Germination of faba beans (*Vicia faba* L.) for organic weaning piglets

P. Schwediauer · W. Hagmüller · W. Zollitsch

Received: 30 May 2017 / Accepted: 4 September 2017 / Published online: 16 September 2017
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Abstract Faba beans (*Vicia faba* L.) contain anti-nutritive compounds that can reduce digestibility and palatability. Germination has been reported to reduce some of those components. The effect of including germinated faba beans in their feed was tested on 160 weaner pigs that were assigned to one of four diets containing either 19% peas (RP19), 16% raw faba beans (RFB16), 16% germinated faba beans (GFB16) or 24% germinated faba beans (GFB24). Crude protein was slightly higher in germinated as compared to raw beans. Most of the essential amino acids decreased due to germination, their contents relative to lysine remained the same. There were no significant differences in live weight on days 8, 15 and 22. At the end of the trial (day 29), live weight of GFB24 was significantly reduced when compared to RP19 and RFB16, but not to GFB16. In week 4, daily weight gain of GFB24 was significantly lower than of all other treatments. There were no significant differences in feed intake between the treatments. It was possible to feed germinated faba bean in amounts up to 240 g kg FM⁻¹ without a reduction in feed intake or a higher incidence of diarrhoea, although live weight

and daily weight gain were reduced. Under the circumstances of this study and considering the effort related to the process, germination cannot be recommended as a method to improve the nutritive value and acceptance of faba beans for feeding of weaner pigs.

Keywords Grain legumes · Germination · Sprouts · Organic farming · Feeding

Introduction

The European demand for organic feedstuffs rich in high-quality protein, necessary for the formulation of diets that allow for an efficient production of lean pigs, exceeds the availability. This results in a dependency on imports, mainly of expensive soybeans and soybean cake (Zollitsch 2007; Früh et al. 2015).

Faba bean (*Vicia faba* L.) is a domestic crop rich in protein, but contains so-called anti-nutritional factors (ANF). These secondary plant metabolites reduce the nutritive value of faba beans and constrain their use as a feedstuff (Crépon et al. 2010). Additionally, structural properties of the storage protein of faba beans itself could limit their digestibility (Carbonaro et al. 2000, 2014). Usual recommendations for inclusion of faba beans in rations for weaner pigs range from 5% in conventional to 10–20% in organic systems (Zollitsch et al. 2002; Blair 2007; Jeroch et al. 2008). If the content of ANF can be decreased, it is possible to feed amounts exceeding these recommended limits (Zijlstra et al. 2008; Emiola and Gous 2011).

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In human nutrition, germination is a common and traditional method for enhancing the nutritional value and palatability of grain legumes (Kaukovirta-Norja et al. 2004; Chaudhary et al. 2015). It is known to increase contents and availability of dietary minerals, protein and monosaccharides (Fernandez and Berry 1989; Frias et al. 2005) and to decrease ANF (Gulewicz et al. 2014).

The most relevant ANF in faba beans are tannins and α -galactosides of the raffinose family oligosaccharides (RFO) (Makkar et al. 1997; Rubio 2007). RFO can promote bloating due to fermentation in the colon and increase the risk of diarrhoea because of a shift in the osmotic gradient (Dersjant-li and Peisker 2010). Tannins can reduce the digestibility of protein and the nutritional value of dietary energy (Crépon et al. 2010; Sarwar Gilani et al. 2012).

In faba beans, condensed tannins were significantly reduced after 24 and 72 h of germination (Alonso et al. 2000). RFO (raffinose, stachyose, verbascose, ajugose), which accounted for up to 50% of sugars in ungerminated faba bean, were markedly reduced after the second day of germination (Goyoaga et al. 2011). When feeding germinated legumes to rats, increased utilisation of protein was attributed to a decrease in contents of RFO (Donangelo et al. 1995).

The amino acid (AA) profile of faba beans is low in methionine and cysteine when compared to soybean. During germination storage, proteins are hydrolysed and the share of polypeptides, peptides and free amino acids increases (Urbano et al. 2005a, b). Those are potentially used for the synthesis of new compounds (Boulter and Barber 1963), which can be assembled from other amino acids than the former storage proteins and therefore alter the pattern of amino acids in germinated seeds (Peer and Leeson 1985; Ahmed et al. 1995). A general prediction of the effects of germination is difficult, as the outcome seems to depend on the species and variety studied, as well as the technical parameters of germination such as duration or temperature.

