UNION FOR THE PROMOTION OF OIL AND PROTEIN CROPS E.V.

UFOP PRACTICE INFORMATION

Faba bean, grain pea, sweet lupin and soybean for pig feeding

Authors

Dr Manfred Weber
Saxony-Anhalt State Institute for Agriculture and Horticulture, Iden

Dr Wolfgang Preißinger
Bavarian State Research Centre for Agriculture, Schwarzenau

Prof. Dr Gerhard Bellof
Weihenstephan-Triesdorf University of Applied Sciences, Weihenstephan

Content

Introduction

Grain legumes have long been considered valuable crops for farmers. In addition to providing a break in cereal-based crop rotations, they make an important contribution to the regenerative nitrogen (N) supply in arable farming through their ability to fix N with the help of root nodule bacteria. Pea, faba bean, sweet lupin and also European-grown soybean have recently attracted increasing interest. The potential of domestic grain legume production to contribute to the sustainable development of our farming systems is receiving increasing attention. It broadens the feed resource base. This and measures in the Common Agricultural Policy are reflected both in the expansion of cultivated areas and in the breeding of new varieties.

This UFOP publication provides an overview of the constituents, feed value and possible applications of grain grain legumes in pig feed. Results of feeding trials of the last ten years have been taken into account. The brochure covers both white-flowered and variegated cultivars of field bean. For pea, the focus is on the white-flowered cultivars as these dominate the market and are particularly suitable for feeding pigs. The information on lupin refers to the blue and white sweet lupin. Other lupine species are not currently grown. However, due to their nutrient composition, they could become interesting again for pig feed in the future. Full-fat soybean and soybean cake produced from them are the most important feedstuffs from domestic or European soybean cultivation.

Constituents of grain legumes

Nutritional constituents

The value-determining constituents of the "classic" domestic grain legumes (faba bean, white-flowered pea and sweet lupin, and soybean as a "new" European-grown grain legume) are shown in Tables 1a and 1b. Grain legumes are used in livestock feed primarily for their high protein content. The crude protein contents for the grain legumes, shown in Tables 1a and 1b, differ considerably. The protein content of pea is about 20%. Faba bean has a higher protein concentration. Soybean and sweet white lupin (Table 1b) have the highest crude protein concentrations with more than 30%. However, it should be noted that the data are still uncertain for conventional soybean produced in Europe. According to Aulrich (2011), the farming system used (conventional/organic) does not influence crude protein content. Therefore, differences between production systems are not considered further here.

In addition to crude protein, fat, starch and sugar are of interest in pig feed due to the energy they provide. Faba bean and pea have high starch contents with practically no oil. In contrast, the oil content of sweet blue and white lupins, and especially soybean, is relatively high. This can limit the use of whole soybean in feeding. Therefore, soybean cake, with a residual fat content of no more than 10%, is more suitable as a feed. The oil extraction leads to increased concentration of the other ingredients - including the protein - in the cake.

In Tables 1a and 1b the content for essential minerals are shown for the above-mentioned feedstuffs. Faba bean and pea have rather low calcium contents. Lupin and soybean are at a medium level here. Whereas pea and sweet lupin have medium phosphorus contents, the phosphorus content of soybean is high. However, it should be noted that phosphorus is predominantly bound to the molecule phytin and is therefore only available to pigs to a limited extent.. In conventional pig feeding, phosphorus digestibility can be significantly improved by adding the enzyme phytase. This makes it possible to reduce the addition of mineral phosphorus in the feed mixtures. Grain legumes have very low low sodium contents.

Table 1a: Concentration of major value-determining constituents in pea and faba bean (mean contents and content ranges in g/kg at 88% Dry Matter (DM))

Ingredients	Pea (white flowering)		Faba bean (white / coloured flowering)	
Crude ash	33	25–50	35	28–42
Crude protein	200	150–260	260	230–290
Crude fibre	57	50–70	86	50–100
Ether extract	13	10–20	14	10–20
Starch	430	350–500	390	330–430
Sugar	40	20–60	28	10– 40
NSP[1]	190		175	170–180
aNDFom[2]	100	80–120	135	100– 200
ADFom[3]	70	60–80	106	75– 130
Calcium	1.0	0.6–2.0	1.2	0.8– 1.6
Phosphorus	4.1	3.5–5.0	5.5	4.0– 7.0
Potassium	11.7	11.1–12.0	13.9	11.7– 14.7
Sodium	0.2	0.1–0.3	0.2	0.1– 0.4
Magnesium	1.3	1.2– 1.5	1.4	1.1– 1.8
Lysine	15.0	12.0–18.0	16.3	13.6–18.6
Methionine	1.9	1.6–2.3	1.8	1.7–2.0
Cystine	2.5	2.3–2.8	3.4	
Threonine	7.9	6.8–9.0	8.9	8.5–10.0
Tryptophan	1.9	1.7–2.1	2.3	1.8–3.0

[1] NSP: non-starch polysaccharides

[2] aNDFom: Neutral detergent fibre after amylase pretreatment using ashing

[3] ADFom: acid-detergent fibre using ashing

Sources: UFOP 2015, Mitteilungen Bayerische Landesanstalt für Land- wirtschaft 2013 - 2015, Jeroch et al. 2016, DLG 2014

Table 1b: Concentration of major value-determining constituents in sweet lupin and soybean pea and (mean contents and content ranges in g/kg at 88% DM)

