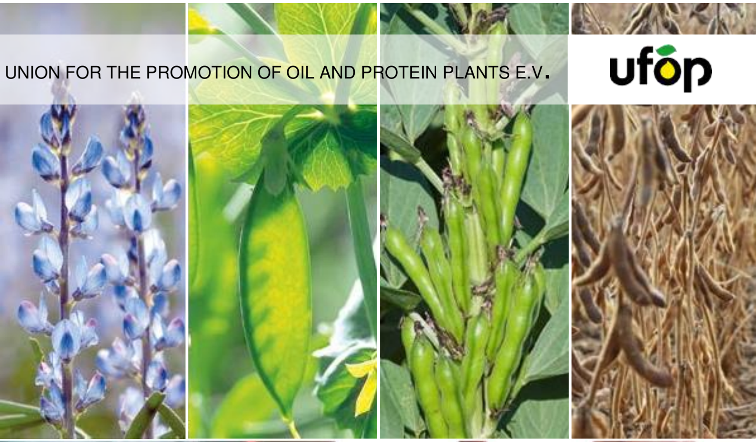
UNION FOR THE PROMOTION OF OIL AND PROTEIN PLANTS E.V.



UFOP PRACTICE INFORMATION

Faba bean, grain pea, sweet lupin and soybean in poultry feeds

Authors

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

PD Dr Ingrid Halle
Friedrich Loeffler Institute Braunschweig

Prof. Dr Markus Rodehutscord
University of Hohenheim

Contents

Introduction

Grain legumes have long been considered valuable crops in agriculture. In addition to providing a break in cereal-based crop rotations, they make an important contribution to the regenerative N supply in arable farming through their ability to fix nitrogen 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. They broaden 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 composition, feeding value, and possible uses of grain legumes in poultry feed. In particular, the results of feeding trials over the last ten years are considered. For faba bean, both white-flowered and coloured-flowering varieties are considered. For pea, the focus is on white-flowered varieties. These dominate the market and are particularly suitable for poultry feed. Sweet blue lupin and white lupin are also considered. Currently, the sweet yellow lupin is not grown. However, due to its nutrient composition, the yellow lupin could become attractive again for poultry feed in the future. Full-fat soybean and soybean cake are the most important feedstuffs from domestic (European) soybean cultivation.

Constituents of grain legumes

Constituents that determine feeding value

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 cause differences in crude protein content. Therefore, differences between production systems are not considered further here.

In addition to crude protein, crude fat, starch and sugar are of interest in poultry 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 lupin, 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.

Significant mineral contents (quantitative elements) are shown for the feedstuffs mentioned above In Tables 1a and 1b,

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)

Feature		Pea (white flowering)		Faba bean (white / coloured flowering)	
Crude ash	G	33	25–50	35	28–42
Crude protein	G	200	150–260	260	230–290
Crude fibre	G	57	50–70	86	50–100
Crude fat	G	13	10–20	14	10–20
Starch	G	430	350–500	390	330–430
Sugar	G	40	20–60	28	10– 40
NSP[1]	G	190		175	170–180
aNDFom[2]	G	100	80–120	135	100– 200
ADFom[3]	G	70	60–80	106	75– 130
Calcium	G	1.0	0.6–2.0	1.2	0.8– 1.6
Phosphorus	G	4.1	3.5–5.0	5.5	4.0– 7.0
Potassium	G	11.7	11.1–12.0	13.9	11.7– 14.7
Sodium	G	0.2	0.1–0.3	0.2	0.1– 0.4
Magnesium	G	1.3	1.2– 1.5	1.4	1.1– 1.8
Lysine	G	15.0	12.0–18.0	16.3	13.6–18.6
Methionine	G	1.9	1.6–2.3	1.8	1.7–2.0
Cystine	g	2.5	2.3–2.8	3.4	
Threonine	g	7.9	6.8–9.0	8.9	8.5–10.0
Tryptophan	g	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-Monitoring 2015, Mitteilungen Bayerische Landesanstalt für Landwirtschaft 2013-2015, Jeroch et al. 2016, DLG-Futterwerttabellen Schweine 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% dry matter)