Klose et al. (2009) found an increase in all free amino acids in oats after malting. In lupins, the amount of all essential AA was lower after 4 days of germination (g kg protein^{-1}). Due to a higher amount of crude protein (CP), some AA (Thr, Arg, His, Val, Ile, Leu, Phe) were found in higher quantities after germination (g kg DM^{-1}). Standardised ileal digestibility of methionine and lysine in pigs was lower for germinated as compared to raw

lupin seeds (Chilomer et al. 2013). Khalil and Mansour (1995) found no influence of germination on the content of essential AA in faba beans, but in vitro protein digestibility was reported to be higher in germinated faba beans (Khalil and Mansour 1995, Alonso et al. 2000).

The optimal length of germination seems to be the result of a trade-off between reduction of ANF and loss of nutrients due to respiration. After germinating peas for 3 days, daily intake and utilisation of protein by rats were significantly higher when compared to raw peas, the highest reduction of ANF was reached after 6 days of germination (Vidal-Valverde et al. 2002; Ayet et al. 1997). After 6 days, however, feed intake decreased (Urbano et al. 2005a, b) and highest mobilisation of protein by hydrolysis was found after 3 days of germination (Goyoaga et al. 2011). In this study, the length of germination was 4 days, as predetermined by the device we used.

To our knowledge, no studies have been published on the potential of fresh sprouts as a feedstuff for young growing pigs in diets fed on organic farms. In this study, we tested the effects of feeding sprouts of faba bean, germinated on-farm, on production parameters of organic weaner pigs.

Animals, materials and methods

The study was conducted at the Institute of Organic Farming and Farm Animal Biodiversity (part of the Agricultural Research and Education Center) in Wels (Austria). The overall experiment consisted of four consecutive runs, each of these lasting for 4 weeks. The feeding trial complied with the rules of the EU Directive 2010/63/EU on the protection of animals used for scientific purposes (The European Parliament and the Council of the European Union 2010) and the Austrian Act on Animal Experiments. No invasive procedures were performed on the piglets.

Experimental design and animals

In total, 160 weaner piglets ([Landrace $\times$ Large White] $\times$ [Pietrain]) were selected and assigned to one of the four treatments considering litter (sow), sex and bodyweight, resulting in a group size of 10 in each of the four replicates. The treatment groups were allocated to the pens following a 4×4 Latin square with balanced

block design. The allocation of the treatments changed with every replicate, ensuring that each ration was fed once in each pen.

The animals were weaned at an age of 44.4 ± 6 days (mean $\pm$ standard deviation), weighed 12.5 ± 2 kg and remained in the experiment for 28 days (day 1 to day 29). Only animals without clinical signs of illness were selected to participate, one pig died during the first week of the first experimental round. Whenever pigs displayed signs of watery faeces or a soiled anal region, they were subjected to an anti-bacterial medication (Baytril®). During the trial, the piglets were housed in pens of 5×1.7 m which were equipped with a heated creep area, an outdoor run (3×1.7 m), a feed trough (2.2 m) and two drinkers (located in the pen and outside run). All 160 pigs were habituated to the taste of sprouts by providing each litter with 0.5 kg germinated faba beans 3 days prior to day 1 of the experiment.

Feeding regimen

We designed four treatments: One control group with 19% pea as the main domestic protein-rich feed component and three experimental groups containing 16% raw faba bean (RFB16), 16% germinated faba bean (GFB16) and 24% of germinated faba bean (GFB24). The second main source of protein in all rations was soybean cake. The rations (see Table 1) were calculated using the software EvaPig® (version 1.3.1.7.). Nutrient contents for all components, excluding faba bean, soybean cake and oat flakes, were adopted from the INRA database implemented in the software. Values of soybean cake were adopted from Baldinger et al. (2016a) and oat flakes from DLG (2014). The treatments containing germinated faba beans were calculated based on the analysis of the nutrient profile of raw faba beans. All diets were formulated to have the same lysin content and to be iso-energetic, if possible. In 19% peas (RP19), RFB16 and GFB16, the same proportion of soybean cake was used (17%), while in GFB24, its share was reduced to 9%, resulting in slightly lower levels of CP, lysine and methionine. The amount of all other components of treatments RFB16, GFB16 and GFB24 were the same. In RP19, the share of wheat, oats and sunflower oil was adjusted in order to achieve the same level of lysin and ME (Table 1). The faba beans used in the experiment were of the coloured variety JULIA (Table 2). The device used for germination (“Keimrad 100”®, Söllradl GmbH, 4550 Kremsmünster, Austria) consisted of a rotating cylinder

