



Lucerne (*Medicago sativa*) plant tips as protein feed for lactating sows in an organic farming system

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Abstract Lucerne is a very interesting feed for sows in organic pig production because it is rich in the essential amino acids lysine and methionine. The amount of protein can be increased through innovative harvesting methods as the so-called lucerne plant tips can be separated from the rest of the plant (crude protein: 274 g/kg dry matter (DM)). The present feeding trial evaluated the use of hot-air dried lucerne plant tips as a protein source for lactating sows in an organic farming system. Twenty-two lactating sows were fed either a control concentrate mixture or a test concentrate mixture containing lucerne plant tips (20%, based on fresh matter) during an average lactation period of 45.8 days. The daily feed intake, the growth rate of the piglets, and the change in backfat were measured. Due to the sows' high initial backfat thickness (control group: 26.7 mm and lucerne group: 29.3 mm, $p=0.22$), the daily feed intake was low in both groups. Additionally, the test group showed significantly lower energy intake (control group: 81.4 MJ ME/d; lucerne group: 65.8 MJ ME/d, $p<0.0001$), indicating the need for acclimatization to lucerne plant tips in the gestation period. Nevertheless, a lower growth rate of the piglets was not detected (control group: 268 g and lucerne group 254 g, $p=0.33$). On day 42, the piglets' individual weight for the control and lucerne groups was 13.6 kg and

13.3 kg, respectively ($p=0.623$). This underlines the resilience of lactating sows.

Keywords Lucerne · Protein feed · Organic farming system · Sows · Suckling period · Body condition

Introduction

Organic farming is subject to the framework directives of the European Union (Regulation (EU) 2018/848). The Regulation states that animals should be fed with farm grown or regionally produced organic feedstuffs. In particular, organic pig production faces difficulties in feeding 100% organic feedstuffs. Regarding the needs for essential amino acids (EAA), such as methionine, it is challenging to meet these demands in feeding lactating sows with 100% organic feedstuffs.

One solution is to import organic-certificated feedstuffs that are rich in essential amino acids. However, Regulation (EU) 2018/848 calls for a long-term reduction in imports with negative environmental impacts. The regulation also calls for an increase in regional or farm grown cultivation.

Therefore, recent studies have investigated the use of green legume products, demonstrating a high potential for the protein and amino acid supply for pigs (Sommer and Sundrum 2015; Bellof et al. 2021). Green legumes—like lucerne, for example—are already part of the crop rotation in organic farming

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systems (Kolbe 2008). Lucerne is a protein-rich fodder plant. It has a higher crude protein (CP) content in its leaves and tips than in the whole plant (Bellof et al. 2021). Moreover, lucerne delivers a considerable amount of dietary fiber, which supports the sows' digestive tract (Bellof 2025). The feeding value is reduced through saponins. The amount of saponins in the tips is lower than in the leaves (Górski et al. 1984).

An innovative harvesting method called high-cut leads to a protein-enriched lucerne part product named lucerne plant tips (LTH). The plants were cut at a height of 60% of the whole plant so that the upper 40% could be collected as plant tips and subjected to hot-air drying and pressed into pellets. While harvesting only the plant tips reduces the crude fiber (CF) delivery, the CF remaining in the tips is still essential for the roughage feeding of sows. By reducing the fiber content, the digestibility of the lucerne product increases, which improves the energetic feeding value of this feedstuff (Weber et al. 2024). The present study aims to evaluate the use of LTH as a protein source in the concentrate mixture for lactating sows. The following research questions were investigated: How do the lactating sows accept a concentrate mixture containing 20% LTH (based on fresh matter)? The following research questions were investigated: How do the lactating sows accept a concentrate mixture containing 20% LTH (based on fresh matter)? And, how does the use of LTH affect the lactation performance and the sows' body condition?

Material and methods

The experiment took place at the Educational Center and Experimental Station for Organic Farming of Bayerische Staatsgüter Kringell (Hutthurm, Germany) from December 2022 to May 2023. Animal husbandry followed the Regulation (EU) 2018/848. During the lactation period, in total 22 sows were fed either a lucerne-based concentrate mixture containing 20% LTH based on fresh matter or a control concentrate mixture. During the lactation period, a total of 22 sows were fed either a lucerne-based concentrate mixture containing 20% LTH based on fresh matter or a control concentrate mixture. The sows were assigned to either group based on breed, parity, and farrowing date. Each group consisted of 10 German

Landrace sows and one Large White sow to ensure a balanced distribution in the groups.