Feature		Sweet blue lupin		Sweet white lupin		Soybean (European)	
Crude ash	g	35	30–50	35	30–50	47	45–53
Crude protein	g	289	180–330	339	200-350	340	250–450
Crude fibre	g	140	110–170	113		55	30–80
Crude fat	g	56	42–65	83		200	140–240
Starch	g	(70)[1]	10–150	(77)[1]		(52)[1]	20–70
Sugar	g	50	20–70	64		71	60–90
NSP2	g	389		315		257	
aNDFom[3]	g	220	150–240	167		130	100–150
ADFom[4]	g	180	140–240	128		90	70–100
Calcium	g	2.5	2.0–2.9	1.9	1.4–2.7	2.5	1.7–3.3
Phosphorus	g	4,1	3.4–4.9	4.8	3.3–4.1	5.8	5.0–7.0
Potassium	g	13.4		10.6	7.3-11.5	19.9	15.7–23.9
Sodium	g	0.1		0.4	0.1–0.8	0.2	0.1–0.4
Magnesium	g	1.7	1.5–1.8	1.3	1.4–1.8	2.5	2.1–3.2
Lysine	g	14.0	11.5-14.6	15.9		21.8	17–29
Methionine	g	1.8	1.7–2.1	2.0		4.8	4.6– 5.1
Cystine	g	4.4		5.0		5.0	4.7–5.6
Threonine	g	10.5	9.0–11.5	11.9		13.4	13.0–14,0
Tryptophan	g	2.4	2.3–2.7	2.7		4.8	2.8–6.4

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

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

Faba bean and pea have relatively low calcium contents, while lupin and soybean contain medium levels. The phosphorus content of faba bean and soybean are higher than in pea, and sweet lupin have medium phosphorus contents. However, it should be noted that phosphorus is predominantly bound to phytin, and therefore the availability to poultry is limited. The addition of the enzyme phytase can significantly improve phosphorus digestibility allowing reductions in the added phosphorus. Grain legumes have very low sodium contents.

Secondary plant compounds

So-called secondary constituents - mainly tannins, but also protease inhibitors, lectins and saponins – are present in grain legumes. Levels are strongly influenced by genetics (variety). For example, dark-flowered faba bean and pea varieties have higher tannin contents compared to white-flower varieties. In high concentrations, these substances can inhibit animal metabolism and reduce feed intake and nutrient digestibility. The content of secondary substances can be reduced by mechanical and thermal treatment.

The glucosides vicin and convicin must also be taken into account in the feeding of faba bean to laying hens. Vicin and convicin are inside the seed and are relatively heat-resistant. Neither de-hulling the seeds nor heat treatment removes these antinutritive substances.

The trypsin inhibitors are particularly significant for soybean. These substances can inhibit the action of the protein-cleaving enzyme trypsin in the small intestine. It is necessary to inactivate them using heat before feeding soybean and its processed products to monogastrics (pigs and poultry). However, heat treatment also carries the risk of reducing the nutritional value of protein through denaturation. Therefore, a compromise between the positive effects (elimination of growth-inhibiting ingredients and enzymes, gentle denaturation of the anti-nutritional components) and the onset of protein-damaging reactions is the goal. Even a slight excess of heat can damage the sulphur-containing amino acids cysteine, methionine and lysine.

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 gains were found in broilers and fattening pigs when KOH solubility was lower than 72%. Soybeans with high protein solubility in KOH had very good protein digestibility as long as the urease activity was in the recommended range.

Feed value

In addition to the crude protein content, the nutritional quality and the energetic feed value resulting from the digestibility of the nutrients are important for the feed value. The protein quality for poultry is characterised by the content of the most important essential amino acids; lysine, methionine + cysteine, threonine and tryptophan. In addition, the digestibility of the amino acids is important. This varies between amino acids and between different grain legumes (Table 2).

The crude protein content and thus the total content of the amino acids clearly distinguish pea, faba bean from soybean meal (44% crude protein). Pea and faba bean contain significantly less crude protein and, therefore, also less amino acid than soybean meal. However, the amino acid profiles within the protein are similar. The sulphur-containing amino acids (methionine and cysteine), which are particularly important for poultry, are an exception. These are lower in pea, faba bean and lupin. A balance must be achieved when using grain legumes, especially for the sulphur-containing amino acids, to cover animals' requirements.