made of stainless steel with four separate and perforated chambers which could be opened and closed individually. Each day, fresh sprouts were removed from one of the four chambers and the chamber filled with a defined amount of ungerminated beans (max. 8 kg raw seeds per chamber and day). This method implied a germination period of 96 h. The sprouts were automatically watered for 20 s, left for soaking for 1 h and for ventilation for another 3 h, resulting in one full rotation over 4 h. Room temperature was maintained at 16.4 ± 1.4 °C. All rations were fed five times a day as pelleted compound feed. Feed allowance was quantitatively restricted and increased slightly over the experimental period, using an automated feeding system. The daily amount of fresh germinated beans (GFB16, GFB24) was fed once a day in the morning. Before weaning, all piglets were offered ad libitum access to a commercial organic piglet starter (nutrient contents in g kg^{-1} : 206.6 RP, 35.3 ether extracts, 6.9 lysine, 6.9 calcium, 2.2 phosphorus). In the first 4 days after weaning, the amount of feed was restricted to 80% of the total allowance to prevent diarrhoea.

Data collection and analytical procedures

After the initial restriction, the amount of feed was adjusted daily in a way that ensured that all of the feed was consumed by the piglets and no residuals were left in the trough. Possible leftovers were weighed and subtracted from the total amount that had been fed. If a treatment group left no feed at all, its feed allowance was increased. All animals were weighed individually prior to the first feeding on days 1, 8, 15, 22 and 29.

Raw and germinated faba beans were analysed for nutrient contents ($n = 1$). Pooled samples of each diet were taken from feed bags at the beginning and end of the experiment ($n = 2$). The samples of compound feed and faba beans were analysed at the Feed laboratory of the Provincial Chamber of Agriculture of Lower Austria, 3250 Wieselburg-Land, Austria, according to the German Handbook of Agricultural Experimental and Analytical Methods (VDLUFA 2007; method number in brackets). The dry matter content of feed was determined by oven-drying at 105 °C (3.1); crude protein was analysed by Dumas combustion (4.1.2). Contents of metabolizable energy (ME) were calculated according to GfE (2008).

Samples of raw and germinated faba beans were analysed for their amino acid profile at the Department of Chemistry, Division of Biochemistry at BOKU-University of Natural Resources and Life Sciences

Table 1 Composition and calculated nutrient and energy contents of the experimental diets

	Diets			
	RP19	RFB16	GFB16	GFB24
Composition				
Faba beans, raw	–	160	–	–
Faba beans, germinated	–	–	160	240
Peas	190	–	–	–
Soybean cake	170	170	170	90
Wheat	200	235	235	235
Barley	260	250	250	250
Sunflower oil	15	20	20	20
Skimmed milk powder	30	30	30	30
Wheat bran	50	50	50	50
Oat flakes	60	60	60	60
Mineral and vitamin premix	25	25	25	25
Nutrients and energy				
Crude protein (g kg ⁻¹)	183	190	190	178
ME (MJ kg ⁻¹) ^a	13.25	13.24	13.24	13.08
Lysine (g kg ⁻¹)	10.2	10.3	10.3	9.7
g Lys MJ ME ⁻¹	0.77	0.78	0.78	0.74
Cysteine (g kg ⁻¹)	3.2	3.3	3.3	3
Methionine (g kg ⁻¹)	2.7	2.7	2.7	2.4
Methionine + cysteine (g kg ⁻¹)	5.9	6	6	5.4
Threonine (g kg ⁻¹)	6.8	6.9	6.9	6.4
Tryptophan (g kg ⁻¹)	2.2	2.2	2.2	2

RP19 control diet, RFB16 16% raw faba bean, GFB16 16% germinated faba bean, GFB24 24% germinated faba bean

^aMetabolizable energy content calculated according to GfE (2008)

Vienna with a high-performance liquid chromatographic (HPLC) system (Hewlett Packard 1050) and a variable wavelength fluorescence detector (Shimadzu RF 535). After freeze-drying and milling of germinated faba beans, the samples were subjected to hydrolysis for 20 h in 6 M HCl. The samples were oxidised to prevent losses of methionine and cysteine; tryptophan was stabilised with alkaline Ba(OH)₂.