Diet preparation

On September 21, 2022, the LTH were harvested (bud stage, 4th cut) using the high-cut technique from Zürn Harvesting GmbH (TOPCUT collect harvester, Schöntal-Westernhausen, Germany). The following day, the LTH underwent a hot-air drying and were pressed into pellets at Futtertrocknung Lamerdingen eG (Lamerdingen, Germany). The drying temperatures initially ranged from 200 to 600 °C and decreased to 100 °C at the end of the drying drum. The process took roughly five minutes. The lucerne concentrate mixture contained 20% LTH on an as-fed basis. Both lactation concentrate mixtures were designed as isocaloric and isonitrogenous based on the supply recommendations (GfE 2006), and they included the same basic feed components. Soybean cake was bought from the company Witzmannmühle (Aspach, Austria) and had a trypsin inhibitor activity (TIA) of 5.6 mg/g. Table 1 shows the nutrient composition of the main protein feedstuffs used in the lactation concentrate mixtures.

The concentrates were mixed on-site. The crude nutrient composition was analyzed by LKS mbH (Lichtenwalde, Germany), and the amino acid composition was analyzed by AGROLAB LUFA GmbH

Table 1 Analyzed nutrient composition of the primary protein sources used in the lactation concentrate mixtures

Item		LTH ^a	Soybean cake	Faba beans
Dry matter	g/kg FM	926	927	872
Crude ash	g/kg DM	90	62	45
Crude protein	g/kg DM	274	465	311
Crude fiber	g/kg DM	139	45	116
Crude fat	g/kg DM	36	145	9
Starch	g/kg DM	12	34	410
Sugar	g/kg DM	97	83	18
Lysine	g/kg DM	12.8	28.3	19.1
Methionine	g/kg DM	4.5	6.2	2.0
ME	MJ/kg DM	10.1 ^b	17.0 ^c	13.9 ^c

^a lucerne plant tips, hot-air dried

^b ME: metabolizable energy calculated by GfE (2006) based on digestibility of nutrients for hot-air dried lucerne plant tips by Weber et al. (2024)

^c ME calculated by GfE (2006)

(Kiel, Germany). DM, crude nutrients, sugar, and starch were analyzed according to VDLUFA (2012). The amino acids were analyzed according to Commission Regulation (EC) No 152/2009. Table 2 shows the ingredients and calculated nutrient composition of both lactation concentrate mixtures.

Procedure of feeding trial

Ten days before farrowing, the sows were moved to the farrowing house. The farrowing house was

Table 2 Ingredients (%) and calculated nutrient composition of the lactation concentrates (on an as-fed basis)

Item	Control concentrate	Lucerne concentrate
Ingredients		
Lucerne plant tips, hot-air dried	-	20.0
Soybean cake (14% crude fat)	24.0	19.0
Field beans	6.0	5.0
Barley	52.4	19.0
Triticale	10.0	20.0
Corn	4.0	12.0
Soybean oil	-	2.0
Limestone	0.8	-
Monocalcium phosphate	-	0.2
Premix ^a	2.8	2.8
Nutrient composition, g/kg		
Dry matter	902	907
Crude ash	61	64
Crude protein	185	196
Crude fiber	49	57
Crude fat	46	64
Starch	402	332
Sugar	30	42
Lysine	9.57	9.75
Methionine	2.51	2.81
ME (MJ/kg) ^b	13.17	13.16

^a The premix provided the following (per kg): Ca 175 g; P 45 g; Na 65 g; Mg 20 g; vitamin A 280000 I.E., vitamin D 37000 I.E., vitamin E 4000 mg; vitamin B1 65 mg; vitamin B6 90 mg; vitamin B12 15000 mcg; L-Carnitine 1250 mg; choline chloride 12000 mg; vitamin C 1600 mg; iron-(II)-sulfate 4000 mg; copper-(II)-sulfate 150 mg; dicopper chloride trihydroxide 150 mg; zinc oxide 1000 mg; zinc chloride 1000 mg; manganese-(II)-oxide 600 mg; calcium iodate 60 mg; Sodium selenite 8 mg; Se 2.5 mg