A compilation of available data on the digestibility of amino acids shows a relatively high level of amino acid digestibility overall (Fig. 1). Lupin and pea hardly differ from soybean meal in terms of the digestibility of lysine. The digestibility of threonine is also not lower in lupin and pea compared soybean meal. However, faba bean, for which there are very few trials, shows a lower level of amino acid digestibility. The digestibility values for whole soybean shown in Figure 1 only apply if the soybeans have undergone a heating process prior to feeding. If soybeans are not heated, the amino acids are only digestible to a significantly smaller extent in a lower proportion for poultry. Soybean that is not heat-treated is not suitable for feeding.

Table 2: Nutrient contents of the major grain legumes for poultry (per kg, 88% dry matter)

Feature		Pea (white)	Faba bean (white/ coloured)	Sweet blue lupin	Sweet white lupin	Soybean (toasted)
Energy AME_N [1]	MJ	11.8	10.7	8.0	110.1	13.6
Crude protein	g	200	260	289	339	340
Lysine	g	15.0	16.3	14.0	15.9	21.8
Lys. digestible	g	13.2	13.0	12.5	14.6	18.5
Methionine	g	1.9	1.8	1.8	2.0	4.8
Meth. digestible	g	1.5	1.4	1.5	1.8	4.1
Cystine	g	2.5	3.4	4.4	5.0	5.0
Cyst. digestible	g	1.8	2.0	3.7	4.8	3.8
Threonine	g	7.9	8.9	10.5	11.9	13.4
Thre. digestible	g	6.2	6.2	9.1	11.2	10.7
Tryptofan	g	1.9	2.3	2.4	2.7	4.8
Trypt. digestible	g	1.4	1.6	2.0	2.2	3.8

[1] AME_N according to WPSA formula (analysed starch contents - see Table 1b – were taken into account).

Sources: Adedokun et al. 2008; Bryden et al. 2009; Jeroch et al. 2016; Kluth et al. 2005; Kluth and Rodehutscord 2006; Rezvani et al. 2008a, b; UFOP projects; Valencia et al. 2009, Sauvant et al. 2004

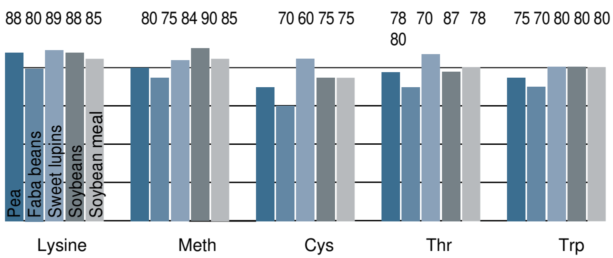


Figure 1. Mean digestibility of selected amino acids of grain legumes (pea, faba bean, sweet lupin, soybean, and soybean) and soybean meal (The data for soybean refer to heat-treated soybean)

Sources: Adedokun et al. 2008; Bryden et al. 2009; Kluth et al. 2005; Kluth and Rodehutscord 2006; Rezvani et al. 2008a, b; UFOP projects; Valencia et al. 2009

The nitrogen-corrected apparent metabolisable energy (AME_N) is used to assess the energy feed value for poultry. The digestibility is decisive in addition to the contents. While lupin has comparatively low contents at 8.1 to 10.1 MJ/kg due to the relatively high content of fibre, the AME_N contents of pea and faba bean are higher at 11.8 MJ and 10.7 MJ/kg, respectively (Table 2). Whole soybean contains considerably more AME_N than the other grain legumes and also more than soybean meal (9.9 MJ/kg) mainly due to the fat in the soybeans. The fat content and fatty acid profiles have a direct influence on the composition of body fat when using oilseeds in feed rations for poultry. Soya oil (fat) contains a significantly higher proportion of polyunsaturated fatty acids, as shown in Table 3, compared to other oils and fats used in feeding. Since the fat composition of the feed affects the fat quality of the body fat, the use of whole soybean can result in excessively soft and unstable fat in the carcass. This affects the meat processing.