Statistical analysis

Statistical analysis of data was conducted with SAS 9.4 (SAS Institute Inc.).

Body weight was measured on individual piglets at multiple time points, and the parameters “body weight” and “daily weight gain” therefore were treated as repeated measurements. The interval between measurements

was 7 days (days 1, 8, 15, 22, 29) in the replicates one, two and three. In replicate four, piglets were weighed on day 14 instead of day 15. This unbalanced measurement was corrected for by addition of one average daily body weight gain between days 15 and 22.

To consider the random effect of the individual piglet, body weight and daily weight gain were analysed using the procedure MIXED. Because of the Bayesian information criterion (BIC) being closer to zero, differences of correlations within repeated measurements on one individual piglet were accounted for using statement repeated.

Four suitable covariance structures were tested (Toeplitz, autoregressive (1), unstructured, variance components), of which Toeplitz was chosen because of the BIC being closest to zero. Multiple comparison of means were conducted using the Tukey-Kramer test and statistical differences interpreted as significant when $P < 0.05$.

Table 2 Nutrient contents of raw and germinated faba bean seeds (g kg DM⁻¹ unless stated otherwise) (*n* = 1)

	Faba bean, raw	Faba bean, germinated	Difference (%)
Energy (MJ ME)	14.52	14.48	− 0.3
Crude fibre	81	85	+ 5.0
Ether extracts	15	15	−
N-free extracts	550	542	− 1.5
Crude protein	317	321	+ 1.0
Lysine ^a	7.82	7.70	− 1.5
Methionine ^a	1.00	0.98	− 2.0
Cysteine ^a	1.64	1.62	− 1.2
Methionine + cysteine ^a	2.64	2.57	− 2.7
Tryptophan ^a	1.02	1.05	+ 2.9
Threonine ^a	3.85	3.84	− 0.3
Serine ^a	4.59	4.74	+ 3.3
Histidine ^a	2.76	2.81	+ 1.8
Glycine ^a	4.46	4.36	− 2.2
Arginine ^a	11.21	11.11	− 0.9
Alanine ^a	4.65	5.16	+ 11.0
Tyrosine ^a	3.31	3.23	− 2.4
Valine ^a	5.10	5.08	− 0.4
Isoleucine ^a	4.59	4.54	− 1.1
Phenylalanine ^a	4.81	4.83	+ 0.4
Leucine ^a	8.8	8.74	− 0.7
Aspartic acid ^a	11.58	11.21	− 3.2
Glutamic acid ^a	18.80	18.99	+ 1.0
Lys/Met + Cys/ Thr/Tr	1:0.3:0.5:0.13	1:0.3:0.5:0.14	

^a Amount of AA in percentage of hydrolysed protein

Daily feed intake (g day⁻¹ piglet⁻¹) and feed conversion ratio (kg feed intake kg⁻¹ weight gain) were analysed on group level using procedure GLM. The effect of sex was not significant in any of the two models and was therefore removed from the model. The following models were used for analysis:

Body weight and daily weight gain

$$Y_{klmnop} = \mu + \text{diet}_k + \text{pen}_l + \text{replicate}_m + \text{sow}_n(\text{replicate}_m) + \text{day}_o + \text{day}_o \times \text{diet}_k + \text{piglet}_p(\text{diet}_k) + b_1 \times \text{bw_weaning} + \varepsilon_{klmnopq}$$

Feed intake and feed conversion ratio

$$Y_{klm} = \mu + \text{diet}_k + \text{pen}_l + \text{replicate}_m + b_2 \times \text{day} + b_3 \times \text{day}^2 + \varepsilon_{klm}$$

Legend:

Y = variable studied; μ = intercept; diet_k = fixed effect of diet (*k* = RP19, CG, GFB16, GFB24); pen_l = fixed effect of pen (*l* = 1, 2, 3, 4); replicate_m = fixed effect of replicate (*m* = 1, 2, 3, 4); $\text{sow}_n(\text{replicate}_m)$ = fixed effect of sow (*n* = number of ear tag) within replicate; day_o = fixed effect of day (*o* = 8, 15, 22, 29), $\text{day}_o \times \text{diet}_k$ = interaction between day and diet; $\text{piglet}_p(\text{diet}_k)$ = random effect of piglet (*p* = number of ear tag) within diet; bw_weaning = continuous effect of body weight at weaning; day = continuous effect of day; day^2 = quadratic effect of day; b_1 = regression coefficient of body weight at weaning; b_2 = regression coefficient of day; b_3 = regression coefficient of quadratic effect of day; ε = random error.

Results and discussion

In this study we tested the effects of germinating faba beans (*V. faba* L.) in a ration for weaner pigs on the parameters feed intake, body weight, daily weight gain and feed conversion ratio. Results from literature suggest that germination can increase digestibility of protein and the content of essential amino acids (Khalil and Mansour 1995; G Urbano et al. 2005a, b; Ghavidel and Prakash 2007; Gulewicz et al. 2014).

After 4 days of germination, the content of crude protein slightly increased from 317 g kg DM⁻¹ in raw beans to 321 g kg DM⁻¹ in sprouts (*n* = 1). This small increase (+ 1%) might be related to the decline in N-free extracts (− 1.5%) due to degradation of carbohydrates during germination (Donangelo et al. 1995; Chilomer et al. 2013). The fraction of carbohydrates in faba beans is smaller than in cereals such as wheat. This could explain the greater increase in CP found for wheat after 5 days of germination, since respiration leads to a loss of carbohydrates in the range of 5–8% of dry matter (Seggin et al. 2003). Also, starch is metabolised more quickly and used for germination earlier than the crude fibre (CF) fraction, resulting in an increased amount of CF (+ 5%) in sprouts (Table 2).

Although the total amount of amino acids in g kg DM⁻¹ increased after germination due to the increase in crude protein, the proportion of all essential amino acids (except tryptophan) in the total amount of hydrolysed protein decreased by 1.2% (cysteine) to 2% (methionine). These results correspond to those reported by Chilomer et al. (2013) who found that germination decreased the content of all essential amino acids in lupins, but not to those from Luo et al. (2014) who found that lysine content increased after germination of green faba beans (but not of white faba beans). Since there was only one sample of raw and germinated beans analysed, no information is available on the potential variability of nutrient contents of the faba beans used in this experiment.

A considerable amount of the studies on germination as a method to increase the nutritional value of raw seeds were conducted for human nutrition. In these studies, rats were frequently used as a model; they require only relatively small quantities of germinated seeds, which can be freeze dried and milled in the laboratory before being processed together with the other ingredients of the ration. Only few studies were conducted in which sprouts were fed to pigs. Hunger (2011) studied the effects of feeding germinated wheat to weaner pigs. After germination, the sprouts were dried (90% DM), ground and, together with the other dietary components, processed as pellets. Kaspróicz-Potocka et al. (2013) also dried (90% DM) and ground sprouts of germinated lupins before feeding them to weaner pigs. Both studies used synthetic amino acids to supplement the rations, which was not done in the current study because of the ban of synthetic amino acids in diets of organic livestock (EU 2008).

In this experiment, a defined amount of fresh sprouts was fed once daily in the morning. The animals consumed their daily amount of germinated faba beans within a few hours. As the other components were fed in pelleted form and in five meals over the course of 1 day, the animals probably consumed a protein-rich portion of their diet, not ideally balanced for AA, at the beginning of each day, which might have influenced the piglets' performance (Boisen et al. 2000; Kim et al. 2012).

Contrary to the hypothesis that the physiological processes which occur during germination may lead to a higher feeding value and cause an improved animal performance, results for body weight and daily weight

gain of treatment groups containing sprouts were mostly lower than those of RP19 and RFB16 (Table 3). The interaction between day and treatment was significant for body weight ($P < 0.01$) and daily weight gain ($P < 0.01$), as the reduced growth of pigs in treatments GFB16 and GFB24 occurred in weeks 3 and 4 of the trial, while in the first 2 weeks, no clear trend was recorded.