^b ME: metabolizable energy calculated according to GfE (2008)

divided into three barns with eight pens each. Each pen had an indoor area and an outdoor area. Indoors, sawdust was used as litter, and in the outdoor run straw was used. All sows were treated against endo- and ectoparasites. For passive immunization of the piglets, all sows got vaccinated against neonatal diarrhea (Suisen-G). On the farrowing day, the piglets were weighed and received a navel disinfection. All piglets received an iron supplementation on day 3 and on day 14. On day 14 a vaccination against *E. coli* (STEC) took place. All piglets were vaccinated against Porcine Circovirus 2, *Mycoplasma hyopneumoniae* on day 21. For castration, the male piglets were given analgesia (Meloxicam) and inhalation anesthesia (Isoflurane). At farrowing, prostaglandin (Enzaprost), Oxytocin, Metamizol, Genabil, and Monzal were used to a limited extent. Five sows and five piglets needed antibiotic therapy for two to six days. The weaning took place after approximately 45.8 (SD: ± 4.9) days of suckling.

The blending of the gestation and lactation concentrate mixtures started on day 110 of gestation. On the day of farrowing, the diet consisted of 50% gestation concentrate mixture. The percentage decreased gradually until day 7 when no gestation concentrate mixture was fed anymore. The feed was offered twice daily. In the first week, the feed allowance was increased to the energy level recommended by GfE (2006), based on the sow's live weight and litter size. The sow was assigned to a feed curve according to her initial live weight. Feed curves were predefined for the weight classes 225, 245, 265, 285 and 305 kg. The allocation of the feed quantity could also be adjusted between 75 and 115% of the feed curve depending on the body condition and the sow's satiety.

The Spotmix-Feeding Automatic System (Schauer Agrotroic GmbH, Prambachkirchen, Austria) weighed the grounded meal for each individual and filled the trough with water (liquid feeding). Further water was offered ad libitum for sows and piglets through nipple- and cup-drinkers.

Sows with a low initial feed intake (e.g. they avoided the meal) received a supplementary concentrate (13.3 MJ ME/kg; 12.6 g lysine/kg) in addition to the lactation concentrate mixture. This concerned eight sows of the lucerne group and four sows of the control group. There was no set limit on quantity of supplementary feed – the maximum amount given was 2 kg/d to one sow during the first two weeks of

lactation. Other feedstuffs included cow milk and skim milk. Some sows received approx. 2 L of cow milk daily during the first week of lactation to ensure a good start. This counted for 13 sows (seven control and six lucerne sows). In addition, all sows were offered an unrecorded amount of maize silage as roughage in the outdoor run, as well as hay for nest building at farrowing.

In the first few days of life, the piglets were offered an electrolyte drink in the piglet nest. The piglets were adapted to solid feed beginning in the 2nd week of life by offering creep feed in the piglet nest. The creep feed was provided in ground form, and the quantity was adjusted to increase consumption. The quantity presented was recorded. Leftovers could not be recorded as the feed mixed with the bedding material. Litters in which piglets grew apart or the sow showed a lack of milk received skim milk. This counted for two litters in the control group and four litters in the lucerne group. These litters received on average 4 L per day for the length of 13 (min 4, max 27) days.

At weaning, feeding was switched off before the morning feed, and the sow moved to the mating center while the piglets stayed in the farrowing pen for one more week. Then they were transferred to the farm's rearing pens.

Data collection

The trial started with farrowing and ended with weaning. The evaluation period was set from days 1 to 42 of lactation, as the number of sows remaining in the trial decreased after that, which would limit a robust analysis. The sows were weighed when stabling (approx. day 108 of gestation, six days before farrowing), at weaning, and on day 28. The weight of the pregnancy products was determined at birth and subsequently deducted from body weight. The gestation products consist of the weight of the dead and live piglets and a correction factor of 3 kg for birth by-products such as placenta and amniotic fluid. The exponential weight development of the fetuses in the last days before birth cannot be considered, as no literature data is available on this. The correction factor is derived from two control weights of placentae and estimates of further placentae. This subsequent correction allows the accurate weight of the sow to

be derived after farrowing. The stress of weighing shortly after birth could thus be avoided.