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

Fatty acids	Soyabean	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)	48	11	1	50	0.3	-
Melting point, °C	-12	-13	-17	-20	25–35	23

Source: Durst et al., 2012

Trials

Laying hens

Only a few feeding trials have looked at different grain legumes for feeding laying hens. Some older studies from 2004-2007 indicate that there is good potential for using pea included at 10-40% in complete feed for laying hens. Inclusion of 50% pea increased feed intake but not performance. A more recent study (Laudadio and Tufarelli 2012) looked at completely replacing soybean meal in complete feed mixtures using 30% de-hulled and micronised pea. No differences in laying performance were observed between the control and the pea-fed group in the ten-week trial (week 18 to 28 of life).

Testing of the use of sweet blue lupin as a substitute for soybean meal at levels of 15% and 25% in complete feed mixtures (CFM) for laying hens showed that even 15% lupin tended to have a negative effect on feed intake and thus on the performance of the hens (Hammershoj and Steenfeldt 2005). Inclusion of 25% lupin reduced the daily feed intake of the hens by 20%, and as a result, the performance (laying performance, egg weight, egg mass production, feed conversion) declined significantly. In another study, de-hulled and micronised lupin was included at 18% replacing soybean meal (Laudadio and Tufarelli 2011). Despite the refining of the lupin, the 18% inclusion in the whole feed led to a significantly reduced feed conversion efficiency.

Two faba bean varieties (Condor, Divine) differing in the content of vicin and convicin were tested at the end of the laying period ($10^{th}/11^{th}$ month of laying) in mixture proportions of 0/5/10/20/30% (Dänner, 2003). Despite the higher content of these antinutritional substances in Condor, no differences in performance were found between the groups. In contrast, in another study, (Hall 2004) with hens at the beginning of the laying period (23-26 weeks of age), there was a decline in feed intake and performance characteristics with higher levels (20/30%) of conventional vicin and convicin-containing faba beans in the feed. In another ten-week (18-28 weeks of age) trial reported by Laudadio and Tufarelli (2010), 24% de-hulled and microised faba beans in the CFM substituting for soybean meal. Despite the treatment of the faba beans, the 24% content in the feed resulted in a reduced daily feed intake. Studies on laying hens (Halle 2015) showed that the combination of peas (35% mix) with rapeseed extraction meal (12%) as protein sources could completely replace soybean meal.

Broilers and turkeys

There are published studies on the use of faba beans in broiler production. The older data available are based on results with coloured-flowered (high tannin) faba beans. In these studies, animal protein sources were primarily used in the feed mixtures of the control and experimental groups. The relevance to contemporary feeding systems is limited. Jeroch et al. (1985) tested coloured and white-flowered (low-tannin) faba beans (up to 45% inclusion) in broiler mixtures based on maize, fishmeal, meat and bone meal and soybean meal. They found no differences to the control with respect to feed intake, growth, and carcass composition. In contrast, Meixner et al. (1983) found adverse effects on growth and carcass performance results in mixtures based on maize-soybean fish-meal, meat and bone meal, and yeast with about 20% faba beans (coloured-flowering) in the fattening feed. As a possible cause for the reduced performance, the authors discussed a suboptimal supply of methionine or sulphur-containing amino acids. For practical use, these authors recommend a maximum proportion of 10% faba beans.

Halle (2016) used increasing proportions (5%; 10%; 20%) of the coloured faba bean variety "Tiffany" (low in vicin and convicin) in complete feed mixtures for broiler production. Compared to the control with soybean meal as the sole protein supplement, there were no differences in feed intake with a simultaneous increase in final weight and improved feed input, even with a 20% inclusion of faba bean.

A number of recent studies have examined the use of pea for broilers. These were mainly carried out with white-flowered varieties. Richter et al. (2008) tested mixture proportions of up to 30% white-flowered pea in wheat-soybean mixtures. They found no adverse effects for either feed intake or growth performance parameters. Thacker et al. (2013) came to a similar conclusion. For maize-soybean mixtures, the partial replacement of soybean and maize with 30% pea resulted in the same fattening and slaughter performance. Both groups of authors and Halle (2016) conclude that 30% of pea in complete feed mixtures for broilers is possible. Weindl et al. (2016) tested combinations of pea and rapeseed extraction meal in exchange for soybean meal for broiler fattening. They concluded that a mixture of 20% pea and 15% rapeseed meal can be used in fast-growing Ross 308 broilers without any loss in performance if the complete feed mixtures are optimised to requirements using supplements, particularly using amino acid supplementation.