There were no statistically significant differences in the live weight of the animals on days 1, 8, 15 and 22 (Table 3). Despite not reaching significance, the lower body weight of treatments fed germinated beans was already observable on day 22. On day 29, body weight of GFB24 pigs was significantly lower than that of RP19 and RFB16, while GFB16 did not differ significantly from either treatment. Accordingly, while there were no significant differences in the daily weight gain of RP19, RFB16 and GFB16 in week 4, weight gain of GFB24 was significantly lower than in the other groups.

Overall, the performance in this trial was similar to two previous studies using the same control group and feeding technology for studies on sainfoin (Baldinger et al. 2016a) and grass pea (Baldinger et al. 2016b) as a home-grown source of protein for weaner pigs. Mean daily weight gain in the sainfoin study was in the range of 292 to 395 g day⁻¹ and of 403 to 412 g day⁻¹ in the grasspea study. Despite higher feed intake, mean daily weight gain of RP19 (391 g day⁻¹) was slightly lower than in the control group of the grasspea study (412 g day⁻¹), but about the same as in the sainfoin study (395 g day⁻¹).

No analysis of ANF was performed in this study; therefore, the discussion of potential effects of germination is limited to an examination of the performance parameters. Since performance of RFB16, containing ungerminated faba beans, was better than both of the experimental groups with germinated beans as well as the control group containing peas, it seems reasonable to assume that ANF did not substantially influence the availability of nutrients and the performance of the animals (Rubio et al. 2002). Consequently, there were no visible effects of a potential reduction of ANF due to germination (Alonso et al. 2000; Gulewicz et al. 2014).

The crude protein and energy contents of the rations were about 1.6 ± 0.43 g kg DM⁻¹ lower and 0.6 MJ ME kg DM⁻¹ higher, respectively, than planned. To calculate the intake of RP, ME and AA, this deviation was accounted for in the calculation of amino acid contents of the different rations.

Table 3 Body weight and daily weight gain of piglets fed organic diets with and without germinated faba beans

Trait	Days	Diets				<i>P</i> values			
		RP19	RFB16	GFB16	GFB24	Diet	Pen	Replicate	Day
Body weight (kg) ^a	1	12.5	12.5	12.5	12.5				
	8	13.3	13.3	13.3	13.2				
	15	16.0	15.8	15.9	15.6				
	22	19.2	19.1	18.8	18.6				
	29	23.5a	23.8a	23.0ab	22.2b				
	SEM	0.25	0.25	0.25	0.25	0.180 ^a	0.093	< 0.001	< 0.001
Daily weight gain (g) ^a	1–8	124	115	120	122				
	9–15	375	355	374	333				
	16–22	455	472	408	421				
	23–29	608a	660a	601a	499b				
	Overall	391a	401a	376ab	344b				
	SEM	19.5	19.3	19.2	19.4	0.001 ^a	0.02	< 0.001	< 0.001

The table shows least-square estimates and *P* values of the effect of diet. In addition, least-square estimates for individual time periods are given for further illustration. *P* values < 0.05 are considered to indicate significant differences and are in italics. Entries followed by different lowercase letters are significantly different

RP19 control diet, RFB16 16% raw faba beans, GFB16 16% germinated faba beans, GFB24 24% germinated faba beans.

^a *P* values of sow(replicate) and bw_weaning < 0.001

Table 4 Feed intake and FCR of piglets fed organic diets with and without germinated faba beans