Ingredients	Sweet blue lupin		Sweet white lupin		Soybean (European)	
Crude ash	35	30– 50	35	30– 50	47	45– 53
Crude protein	289	180– 330	339	200– 350	340	250– 450
Crude fibre	140	110– 170	113		55	30– 80
Ether extract	56	42– 65	83		200	140– 240
Starch	(70)[1]	10– 150	(77)[1]		(52)[1]	20– 70
Sugar	50	20– 70	64		71	60– 90
NSP [2]	389		315		257	
aNDFom [3]	220	150– 240	167		130	100– 150
ADFom [4]	180	140– 240	128		90	70– 100
Calcium	2.5	2.0– 2.9	1.9	1.4–2.7	2.5	1.7– 3.3
Phosphorus	4.1	3.4– 4.9	4.8	3.3– 4.1	5.8	5.0– 7.0
Potassium	13.4		10.6	7.3–11.5	19.9	15.7– 23.9
Sodium	0.1		0.4	0.1–0.8	0.2	0.1– 0.4
Magnesium	1.7	1.5– 1.8	1.3	1.4– 1.8	2.5	2.1– 3.2
Lysine	14.0	11.5– 14.6	15.9		21.8	17– 29
Methionine	1.8	1.7– 2.1	2.0		4.8	4.6– 5.1
Cysteine	4.4		5.0		5.0	4.7– 5.6
Threonine	10.5	9.0– 11.5	11.9		13.4	13.0– 14.0
Tryptophan	2.4	2.3– 2.7	2.7		4.8	2.8– 6.4

[1] Starch, measured by the polarimetric method, which also includes non-starch components.
[2] NSP: non-starch polysaccharides
[3] aNDFom: Neutral detergent fibre after amylase pre-treatment and ashing
[4] ADFom: acid-detergent fibre after ashing

Sources: UFOP 2015, Mitteilungen Bayerische Landesanstalt für Landwirtschaft 2013 - 2015, Jeroch et al. 2016, DLG 2014, Zuber et al. 2019

Secondary phytochemicals

So-called secondary compounds - mainly tannin, but also protease inhibitors, lectins and saponins - are found in grain legumes. A pronounced genetic influence is evident. For example, coloured-flowering faba bean and pea cultivars have higher tannin contents, while white-flowered cultivars have lower tannin contents. In high concentrations, these substances can inhibit animal metabolism and reduce feed intake and nutrient digestibility. Mechanical and thermal treatment processes can reduce the content of secondary ingredients.

Trypsin inhibitors are particularly significant in soybean and its products. These substances can inhibit the action of the protein-cleaving enzyme trypsin in the small intestine. Thermal inactivation of the trypsin inhibitors is necessary prior to feeding soybean and its processed products to monogastric animals (pigs and poultry). However, thermal treatment can damage the protein. A compromise must therefore be found between the positive effects (elimination of growth-inhibiting substances and enzymes that impair shelf-life, gentle denaturation of the protein bodies) and the onset of protein-damaging reactions. Even a slight excess of heat can impact on the sulphur-containing amino acids cysteine and methionine, and lysine, or reduce their content.

A number of simple analytical methods have been have been developed to verify whether the soybean have been properly heat-treated and that the feed is of high quality quality. These include the determination of urease activity, cresol red absorption, and protein solubility.

The direct determination of the trypsin inhibitor activity (TIA) can also be carried out according to the official A.O.C.S. method (1990). The inhibitor's activity is indicated in mg trypsin inhibitor per g crude protein (mg TI/g CP). This method is time-consuming and expensive. Therefore, the activity of another characteristic enzyme of the soybean, the enzyme urease, is measured as an indirect substitute. For optimally toasted soy products, the urease activity must be below 0.4 mg N/g/min. After reaching 100°C, the urease activity drops very quickly to low values whose variations are meaningless. Thus, the method identifies batches that include insufficiently heated grains.

The protein solubility in water (protein dispersibility index, PDI) is another common criterion for testing the effect of heat treatment. According to Naumann and Bassler (1988), an optimum range of 10 to 35% can be

assumed for soy products, whereby values in the range of 10 to 20% indicate overheating. It is remarkable that, especially for the range of overheating, no clear limit is defined. In addition to the protein solubility in water (PDI), the protein solubility in potassium hydroxide solution (KOH) is often determined as a further parameter. In studies, significantly lower growth rates were observed in broilers and fattening pigs when KOH solubility was lower than 72%. Soybean with high protein solubility in KOH had very good protein digestibility as long as the urease activity was in the recommended range. In studies, significantly lower gains were found in broilers and fattening pigs when KOH's solubility was lower than 72%. Soybeans with a high protein solubility in KOH had excellent protein digestibility as long as the urease activity was in the recommended range.

Feed value of grain legumes

In addition to the crude protein content, the nutritional quality and the metabolisable energy value resulting from the digestibility of the nutrients are important for the feed value. The protein quality for pigs is characterised by the content of the most important essential amino acids: lysine, methionine+cysteine, threonine and tryptophan. The digestibility of the amino acids is important. This is expressed as precaecal digestibility for pigs (Figure 1).

The amino acid contents are shown in Table 2. Faba bean, grain pea, and sweet lupin are rich in lysine and lack sulphur-containing amino acid methionine and cysteine. Tryptophan contents are also low in pea. Soybean and soybean cake have higher contents of the mentioned amino acids than the other grain legumes. In relation to the requirements of growing pigs, soy protein is also characterised by its low methionine content.

When calculating the ration, it is therefore imperative to compensate for this when using grain legumes. If we look at the amino acids' precaecal digestibility, we see that sweet lupin have similar feed values to those of soybean meal. This almost compensates for the slightly lower gross lysine value compared to the other grain legumes. Faba bean and pea fall short of requirements, especially in the sulphur-containing amino acids. The low content and low digestibility of these amino acids thus widen the supply gap for pigs.

In contrast to coloured-flowered faba bean, white-flowered faba bean are more suitable for monogastric animal feed due to their lower tannin content and, therefore, better digestibility. However, coloured-flowered faba bean has better agricultural properties and currently produce even higher yields.