Roth-Maier and Paulicks (2003) used sweet blue and white lupin in broiler production. In each case, 20 or 30% were mixed into complete feed mixtures otherwise based on wheat-maize-soybean meal. Compared to the control, no significant impairment of fattening performance was observed. The authors recommend mixing proportions of 20% for both types of lupin. In contrast, Nalle et al. (2011) found that sweet blue lupin (10% in the starter feed, 15% in the growth feed and 25% in the final fattening feed) substituting for soybean meal resulted in a lower feed intake and consequently a delayed weight development. Therefore, they recommend not using lupin in the starter phase and incorporating them later up to a maximum of 15% together with sufficient supplementation with sulphur-containing amino acids. Jeroch et al. (2016) pointed out that the oligosaccharides found more abundantly in sweet lupin than in other legume species can trigger various antinutritional effects, especially in young chicks and/or when fed at higher rates. This can be problematic in today's highly productive fattening animals compared with earlier broiler breeds with lower growth rates.

European-grown soybean and soybean press cake is widely used in organic poultry production. Steiner and Bellof (2009) successfully used soybean press cake included at 20% in rearing mixtures and 15% in fattening mixtures for organic broiler (slow-growing genotype ISA J957).

Fattening turkeys have even higher protein and amino acid requirements compared to broilers. Thus, the use of protein alternatives must be considered particularly carefully. There are only a few recent reports on the use of grain legumes other than soybean in turkey fattening. Savage et al. (1986) used pea in the starter feed (up to 25% inclusion) and the finisher feed (up to 55% inclusion) for turkeys. They found no adverse effects on feed intake, growth and slaughter performance.

According to Mikulski et al. (2014) and Zdunćzyk et al. (2014), the inclusion of 18% sweet blue or yellow lupin soybean meal can partially replace soybean meal in complete feed mixtures for fattening turkeys from the 12th week of life. There were no disadvantages with respect to growth and carcass quality. Krawczyk et al. (2015) observed that the use of 16% sweet yellow lupin in starter rations (up to the 4th week of life) did not influence female turkey performance, whereas 24% lupin in the feed mixture reduced growth. In the second fattening period (5-8 weeks of life), compensatory growth was observed. The authors concluded that up to 24% lupin can be used in the complete feed mixtures from the 5th week of life without adverse effects on growth and carcass quality.

Heat-treated soybean press cake is a suitable protein feed for organic turkeys. Bellof et al. (2014) recommend a maximum of 20% for complete feed mixtures for rearing (up to 4 weeks of age) and a maximum mixing ratio of 15% from 16 weeks on.

Recommendations for use

Laying hens

Grain legumes are well suited for feeding laying hens. The possibilities of using them in rations for hens are improving in line with the progress in plant breeding and the lowering of antinutritional ingredients.

Safe use of faba beans in laying hens feed is only possible when low-vicin and low-convicin varieties are used. Of these varieties, up to 30% faba bean can be mixed into complete feed mixtures for laying hens. Faba bean with unknown contents of antinutritive substances

should be included at a maximum of 10% (Table 4).
In the studies presented, it was shown that hens could be fed with feed mixtures containing up to 40% pea without a negative effect on feed intake and laying performance. Increasing the pea content in the complete feed for laying hens reduces both the amount of soybean meal and cereals (e.g., wheat). However, more supplementary methionine is required. Therefore, it is recommended to limit the proportion of pea in complete feed mixtures for laying hens to 30% (white-flowered varieties; Table 4).

Based on the results of the studies presented and the recommendations of other authors (Jeroch et al., 2013 and 2016), it can be concluded that 10% is the upper limit in a mixture share for sweet lupin.