Trait	Days	Diets				SEM	<i>P</i> values			
		RP19	RFB16	GFB16	GFB24		Diet	Pen	Replicate	Day
Feed intake (g day ⁻¹)	1–8	301	294	309	292	20.2				
	9–15	557	550	565	548	17.7				
	16–22	869	862	876	859	17.7				
	23–29	1236	1229	1244	1227	20.2				
	Overall	741	734	748	731	15.5	0.865	0.006	0.456	< 0.001 ^a
Feed Conversion Ratio (kg LW ⁻¹)	1–8	2.37	2.31	2.47	2.51	0.15				
	9–15	1.75	1.69	1.85	1.89	0.14				
	16–22	1.68	1.62	1.79	1.82	0.14				
	23–29	2.17	2.10	2.27	2.30	0.15				
	Overall	1.99	1.93	2.10	2.13	0.12	0.614	0.7	0.161	< 0.001 ^a
ME intake (MJ day ⁻¹)	Overall	9.95	9.90	10.03	9.59	0.21	0.466	0.007	0.448	< 0.001 ^a
CP intake (g day ⁻¹)	Overall	124.51	127.62	131.76	124.73	2.71	0.211	0.007	0.47	< 0.001 ^a
Lysine intake (g day ⁻¹)	Overall	6.98	6.92	7.18	6.83	0.15	0.381	0.006	0.462	< 0.001 ^a
Methionine intake (g day ⁻¹)	Overall	1.83a	1.83a	1.91a	1.67b	0.04	0.001	0.01	0.467	< 0.001 ^a

The table shows least-square estimates and *P* values of the effect of diet. In addition, least-square estimates for individual time periods are given for further illustration. *P* values < 0.05 are considered to indicate significant differences and are in italics. Entries followed by different lowercase letters are significantly different

RP19 control diet, RFB16, 16% raw faba beans, GFB16 16% germinated faba beans, GFB24 24% germinated faba beans

^a *P* value of day × day < 0.001

According to Kasproicz-Potocka et al. (2013), germination of lupin reduces feed palatability and feed intake and Bau et al. (2000) advise that, to ensure nutritive quality, due to possible microbial contamination or oxydation of lipids, sprouts of soybeans should be heated before consumption if germination lasts longer than 3 days. Still, increased palatability is often mentioned as a benefit of germination (Urbano et al. 2005a, b; Luo et al. 2014; Mäkinen and Arendt 2015). Our data on feed intake do not confirm this hypothesis. When feeding 24% ungerminated faba beans to weaner pigs, a decrease in feed intake was found (Partanen et al. 2006). In this study, the treatment group GFB24 (24% germinated beans) showed the lowest mean feed intake (731 g DM day⁻¹), but differed only negligibly (17 g DM day⁻¹) from GFB16, the group with the highest feed intake. Consequently, no significant differences were found for the feed intake between treatments (Table 4).

Feed was not offered ad libitum to the animals, instead the daily amount of feed offered was based on the leftovers collected from the trough. In this case, differences in feed intake might be less pronounced than when fed ad libitum, but should still be visible.

Intake of methionine was significantly lower in GFB24 than in all other treatments. This was due to the lower level of methionine in the diet, which could not be compensated for by germination. The lower body weight and daily weight gain of GFB16 as compared to RFB16 might indicate that digestibility of methionine and lysine could have been lower after germination (Tables 1 and 4).

There were no significant differences in the feed conversion ratio of the four treatments. Feed conversion of RFB16 was numerically consistently better than that of RP19, GFB16 and GFB24. While GFB16 had the highest CP intake, its conversion ratio for CP was also the highest (data not shown).

Germination seemed to have no influence on the occurrence of diarrhoea. Treatments were recorded for 33% of animals in RP19, 40% in RFB16, 33% in GFB16 and 30% in GFB24, which is comparable to Baldinger et al. (2016a), who noted 29–37% of animals as having received treatments for diarrhoea.

Conclusions

Germination of raw faba beans had no positive effects on daily weight gain and body weight of organic weaner

pigs. There was no significant effect of germination on total feed intake. Germinated faba beans could be fed in proportions up to 240 g kg diet⁻¹ without a decline in feed intake. Still, the lower intake of essential amino acids of GFB24 could not be compensated for by germination, resulting in a significantly lower weight gain and body weight at the end of the feeding trial. Under the circumstances of this study and considering the effort related to the process, germination cannot be recommended as a method to improve the feeding value of protein in faba beans for feeding of weaner pigs.

Acknowledgements Open access funding provided by University of Natural Resources and Life Sciences Vienna (BOKU). We want to thank Fa. Söllradl for the provision of the germination device and Johann Ollmann (Bioschwein Austria) for financially supporting the first author.

Compliance with ethical standards The feeding trial complied with the rules of the EU Directive 2010/63/EU on the protection of animals used for scientific purposes (The European Parliament and the Council of the European Union 2010) and the Austrian Act on Animal Experiments.

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