When feeding complete soybeans, it must be ensured that they have been subjected to a heating process beforehand, as the antinutritive substances - especially the trypsin inhibitors - have a negative effect on digestibility.

In addition to the constituents, their digestibility (Figure 1) is decisive for the energetic feed value. While faba bean has the lowest energy content of 12.4 MJ/kg, pea has a significantly higher level due to the high starch content. The energy content of lupin is high due to the higher fat content. However, they are still surpassed by the soybean in ME content. Coloured faba bean has a lower energy content compared to the white-flowered.

Table 2: ME and Nutrient contents of the major grain legumes for pigs (per kg, 88% DM)

Item		Pea (white)	Faba bean (white/coloure)	Sweet blue lupin	Sweet white lupin	Soybean (toasted)
Metabolisable energy	MJ	13.3	12.4	13.5	14.2	15.9
Crude protein	g	200	260	289	339	340
Lysine	g	15.0	16.3	14.0	15.9	21.8
pcd[1] lysine	g	12.6	13.4	12.2	13.0	17.4
Methionine	g	1.9	1.8	1.8	2.0	4.8
pcd methionine	g	1.4	1.2	1.5	1.5	3.7
Cysteine	g	2.5	3.4	4.4	5.0	5.0
pcd cysteine	g	1.7	2.1	3.9	3.8	3.8
Threonine	g	7.9	8.9	10.5	11.9	13.4
pcd threonine	g	5.9	6.7	8.7	9.3	9.9
Tryptophan	g	1.9	2.3	2.4	2.7	4.8
pcd tryptophan	g	1.3	1.5	2.0	2.3	3.6

[1] pcd: precaecal digestibility

Sources: UFOP 2015, Mitteilungen Bayerische Landesanstalt für Landwirtschaft, Jeroch et al. 2016, DLG 2014, Sauvant et al. 2004.

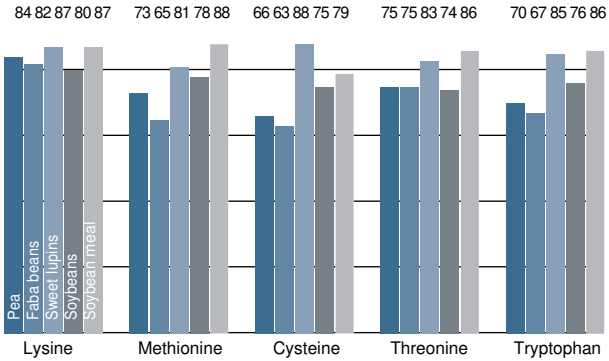

Figure 1: Digestibility of essential amino acids of grain legumes (The data for soybean refer to heat-treated soybean)

Sources: DLG 2014, Jeroch et al. 2016, Mosenthin et al. 2012

The quality of the soybean oil deserves mention. This is particularly important when it is fed as a whole bean to fattening pigs.

Table 3: Fatty acid profiles of vegetable oils (mean proportions in %)

Fatty acids	Soybean	Rapeseed	Sunflower	Linseed	Palm	Coconut
Saturated fatty acids						
Sum C8-C14					1.5	83
Palmitic acid (C16)	6.5	7	8	5.9	45	7
Stearic acid (C18)	4.5	-	2	2.4	4.7	5
Unsaturated fatty acids						
Oleic acid (18:1)	27	61	16	21	39	5
Linoleic acid (18:2)	50	21	71	18	9	-
α-linolenic acid (18:3; ω-3)	8	11	1	50	0.3	-
Melting point, °C	-12	-13	-17	- 20	25– 35	23

Source: Durst et al., 2012

As presented in Table 3, soybean oil contains a high proportion of polyunsaturated fatty acids compared with other oils and fats used in feeding. Since the fat composition of the feed is reflected in the fat quality of the pig's body fat, the use of full-fat soybeans could result in soft and unstable fat in the carcass. This affects the meat quality.

Feeding trials

The increasing importance of grain legumes in pig production prompted the assessment of a range of currently-grown grain legumes in feeding trials (Table 4). Priority was given to trials with fattening pigs. Most of these trials tested increasing proportions of grain legumes in complete feed mixtures against a control mixture using soybean meal as the protein-rich ingredient.

Most studies investigated the feeding of pea. This is certainly due to the fact that pea is the most commonly grown grain legume in Germany. It was shown that inclusion of pea up to 30% did not result in reduced performance in fattening pigs. In two trials by Meyer et al. (2016b) and Weber et al. (2016), the use of peas even resulted in significantly better feed consumption compared to the control group supplied with soybean (extraction) meal.

Faba bean also showed no adverse effects on the fattening and slaughtering performance of the fattening pigs.

Meyer et al. (2016c) reported that this also applied to the use of sweet blue lupins, but this showed a slightly negative influence on the level of meat yield, which, was at a very high level overall.

Combinations of grain legumes with rapeseed extraction meal, as used in Weber et al. (2016), seem to be a good alternative. Further experiments are necessary to provide sufficiently precise recommendations for use.

There are no experiments from Germany on feeding pea and sweet lupin to weaners. Older studies from Italy and the USA clearly show that the inclusion of up to 20% peas in piglet rations do not lead to any performance loss. Preissinger et al. (2014) reported infereior performance in feeding weaners up to 6 and 8% inclusion of faba bean. In contrast, as Wetscherck et al. (2013) showed, soybeans can be used without hesitation up to 10% for weaners. Further trials are necessary to give support more precise recommendations for weaners.

