coarsely ground diet is important in feeding rations with a high share of cereals.

TABLE 1: RYE COMPOUND FEED EXAMPLES FOR SOWS

DIET COMPOSITION	PREGNANCY	LACTATION
Wheat, %	-	17.5
Rye, %	16.0	35.0
Barley, %	10.0	17.5
Soya Bean Meal*, %	3.1	18.1
Rape Seed Meal*, %	2.0	-
Oats, %	5	-
Sunflower Meal*, %	8	4
Sugarbeet Pulps, %	4	2
Vegetable Oil, %	-	2

*extracted; top agrar; source: Kamphues
The share of rye can be increased up to 35 % for lactating sows.

In tables 1 and 2 examples of compound feeds with rye are presented, adding further ingredients is possible.

MIXING EXAMPLES

Pregnant sows

- Rye can replace all other cereals
- When replacing maize with rye, the hind gut has a higher filling factor due to the higher dietary fibre content. At the same time rye stimulates hind gut fermentation due to its high NSP contents (arabinoxylans)
- When replacing barley or oats with rye, it is necessary to include ingredients containing more crude fibre (e.g. DDGS, oat bran or sunflower grain)

Lactating sows

- Rye can replace all other cereals (even maize)
- When replacing maize with rye, fat can be added to reach the same energy density
- Replacing maize with rye does not require additional amino-acids, and also lowers the risk of fusarium toxins
- If rye replaces wheat in compound feed, lysine should be added (+ 3 to 5%)
- The crude fibre content has to be adapted when replacing barley with rye. Consideration should also be made that the final diet contains sufficient coarse particles

Finishing pigs

- Rye can replace all other cereals in finisher diets



△ Sampling the feed; depending on the grinding technique and ingredients.

- When replacing wheat with rye, the lysine content should be slightly be increased (+ 3 to 5%)
- If the compound feed includes rye instead of barley, the diets’ “structure” (share of coarse particles) should be considered. If necessary, crude sources should be added and the grinding technique should ensure an adequate level of coarse particles, that avoids the risk of gastric ulcers

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TABLE 2: EXAMPLES FOR DIET COMPOSITIONS SUCCESSFULLY FED TO FINISHING PIGS ¹⁾

Diet No.	BODY WEIGHT > 20 TO < 50 KG			BODY WEIGHT > 50 TO < 80 KG		BODY WEIGHT > 80 KG	
	1	2	3	4	5	6	7
Wheat, %	31.7	17.5	-	16.0	1.7	3.5	-
Rye, %	10.0	30.0	60.0	25.0	50.0	40.0	70.0
Barley, %	25.0	25.0	10.0	25.0	18.0	25.0	5.0
Soya Bean Meal, %	10.5	13.5	8.1	7.5	8.0	3.0	5.5
Rape Seed Meal, %	2.0	4.5	16.1	4.0	7.5	5.5	9.0
Mill by-products, %	17.0	6.0	-	19.5	11.9	20.0	6.8

¹⁾All mixtures except no. 3 are based on compound feed on farms with diets formulated by Raiffeisen Kraftfutterwerk Mittelweser-Heide (a compound feed producing company in Lower Saxony, Germany). Mixture no. 3 has been tested in experimental studies (thesis Wilke 2020).





Rye - my favourite pig feed!

Cord Penshorn is a German pig finishing farmer and his favourite feed is a rye-based diet. The biological performance is good and swelling characteristics in the pigs' stomach leads to calmer animals.

Cord Penshorn, Bergen, Lower Saxony, Germany, is only feeding high quality cereals. In this context two aspects are very important for him:

- The 30 year old farmer only feeds home produced cereals. This ensures a high-quality feed for his fattening pigs
- Furthermore, the right crop storage is very important for him. The cereals are stored in his own grain shed, dried to 15 % moisture and additionally stabilized by propionic acid

For many years, on Penshorn's farm- the number one feed component is rye. "On our light and dry soils rye is almost the only crop option, particularly due to our limited irrigation availability. Rye is more drought resistant and has a higher yield stability than wheat."

When buying rye seed Penshorn keeps a very close eye on the stability as well as the disease resistance of the varieties. Yields is a secondary consideration, but ergot resistance is paramount. "In the past, we paid a lot of attention to ergot contamination, but this risk has been significantly reduced with new hybrid varieties."

THE DIET USES UP TO 60% RYE

On Penshorn's farm all 3,200 fattening pigs are fed with rye. In the starter diet Cord Penshorn uses 30 % rye. In the grower diet he increases rye to 50 % and up to 60 % in the finisher diet. He does not recommend using rye at greater than 60 % because this might lead to too low a crude fibre content. Penshorn's feed strategy also relies on barley, "to ensure

enough crude fibre, we always include between 20 to 26 % barley in the feed."

According to Cord Penshorn, the advantage of rye relate to its protein content. The protein content of rye is slightly less than wheat, but rye's amino acid profile fits perfectly. Analysis shows his rye has a lysine content of 3.40 g per 100 g crude protein. "We need sufficient amino-acids in the diets for growth and lean meat," the farmer explains. To ensure that the pigs always get sufficient crude protein, Penshorn increased the soya bean meal content in the grower's diet to 18.5 %.

LIMITING THE SHARE OF RYE IN STARTER DIET

If farmers feed high quantities of rye, they must keep an eye on the feed intake. Cord



Penshorn's pigs on the grower and finisher level have no problems with the high share of rye.

However, on the starter's diet he is more careful: "Significantly more than 30 % rye in the feed can mean the feed is not tasty for the pigs, and feed intake decreases. The reason could be the bitter substances, which might come from older rye varieties. Every farm should test its own maximum level," Penshorn recommends.

The farmer is satisfied with the growth rate of his pigs. The daily weight gain is over 900 g and the feed conversion rate of 1:2.67 is satisfying. "The young boars digest the rye-based diets very well. This has a positive effect on our feeding costs which are slightly below the average of my benchmark consulting service", Cord Penshorn says.

CALM PIGS

Rye causes positive effects on animal behavior. Due to the good swelling characteristics in the stomach especially, finishers are very calm. "This is a huge advantage when fattening young boars. On many farms the agile young boars ride up and hurt themselves and other boars. On our farm the pigs are relaxed till the end of the fattening period," Cord Penshorn declared.

By now, Cord Penshorn is also able

to evaluate the reduction of boar taint. There were only three cases of taint out of over 8,000 boars. In regards to salmonella Penshorn's experiences are positive too. His farm is stable in category I which means a Salmonella level of below 10 % since early 2019.

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"Rye is my favourite cereal due to the good results we have achieved by feeding it. For agriculture rye is an important crop and well adapted to the local conditions. Penshorn concludes, "I do not want to fatten my pigs without rye."

SUMMARY

Farmer	Cord Penshorn, Bergen, Lower Saxony, Germany 3,200 finishing pigs
Crop area	100 ha
Main crops	hybrid rye, spring barley, wheat and sugar beet
Feeding strategy	On farm grain store and mixing rations <ul style="list-style-type: none"> • Cord Penshorn cultivates rye for feeding his finishing pigs • The finisher's diet contains 60% rye • Rye contains a high lysine level to ensure good daily weight gains. The good swelling characteristics in the stomach lead to calm pigs. A huge advantage especially for fattening young boars.



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