Table 4. Recommendations for maximum levels of grain legumes in complete feed mixtures for laying hens, broilers and turkeys

Legume species		Laying hens		Chickens for fattening (broilers)		Fattening turkeys		
		Egg production	Reproduction	Starter (until 4th WoL[1])	Fattening (from 4th WoL)	Rearing (P[2]1-2)	Fattening (P3-4)	Fattening (P5-7)
Faba bean	Coloured flowering	10	5	10	20	5/10	15	15
Faba bean	White-flowering	10	5	20	25	15	20	20
Pea	White flowering	30	30	25	30	10/20	30	25
Sweet blue/ white lupin	Low alkaloid	10	10	10	15	10/15	25	20
Soybean	Heat-treated	15	15	15	15	10	10	10
Soybean cake	Heat-treated <10% fat	20	20	20	320	20	20	15

[1] WoL: Week of life
[2] P: Phase
Sources: Bellof 2013; Bellof et al. 2013; Jeroch et al. 2016; Halle 2016; supplemented

Broilers and turkeys

The recommendations for using grain legumes in broiler and turkey production are provided in Table 4. A distinction should be made between coloured and white-flowered varieties when using faba bean. For coloured faba beans, lower maximum levels are recommended for both broilers and turkeys. This distinction is not necessary for peas, as almost only white-flowered varieties are available on the market.

Most organic soybean produced in Europe is used for organic poultry production. Soybean press cake is preferred over whole soybean for poultry feeding due to the lower fat content and the resulting lower intake of polyunsaturated acids. This is expressed in the higher use recommendations for broilers and turkeys (Table 4).

Formulations, feeding guidance and economic aspects

Laying hens

Table 5 provides examples of complete feed formulas for laying hens using a range of grain legumes. These proved successful in the above-mentioned studies when used, for example, for feeding lupin to laying hens. Pea can replace up to 40% of soybean meal. A lupin and faba bean mixture up to 20% can replace soybean meal. The pea-rapeseed meal combination can completely replace soybean meal.

Table 5. Complete feed formulas for laying hens (egg production) with pea, a combination of pea with rapeseed meal, sweet lupin and faba bean

Raw material	Unit	Pea[1]	Pea + rapeseed meal[2]	Sweet lupin[3]	Faba bean[4]
Pea	%	30.00	35.00		
Sweet blue lupin	%			10.00	
Faba bean	%				8.00
Rapeseed meal	%		12.00		
Soybean meal	%	11.60		10.00	13.77
Soybean meal (HP)[5]	%			1.60	
Wheat	%	40.40	34.64	35.00	61.96
Maize	%			15.00	
Bran	%			5.81	
Grass meal	%	2.00	3.60	3.65	2.00
Oil/fat	%	3.77	4.74	3.00/4.00	3.21
Calcium carbonate	%	8.64	7.63	8.24	8.52
Dicalcium phosphate	%	in premix	0.88	1.85	in premix
Sodium chloride	%		0.37	0.57	
Premix	%	3.40	1.00	1.00	2.50
L-lysine HCl	%			0.15	
DL-methionine	%	0.19	0.14	0.13	0.04

[1] Fru-Nij et al. 2007
[2] Hall (2015)
[3] Own calculation
[4] Fru-Nij et al. 2007
[5] 49% Crude protein

The recommendations for using individual grain legumes in feed mixtures for laying hens in organic farming do not differ in principle from the recommendations already mentioned.

It should be noted that when mixtures of grain legumes are used as protein carriers in organic farming, the proportions of undesirable or antinutritional substances (crude fibre, glucosides, tannins) from the various grain legumes can have an additive effect and thus negatively influence the feed intake, performance and health of the hens. Sometimes lesser-known legumes, such as vetch, are also used. Like faba bean, vetches contain the negatively acting glucosides vicin and convicin. Therefore, plant breeding is required to enable the safe use of vetch in hen feed. As long as there are no low-vicin and convicin vetches, it is necessary to analyse the glucoside content of batches and to design the ration accordingly.