Table 4: Feeding trials on the use of grain legumes in pig feeding

			Results				
Author	Grain legume	Pig groups	Input quantities[1] (%)	Daily gains (g/day)	Feed consumption (kg/day)	Feed conversion ratio (kg/kg)	LMC[5]/Index Points
Meyer et al. 2016a	Faba bean	Fattening pig	0	952	2.4	2.53	1.017
			15/20/25	952	2.4	2.53	1.006
Scholz et al. 2016	Faba bean	Fattening pig	0	910	2.29	2.47	0.932
			18/18/18	892	2.21	2.46	0.94
Meyer et al. 2016b	Pea	Fattening pig	8	996	2.71	2.73[a3]	1.005
			15/20/25	1017	2.68	2.63[b]	0.995
Heinze et al. 2015	Pea	Fattening pig	0	819	2.26	n.r.[4]	57.7
			15/20/25	822	2.37	n.r.	57.8
Weber et al. 2016	Pea	Fattening pig	0	912	2.50[a]	2.76[a]	59.5
			10/15/20	905	2.35[b]	2.61[b]	58.3
			10/20/30	886	2.30[b]	2.61[b]	59.3
			20/20/20[2]	894	2.31[b]	2.59[b]	58.3
Heinze et al. 2015	Pea	Fattening pig	0	917	2.53	2.8	57.9
			20/25/30	887	2.46	2.8	57.9
Meyer et al. 2016c	Sweet blue lupin	Fattening pig	0	967	2.48	2.57	1.022[a]
			15/20/20	975	2.5	2.56	1.011[b]
Wetschereck et al. 2013	Soy	Weaner rearing	0	596	n.r.	1.82	n.r.
			10	594	n.r.	1.86	n.r.
Preißinger et al. 2014	Faba bean	Weaner rearing	0	550	0.816	1.49	
			6/8	510	0.783	1.55	

[1] Proportions of grain legume in complete feed mixtures for fattening pigs for initial/middle/final fattening or in mixtures for weaner-rearing.
[2] In this ration, additional rapeseed extraction meal and faba bean were used, and soybean meal was omitted entirely.
[3] Differences statistically confirmed if unequal superscripts
[4] n.r.: not recorded
[5] LMC: lean meat content (in %)

Few trials have been carried out on sow feeding, due to the effort involved. However, recommendations can possibly be derived from results from fattening pigs as the requirements of fast-growing pigs are comparable to those of lactating sows.

Guidance for use

Grain legumes are well suited for feeding pigs. The production area, the direction and level of performance, and the possibilities, especially with amino acid supplementation, determine the proportions of grain legumes in the feed ration.

The recommendations compiled in Table 5 are based on literature data and practical experience and take into account the various animal and feed-specific aspects. They cover relatively wide decision-making ranges for the individual case to be carefully assessed. The quantities to be used must also consider whether different grain legumes are used in the feed ration at the same time. In particular, it must be ensured that there is no deficiency in the supply of methionine + cysteine.

Table 5: Recommendations for the use of grain legumes in pig feeding (maximum mixture proportions for complete feed mixtures, in %)

Pig groups		Pea white flowering	Sweet blue/ white lupin	Faba bean white flowering	Soybean	Soybean cake
Piglets	up to 20 kg	10		55	10	20
	from 20 kg	20			15	20
Fattening pigs	Beginning of fattening	20	15	15	152	15
	End of fattening	25[1]	20	25	102	15
Sows[2]	Pregnant[3]	8	8/6	8	6	5
	Lactating	20	10	15	20	20

[1] Limit for liquid feed because of foaming, in dry feed possibly even higher (up to 40 %).
[2] Empirical values, not yet sufficiently backed up by tests
[3] In organic feeding, higher values (up to 15%) are possible to cover the demand for essential amino acids.
In sows' gestation feed, the maximum possible proportion cannot usually be exhausted for energy and environmental reasons (reducing crude protein).

The nutritional limit for the inclusion of grain legumes in feed for pregnant dry sows is higher than the protein levels set for energy and environmental reasons. The choice of legume-based protein source is therefore not constrained.

In liquid feeding, the high swelling capacity of peas affects the consistency of the feed mix. From practical experience, if pea accounts for more than 25% of the feed dry matter, there is a risk that the resulting liquid feed cannot be pumped.

The use of full-fat soybean in pig fattening rations that have a high proportion of maize is limited by impacts on the quality of fat in the carcase. In summary, about half of the soybean, and a bit more in the case of sweet lupins, can be replaced by other grain legumes in pig rations. However, the low contents of the sulphur-containing amino acids methionine and cysteine must be considered, but free amino acids can easily be supplemented in the rations.

Economic value

Ultimately, the use of an ingredient in feed depends on the cost of the ingredient to the manufacturer of the feed compared with competing products. When calculating the economic value for feeding, grain legumes are usually compared with wheat (energy) and soybean meal (protein). For this purpose, the energy and lysine content of the compared feedstuffs is used, financially evaluated and compared with the contents of the grain legumes using the Löhr substitution method. This results in the following maximum prices for the grain legumes as determined by the market prices for wheat and soybean meal. Grain legumes that are traded below these prices can be included in the feed. If legume crop market prices are higher than that supported by this least-cost approach to ration formulation, then the crop producer will offer the crop to that market rather than have it included in feed.

Example: If wheat costs EUR 160/t and soybean meal EUR 300/t, pea may cost a maximum of EUR 228/t, lupins EUR 220 and faba beans EUR 223 to be considered in least-cost feed mixtures for pigs. However, these are only rough guide values. To check the economic viability of using a grain legume in mixtures for one of the animal categories listed in Table 4, a specific mixture calculation should be carried out, taking into account further parameters (e.g., other essential amino acids, digestibility of essential amino acids) based on linear optimisation. An individual farm calculation, if necessary, taking into account other parameters should be carried out when necessary.