Broilers and turkeys

Examples of complete feed mixtures for broilers and turkeys that include different grain legumes are shown in Tables 6 and 7. The feed mixtures for broilers shown in Table 6 are based on Aviagen specifications (2007) concerning energy, amino acid, mineral and active ingredient contents for the Ross 308 breed (target live final weight 2.0 - 2.5 kg). These mixtures were successfully used in the broiler feeding trial described above (Weindl et al., 2016). Measured using the "European Efficiency Factor" (EEF), which is economically significant for poultry rearing, the differences between the feeding regimes presented and the soybean meal-based control (K) are not statistically significant (EEF for K 451; for pea 459; for pea and rapeseed meal 436). With the rapeseed-pea combination, up to 469 g soybean meal per reared broiler can be replaced. This corresponds to a reduction of about 48% in the use of soybean meal compared to the use of soybean meal as the sole high-protein supplement.

Table 6: Complete feed formulas with pea and a combination of pea with rapeseed meal (RSM) for broilers (the Ross 308 strain)

Raw material		Starter phase (Day 1 to 10)		Growing phase (Day 10-24)		Finishing phase (Day 24 to 35)	
		Pea	Pea + RSM	Pea	Pea + RSM	Pea	Pea + RSM
Peas[1]	%	10.00	10.00	20.00	20.00	20.00	20.00
Rapeseed meal[2]	%		7.50		15.00		15.00
Soybean meal[3]	%	34.00	29.50	23.00	14.50	18.00	10.50
Maize	%	24.80	20.64	23.38	14.92	23.06	13.45
Wheat	%	20.00	20.00	25.00	25.00	30.00	30.00
Vegetable oil	%	6.00	7.20	4.10	6.40	4.50	7.00
Carbonated fodder lime	%	1.95	1.95	1.75	1.65	1.75	1.65
Monocalcium phosphate	%	1.10	1.10	0.90	0.75	0.90	0.75
Premix	%	1.00	1.00	1.00	1.00	1.00	1.00
Sodium bicarbonate	%	0.25	0.25	0.25	0.25	0.25	0.25
Sodium chloride	%	0.20	0.20	0.20	0.20	0.20	0.20
L-lysine HCl	%	0.17	0.17	0.06	0.05	0.04	
DL-methionine	%	0.37	0.34	0.29	0.23	0.24	0.17
L-threonine	%	0.11	0.10	0.07	0.05	0.06	0.03
L-valine	%	0.05	0.05				
Constituents							
Energy	MJ AME_N	12.7	12.7	12.6	12.6	12.8	12.8
Crude protein	%	23.1	23.3	20.3	20.8	18.5	19.4
Lysine	g/kg	14.1	14.2	11.8	12.1	10.4	10.7
Methionine	g/kg	6.8	6.7	5.7	5.4	5.0	4.7
Met + Cys	g/kg	10.4	10.5	8.9	9.2	8.0	8.3
Threonine	g/kg	9.6	9.7	8.1	8.4	7.2	7.6
Tryptophan	g/kg	2.9	2.9	2.4	2.6	2.2	2.4
Arginine	g/kg	14.6	14.5	12.5	12.6	11.2	11.6
Valine	g/kg	10.8	11.0	9.1	9.6	8.3	8.9

[1] 20% crude protein
[2] 35% crude protein
[3] 47% crude protein

The formulation of the mixtures based on the levels of digestible amino acids results in a high crude protein content for the pea-rapeseed mixtures. Since the rapeseed protein is less digestible, higher protein concentrations are required to achieve the same digestible amino acid content. According to recent assessments, feed mixtures for growing turkeys should contain more arginine than lysine. However, this is difficult to realise in practice for turkey feed. Supplementation with free arginine would be possible, but the prices for arginine products are currently very high leading to increased feed costs. Another possibility to optimise the lysine:arginine ratio is the use of sweet lupin and faba bean in the feed mixtures. The protein of these legume species contains significantly more arginine than lysine (lupine protein lysine:arginine = 1:2.3). According to Krawcyk et al. (2015), the arginine requirement for young turkeys can be met by including 8% sweet yellow lupin in a complete feed mixture based on soybean meal-wheat-maize.

The formulations in Table 7 take this into account. Based on the results of Krawcyk et al. (2015), complete feed mixtures for seven rearing phases using sweet blue lupin are presented. The feed mixtures presented are based on Aviagen (2016) specifications with regard to energy, amino acid and protein content, mineral and active substance contents for heavy turkey strains (males with a target final live weight of 22 kg).