Table 6a:
Effect of wheat and soybean meal prices on value of pea (in EUR/t)

Wheat / Soybean meal	120 EUR	160 EUR	200 EUR
300 EUR	207	228	249
400 EUR	255	276	297
500 EUR	303	324	345

Table 6b:
sweet blue lupin (in EUR/t)

Wheat / Soybean	120 EUR	160 EUR	200 EUR
300 EUR	197	220	243
400 EUR	240	263	286
500 EUR	282	305	328

Table 6c:
Effect of wheat and soybean meal prices on the value of value of faba bean (in EUR/t)

Wheat / Soybean meal	120 EUR	160 EUR	200 EUR
300 EUR	207	223	240
400 EUR	260	276	292
500 EUR	313	329	345

Table 6d:
Effect of wheat and soybean meal prices on the value of value of toasted soybean[1] (in EUR/t)

Wheat / Soybean meal	120 EUR	160 EUR	200 EUR
300 EUR	274	292	310
400 EUR	348	266	384
500 EUR	421	439	457

[1] For raw soybeans, these values must be reduced to allow for the cost of toasting and transport (approx. 50-60 EUR).

The break-even values in Tables 6a-d were determined using energy and lysine contents. However, since the methionine content of pea, faba bean and sweet lupin is significantly lower than in soybean meal, the value is reduced by approx. 15-20 EUR/t to compensate for the cost of the supplementary crystalline methionine required (at prices for crystalline methionine of 5 EUR/kg).

Example formulations

Tables 7-10 show examples of feed formulas with grain legumes for breeding sows, young pigs and fattening pigs. The values for white-flowering pea, faba bean and sweet blue lupin were taken into account. Of course, many other formulas are conceivable, also as a combination of several grain legumes. Rapeseed meal is included as an important component. This can partly compensate for the low content of methionine in the grain legumes.

The price of the individual components always plays a decisive role in the calculation of such rations. As these are often very volatile, a ration calculation must always be carried out before deciding to include a grain legume, individually adapted to the components used on the farm (constituents and prices).

Table 7: Use of grain legumes in complete feed mixtures for pregnant sows

Feedstuff		A	B	C	D	E	F	G	H	I	J	K	L
Pea	%	5	5	8	--	--	--	--	--	--	--	--	--
Faba bean	%	-			5	5	7	--	--	--	--	--	--
Sweet lupin		--	--	--	--	--	--	4	4	7	--	--	--
Soybean		--	--	--	--	--	--	-	--	--	3	3	4
Barley	%	47.5	32.5	29.5	47.5	28.5	30.5	53.5	29.5	35.5	54.5	39.5	43.5
Wheat	%	25	40	40	25	44	40	20	44	35	20	35	30
Apple pomace	%	6			6			6			6		
Soy hulls	%	6			6			6			6		
Dried pulp	%	6			6			6			6		
Wheat bran	%	2			2			2			2		
Fibre mix (20% XF)[1]	%		14	20		14	20		14	20			
Grass cobs	%		6			6			6				
Mineral feed[2]	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Analysed ingredients (per kg)													
ME	MJ	12.1	12.0	12.1	12.0	12.0	12.0	12.0	12.0	12.0	12.1	12.0	12.0
Crude protein	g	116	119	117	118	122	120	119	123	124	118	121	119
Crude fibre	g	70	70	70	70	70	70	72	70	70	70	70	70
Lysine	g	6.2	6.0	6.1	6.3	6.1	6.1	6.2	6.0	6.1	6.3	6.1	6.1
M+C	g	4.2	4.2	4.1	4.3	4.3	4.1	4.3	4.3	4.3	4.4	4.4	4.3
Threonine	g	4.1	4.1	4.0	4.1	4.1	4.0	4.2	4.2	4.2	4.2	4.2	4.1
Tryptophan	g	1.4	1.4	1.3	1.4	1.4	1.3	1.4	1.4	1.4	1.4	1.5	1.4
pcd Lys[3]	g	4.9	4.7	4.9	4.9	4.8	4.8	4.9	4.7	4.9	4.9	4.7	4.8
pcd M+C	g	3.3	3.3	3.2	3.3	3.4	3.2	3.4	3.4	3.3	3.4	3.4	3.2
pcd Thr	g	3.0	3.0	3.0	3.1	3.1	3.0	3.1	3.1	3.2	3.1	3.1	3.0
pcd Trp	g	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0
Calcium	g	6.9	6.3	6.2	6.9	6.4	6.3	7.0	6.4	6.4	6.9	6.4	6.3
Phosphorus	g	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.6	3.5	3.6	3.5

[1] XF: Crude fibre.
[2] For all mixture examples: Mineral feed with 20% Ca, 1% P and supplementation with amino acids (Lys, Met, Thr) and phytase.
[3] pcd Lys: precaecally digestible lysine; pcd M+C: precaecally digestible methionine and cysteine; pcd Thr: precaecally digestible threonine; pcd Trp: precaecally digestible tryptophan.