Table 7. Examples of complete feed formulas with sweet blue lupin for 7 rearing phases for heavy turkeys (males)

Raw material		P1 (Day 1-21)	P2 (Day 22-42)	P3 (Day 43-63)	P4 (Day 64-84)	P5 (Day 85-105)	P6 (Day 106-126)	P7 (Day 127-147)
Sweet blue lupins[1)]	%	10.0	15.0	25.0	25.0	20.0	20.0	20.0
Soybean meal[2)]	%	37.0	28.0	21.0	16.0	14.0	12.0	8.0
Wheat	%	25.0	20.0	15.0	15.0	15.0	15.0	15.0
Maize	%	17.9	27.0	28.1	33.5	41.1	43.1	46.9
Vegetable oil[3)]	%	3.5	4.0	5.5	5.5	5.5	6.0	6.5
Mineral feed	%	5.5	5.0	4.7	4.3	3.9	3.5	3.2
L-Lysine HCl	%	0.5	0.5	0.4	0.4	0.3	0.2	0.2
DL-methionine	%	0.4	0.4	0.3	0.3	0.2	0.2	0.2
L-threonine	%	0.1	0.1	0.1	0.1			
L-Valin	%	0.1	0.1					
Ingredient								
Energy AME_N	MJ	11.7	11.9	12.1	12.3	12.6	12.9	13.2
Crude protein	%	25.5	23.0	22.0	20.0	18.0	17.0	15.5
Lysine	g/kg	17.3	15.3	13.5	12.0	10.4	9.4	8.2
Methionine	g/kg	7.5	6.8	5.8	5.2	4.5	4.2	3.9
Met + Cys	g/kg	11.3	10.1	9.0	8.1	7.3	6.9	6.3
Threonine	g/kg	10.1	9.0	8.1	7.4	6.2	5.9	5.3
Tryptophan	g/kg	2.5	2.6	2.3	2.1	1.9	1.7	1.6
Arginine	g/kg	17.7	16.3	16.7	15.2	13.3	12.7	11.5
Valine	g/kg	11.7	10.3	9.2	8.3	7.6	7.2	6.5

[1] 29% crude protein
[2] 47% crude protein
[3] Soybean meal, rapeseed and palm oil

Amino acid supplementation is not possible in organic feeding. Thus, in the case of increased proportions of grain legumes in the mixture, the combined effects of protein feeds with increased contents of sulphur-containing amino acids must be used. For this purpose, sunflower cakes (from dehulled seeds) are particularly suitable for organic feed for broilers and turkeys.

Conclusion

The results presented lead to the following conclusions: Faba beans, grain peas and sweet lupins can be used successfully in laying hen, broiler and turkey fattening feed. These classic grain legumes are limited by their low content of sulphur-containing amino acids. Under conventional production conditions, however, this can be overcome with the supplementation of free methionine.

The white-flowered grain peas that dominate the market can be mixed in high proportions into the respective complete feeds for the animal groups mentioned, as such peas are unproblematic with respect to antinutritional substances. However, peas only have a crude protein content of approx. 20%. Thus, peas substitute for both high-protein constituents and the energy rich constituents (e.g., wheat and maize).

For laying hens, low-vicin and low-convicin faba bean varieties can be used. Such varieties can be used as substitutes for the other types of feed to any appreciable extent. In poultry fattening, the other white-flowered faba bean varieties can also be used successfully in higher proportions.

Sweet blue and white lupin have the highest protein contents values among the classic grain legumes, with approx. 29% and 34% crude protein respectively. The essential amino acids in lupin protein are as digestible as those in soy protein. Thus, a high substitution effect can be achieved with the use of sweet lupins in complete feed mixtures for laying hens and poultry fattening. Combining other protein alternatives - such as rapeseed meal or sunflower cake (dehulled) - can contribute to a balanced amino acid supply. This means that soybean extract meal can be replaced entirely in laying hens feed. In complete feed mixtures for poultry fattening, the soybean meal content can be significantly reduced by deploying such combinations, at least in the final fattening stages.

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 in the Legumes Translated project funded by the European Union through Horizon 2020, Project Grant Number 817634.

Translation: Lauren Dietemann, Research Institute of Organic Agriculture (FiBL) and Donal Murphy-Bokern

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