Table 8: Use of grain legumes in complete feed mixtures for lactating sows

Feedstuff		A	B	C	D	E	F	G	H
Pea	%	16	12	--	--	--	--	--	--
Faba bean	%	-	--	15	11	--	--	--	--
Sweet lupin	%	--	--	--	--	10	10		
Soybean	%	--	--	--	--	-	--	19	13
Soybean meal48	%	8	5	8.5	5	10	5	-	-
Rapeseed meal	%	--	5	--	5		5.5	-	5
Barley	%	37	25	37.5	20	41	30.5	53	29
Wheat	%	25	34	25	40	25	25	25	50
Grain maize	%	10	15	10	15	10	20	-	-
Rapeseed oil	%	1	1	1	1	1	1	-	-
Mineral feed	%	3	3	3	3	3	3	3	3
Analysed ingredients (per kg)									
ME	MJ	13.3	13.2	13.2	13.2	13.3	13.2	13.2	13.2
Crude protein	g	155	152	156	157	169	162	161	161
Crude fibre	g	37	38	37	40	42	45	40	39
Lysine	g	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
M+C	g	5.8	5.9	5.8	5.9	6	6.1	6.1	6.3
Threonine	g	6.3	6.2	6.3	6.3	6.4	6.5	6.2	6.4
Tryptophan	g	1.8	1.9	1.8	1.9	1.9	1.9	2.0	2.0
pcd Lys[1]	g	8.4	8.4	8.4	8.5	8.6	8.5	8.1	8.3
pcd M+C	g	4.9	5.0	4.9	5.0	5.1	5.1	5.0	5.3
pcd Thrg	g	5.3	5.1	5.3	5.2	5.4	5.4	5.0	5.2
pcd Trp	g	1.4	1.5	1.4	1.5	1.5	1.6	1.6	1.6
Calcium	g	7.3	7.6	7.4	7.7	7.6	7.8	7.5	7.7
Phosphorus	g	4.5	4.8	4.5	4.8	4.6	4.8	4.8	5.0
Content of the mineral supplement									
Calcium	%	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Phosphorus	%	3	3	3	3	3	3	3	3
Lysine	%	8	10	8	10	8	10	8	10
Methionine	%	3.0	2.5	3.0	2.5	2.5	2.5	2.5	2.5
Threonine	%	3.5	3.5	3.5	3.5	2.5	3.5	2.5	3.5
Tryptophan	%	-	0.5	-	0.5	-	0.5	-	
Phytase		+	+	+	+	+	+	+	+

[1] pcd Lys: prececally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pcd Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Table 9a: Grain legumes in feed for young pigs (10-20 kg live weight)

Feedstuff		A	B	C	D	E	F	G	H
Pea	%	5	5		-		-		-
Faba bean	%	-	-	5	5			-	
Sweet lupin						10	5	-	
Soybean								10	10
Soybean meal48	%	12.5	10	12.5	10	12	9.5	7.5	5
Rapeseed meal	%	-	5	-	5	-	5	-	5
Barley	%	51.5	40	47.5	35	54	36	53.5	36
Wheat	%	26	35	30	40	24	39.5	25	40
Rapeseed oil	%	1	1	1	1	1	1	0	0
Mineral feed	%	4	4	4	4	4	4	4	4
Analysed ingredients (per kg)									
ME	MJ	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	g	166	170	169	173	170	174	169	174
Crude fibre	g	37	39	37	40	40	42	38	40
Lysine	g	12.0	12.1	12.1	12.1	12.0	12.0	12.1	12.1
M+Cg	g	7.2	7.4	7.3	7.4	7.3	7.5	7.2	7.6
Threonine	g	7.7	7.8	7.7	7.9	7.8	7.9	7.8	7.9
Tryptophan	g	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.4
pcd Lys[1]	g	11.0	10.9	11.0	11.0	11.0	10.9	10.9	10.8
pcd M+C	g	6.3	6.4	6.4	6.4	6.4	6.5	6.2	6.5
pcd Thrg	g	6.6	6.7	6.7	6.8	6.7	6.8	6.7	6.8
pcd Trp	g	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Calcium	g	7.8	8.1	7.9	8.2	7.9	8.2	7.9	8.2
Phosphorus	g	4.7	5.0	4.7	5.0	4.7	5.0	4.8	5.2
Content of the mineral supplement									
Calcium	%	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Phosphorus	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	%	12	12	12	12	12	12	12	12
Methionine	%	5.0	4.5	5.0	4.5	5.0	4.5	4.5	4.5
Threonine	%	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Tryptophan	%	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Phytase		+	+	+	+	+	+	+	

[1] pcd Lys: prececally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pcd Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Table 9b: Use of grain legumes in feed for young pigs (20-30 kg live weight)

Feedstuff		A	B	C	D	E	F	G	H
Pea	%	5	5		-		-		-
Faba bean	%	-	-	5	5			-	
Sweet lupin	%					10	5	-	
Soybean	%	--	--	--	--	-	--	19	13
Soybean meal 48	%	9	6.5	11	8.5	11.0	8.0	6	3.5
Rapeseed meal	%	-	5	-	5		5	-	5
Barley	%	56.5	39	54.5	40	59.5	42	52.5	38
Wheat	%	20	35	25	37	20	35.5	28	40
Rapeseed oil	%	1	1	1	1	1	1	0	0
Mineral feed	%	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Analysed ingredients (per kg)									
MJ	ME	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	g	157	161	163	167	166	168	164	168
Crude fibre	g	39	41	38	40	41	43	38	40
Lysine	g	11.1	11.1	11.2	11.2	11.2	11.1	11.2	11.2
M+C	g	6.7	6.9	6.7	6.9	6.8	7.1	6.9	7.1
Threonine	g	7.1	7.2	7.2	7.2	7.4	7.4	7.3	7.3
Tryptophan	g	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.2
pcd Lys1	g	10.0	9.9	10.1	10.0	10.1	10.0	9.9	9.9
pcd M+C	g	5.8	5.9	5.8	6.1	5.9	6.1	5.9	6.0
pcd Thrg	g	6.1	6.2	6.2	6.3	6.3	6.4	6.2	6.1
pcd Trp	g	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.8
Calcium	g	6.9	7.2	7.0	7.3	7.0	7.3	7.0	7.3
Phosphorus	g	4.5	4.9	4.6	4.9	4.6	4.9	4.7	5.0
Content of the mineral supplement									
Calcium	%	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Phosphorus	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Lysine	%	12	12	12	12	12	12	12	12
Methionine	%	5.0	4.5	4.5	4.0	4.5	4.5	4.5	4.0
Threonine	%	5.5	5.5	5.5	5.0	5.5	5.5	5.5	5.0
Tryptophan	%	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5
Phytase		+	+	+	+	+	+	+	

[1] pcd Lys: prececally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pcd Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Table 10a: Use of grain legumes in whole feed mixtures for fattening pigs (30-60 kg live weight)

Feedstuff		A	B	C	D	E	F	G	H
Pea	%	15	20	-	-	-	-	-	-
Faba bean	%	-	-	15	15	-	-	-	-
Sweet lupin	%	-	-	-	-	15	15	-	-
Soybean	%	-	-	-	-	-	-	10	10
Soybean meal48	%	5	7	5	9	4	9	3	8,5
Rapeseed meal	%	10	-	10	-	10	-	10	-
Barley	%	10	40	-	28	15	43	20	58,5
Wheat	%	32	30	17	45	33	30	54	20
Rapeseed oil	%	25	-	50	-	20	-	-	-
Mineral feed	%	3	3	3	3	3	3	3	3
Analysed ingredients (per kg)									
ME	MJ	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	g	167	160	168	172	183	181	177	170
Crude fibre	g	42	39	42	39	52	48	45	39
Lysine	g	10.5	10.5	10.5	10.7	10.5	10.7	10.5	10.7
M+C	g	6.5	6.3	6.3	6.5	6.6	6.5	6.4	6.3
Threonine	g	6.9	6.7	7.0	6.9	7.1	7.0	6.8	6.8
Tryptophan	g	1.9	1.8	1.7	2.0	2.0	2.0	2.2	2.1
pcd Lys1	g	9.2	9.3	9.1	9.5	9.3	9.7	9.1	9.4
pcd M+C	g	5.4	5.4	5.5	5.6	5.5	5.5	5.4	5.2
pcd Thrg	g	5.7	5.6	5.7	5.9	5.9	5.9	5.5	5.7
pcd Trp	g	1.5	1.4	1.4	1.6	1.6	1.6	1.7	1.7
Calcium	g	6.8	6.2	6.8	6.3	7.0	6.5	6.9	6.3
Phosphorus	g	4.7	4.0	4.6	4.0	4.7	4.1	4.8	4.2
Content of the mineral supplement									
Calcium	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Phosphorus	%	1	1	1	1	1	1	1	1
Lysine	%	10	10	10	10	10	10	10	10
Methionine	%	2.5	4.5	2.5	4.5	2	3.5	0.5	2.5
Threonine	%	3.5	4.5	3.5	4.5	3	3.5	2.5	3.5
Phytase		+	+	+	+	+	+	+	+

[1] pcd Lys: prececally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pcd Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Table 10b: Use of grain legumes in complete feed mixtures for fattening pigs (60-90 kg LM)

Feedstuff		A	B	C	D	E	F	G	H
Pea	%	20	20	-	-	-	-	-	-
Faba bean	%	-	-	20	20	-	-	-	-
Sweet lupin	%	-	-	-	-	20	20	-	-
Soybeans	%	-	-	-	-	-	-	10	10
Soybean meal 48	%	-	4	-	4	-	3	-	5
Rapeseed meal	%	10	--	10	--	8	--	11	-
Barley	%	12.5	43.5	-	18.5	24.5	49.5	22.5	62.5
Wheat	%	30	30	17.5	55	25	25	54	20
Grain maize	%	25	--	50	--	20	--	-	-
Mineral feed	%	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Analysed ingredients (per kg)									
ME	MJ	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	g	153	149	157	162	173	169	169	157
Crude fibre	g	43	40	45	40	56	53	44	40
Lysine	g	9.3	9.3	9.3	9.5	9.4	9.3	9.4	9.3
M+C	g	5.9	5.8	5.8	5.9	6.0	5.9	6.2	5.8
Threonine	g	6.2	6.0	6.3	6.2	6.6	6.3	6.3	6.2
Tryptophan	g	1.6	1.7	1.5	1.8	1.7	1.8	2.1	2.0
pcd Lys1	g	7.9	8.0	7.9	8.3	8.2	8.3	8.0	8.0
pcd M+C	g	4.9	4.9	4.8	5.1	5.0	5.0	5.1	4.8
pcd Thrg	g	5.0	5.0	5.1	5.2	5.4	5.2	5.1	5.0
pcd Trp	g	1.3	1.3	1.2	1.4	1.4	1.4	1.6	1.5
Calcium	g	5.8	5.2	5.8	5.3	6.0	5.5	6.0	5.4
Phosphorus	g	4.5	3.9	4.4	3.8	4.4	3.9	4.8	4.1
Content of the mineral supplement									
Calcium	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Phosphorus	%	1	1	1	1	1	1	1	1
Lysine	%	10	10	10	10	10	10	10	10
Methionine	%	2.5	4.5	2.5	4.5	2	3.5	0.5	2.5
Threonine	%	3.5	4.5	3.5	4.5	3	3.5	2.5	3.5
Phytase		+	+	+	+	+	+	+	+

[1] pcd Lys: preaecally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pcd Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Table 10c: Use of grain legumes in complete feed mixtures for fattening pigs (90-120 kg LM)

Feedstuff		A	B	C	D	E	F	G	H
Peas	%	20	25	-	-	-	-	-	-
Faba beans	%	-	-	20	25	-	-	-	-
Sweet lupins	%	-	-	-	-	20	20	-	-
Soybeans	%	-	-	-	-	-	-	5	5
Soybean extruded meal 48	%	-	--	--	--	-	--	-	6,5
Rapeseedextr. meal	%	4	--	6	--	3	--	12,5	-
Barley	%	34	43	14	15	45	43	18,5	61,5
Wheat	%	25	30	23	58	20	30	62	25
Grain maize	%	15	--	35	--	10	--	-	-
Mineral feed	%	2	2	2	2	2	2	2	2
Analysed ingredients (per kg)									
ME	MJ	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Crude protein	g	140	138	151	155	162	158	160	150
Crude fibre	g	41	41	44	42	55	53	43	39
Lysine	g	8.2	8.3	8.5	8.6	8.4	8.1	8.2	8.3
M+C	g	5.2	4.8	5.4	5.4	5.4	5.5	6.1	5.6
Threonine	g	5.4	5.2	5.7	5.7	5.9	5.7	5.9	5.7
Tryptophan	g	1.5	1.5	1.5	1.6	1.6	1.6	2.0	1.9
pcd Lys1	g	6.9	7.0	7.1	7.4	7.3	7.1	7.0	7.1
pcd M+C	g	4.3	4.0	4.4	4.6	4.5	4.6	5.0	4.6
pcd Thrg	g	4.3	4.2	4.6	4.7	4.8	4.7	4.7	4.7
pcd Trp	g	1.2	1.1	1.2	1.3	1.3	1.3	1.6	1.5
Calcium	g	4.5	4.2	4.7	4.4	4.8	4.6	5.2	4.4
Phosphorus	g	4.0	3.8	4.1	3.7	4.0	3.8	4.8	3.9
Content of the mineral supplement									
Calcium	%	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Phosphorus	%	1	1	1	1	1	1	1	1
Lysine	%	10	10	10	10	10	10	10	10
Methionine	%	2.5	4.5	2.5	4.5	2.5	3.5	0.5	2.5
Threonine	%	3.5	4.5	3.5	4.5	3.5	3.5	2.5	3.5
Phytase		+	+	+	+	+	+	+	+

[1] pcd Lys: prececally digestible lysine; pcd M+C: prececally digestible methionine and cysteine; pdv Thr: prececally digestible threonine; pcd Trp: prececally digestible tryptophan.

Use in organic pig production

Attention must be paid to the supply of amino acids, especially methionine, in feeding pigs to requirements. This can be difficult in organic farming because supplies of suitable methionine-rich ingredients are limited. This results in the particularity that the inclusion of grain legumes in organic pig feeding are more constrained than under conventional feeding conditions. Due to the relatively low methionine content of grain legume protein, soybean cake, the preferred feed for pigs, should be combined with protein feeds rich in methionine, such as partially dehulled sunflower cake. In this way, high crude protein contents in the feed mixtures can be avoided.

Exemplary feed mixtures for the organic feeding of sows and fattening pigs can be found in Tables 11 and 12.

Table 11: Feed mixtures for sows (100% organic feeding; mix proportions in %)

Feedstuff	Breeding sows pregnant*	Breeding sows pregnant*	Breeding sows suckling	Breeding sows suckling
	(12.0 MJ ME/kg)		(13.0 MJ ME/kg)	
Soybean cake, heat-treated	.	4.0	15.0	20.0
Sunflower cake, partially dehulled	.	.	6.5	4.0
Faba bean	17.0	8.0	15.0	8.0
Barley	81.0	86.0	31.0	33.0
Wheat	.	.	30.0	32.5
Mineral feed (22/8/5)	1.3	1.3	2.2	2.2
Carbonated feed lime	0.7	0.7	0.3	0.3
(Clover grass silage)	XX	XX	(X)	(X)

* and XX: Combined feeding; (X): Clover grass silage as roughage source; the possible nutrient supply is not considered.

Table 12: Feed mixtures for fattening pigs (100% organic feeding, 750 g daily gain; mixture proportions in %)

Feedstuff	Beginning of fattening (up to 70 kg; 13.0 MJ ME/kg)	End of fattening (from 70 kg; 12.6 MJ ME/kg)
Soybean cake, heat-treated	20.0	10.0
Sunflower cake, partially dehulled	5.0	2.3
Peas	10.0	
Faba beans		13.0
Barley	32.0	58.0
Triticale	30.0	15.0
Mineral feed (17/2/5)	3.0	1.3
Carbonated feed lime		0.4
(clover grass silage)	(X)	X

(X): Clover grass silage as roughage source; the possible nutrient supply is not taken into account.

Conclusions

Pea, faba bean, sweet lupin and domestically grown soybean are well suited for pig feeding. This applies to both conventional and organic production. The medium to high protein and high energy content of these grain legumes contribute to this.

When feeding, however, attention must be paid to the relatively low content of the essential amino acid methionine. Supplementation using an adapted mineral feed highly endowed with methionine may be required. If the grain legumes are combined with the methionine-rich rapeseed extraction meal, less crystalline methionine needs to be used. Under the conditions of organic farming, supplementation with free methionine is prohibited. Here, the complementary effects of methionine-rich proteins (e.g., sunflower cake) should be used.

The latest studies on antinutritional substances in modern grain legume varieties do not indicate any impairment of animal performance if the recommended maximum quantities are observed. If grain legumes are fed on the farm, varieties low in these substances should nevertheless be used in cultivation.

When using full-fat soybean, care must be taken to ensure sufficient heating to reduce the trypsin inhibitor present. In addition, when used in pig fattening, attention must be paid to the high proportion of unsaturated fatty acids, which can negatively affect the fat quality of the pig. A combination with high maize content should therefore be avoided as far as possible.

Imprint
Union for the Promotion of Oil and Protein Plants e. V.
Claire-Waldoff-Straße 7 · 10117
Berlin info@ufop.de · www.ufop.de

2. updated edition 2020

Cover photo: UFOP/Baer,
UFOP/Habbe

This publication was translated within the Legumes Translated project funded by the European Union through Horizon 2020, Project Grant Number 817634.

Translation: Donal Murphy-Bokern

The original report in German can be found here: www.ufop.de/medien/downloads/agrar-info/praxisinformationen/tierernaehrung/