Backfat was measured using a B-mode ultrasound scanner (linear probe, KX 5200 V, Physia GmbH, Neu-Isenburg, Germany) with the three-point method on the animal's right side as used by Hesse (2003). The Landeskuratorium der Erzeugerringe für tierische Veredelung in Bayern e.V. (LKV, München, Germany) taught the correct data collection via the three-point method in a personal training. The B point is located in the middle of the shoulder blade and ham, approximately 6 cm to the right of the spine. Point A is approximately 15 cm further cranial, without including the shoulder girdle muscles. Point C is 15 cm further caudal. An average of the three points reflects the thickness of the backfat. The linear probe was aligned perpendicular to the spine. Each measurement was saved as an image (Fig. 1). The measurement points were centered at the uppermost edge of the image and the border between the connective tissue layer and the longissimus dorsi muscle. Overall, the backfat consists of the skin, the first (subcutis) and second fat layer (interfascial fat layer), and the underlying connective tissue (fascia lumbodorsalis) (Müller and Polten 2004).

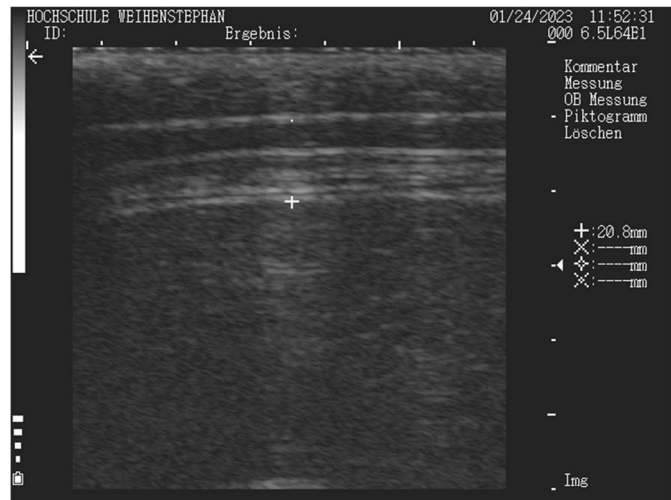
Backfat thickness was measured on average one day before farrowing, as the exact farrowing date could vary, and every 14 days until weaning. Interpolation was used for each sow to give the expected backfat thickness for the same day in relation to its lactation period.

Individual piglet weights were measured from farrowing every seven to 14 days. Piglet losses were weighed, and their causes were recorded in the herd register. In the first four days of life, the litters were balanced regardless of group assignment. The live weights of sows and piglets as well as the backfat thickness were interpolated for each lactation day to depict the development over time.

The feed intake was recorded daily, and refusals were reoffered once and weighed back afterward. The health status of the sows was documented in the first days after farrowing. Body temperature was measured daily, and the staff subjectively evaluated behavior and feed intake. The climatic conditions, temperature, and humidity were recorded at 12 different points in the barn and outdoor run.

The statistical analysis was performed using the PROC GLIMMIX procedure in SAS (Version 9.4,

Fig. 1 Exemplary image of the backfat measurement at Point C. The measurement includes Epidermis, Dermis, Subcutis and Fascia lumbodorsalis. Deeper: musculus longissimus dorsi (outside of the measurement)



2013. A three-factor analysis without interactions was performed by feeding group (control or lucerne), parity group (all parities included: group 1=parity 1; group 2=parities 2–4; group 3=parities 5–6), and time (1 = weaning from February to March; 2 = weaning from April to May). The calculated data are given as least square means with standard error. The p -value < 0.05 indicates significant differences.

Results

Table 3 shows the analyzed nutrient composition of the lactation concentrate mixtures. The amount of CP and the energy level drifted apart between the control and lucerne concentrate mixtures compared with the initially calculated values. Consequently, lysine and methionine also did.

Table 4 shows relevant parameters for the sows selected for the trial initially. Therefore, the groups did not significantly differ from each other. The average parity in the control group was 3.6 (SD: ± 1.37) and in the lucerne group 3.5 (SD: ± 1.92).

The effect of diet on the performance of sows is presented in Table 5. The effects of parity group and time are only occasionally significant, so they are not presented here. For five out of 11 sows in the lucerne group, the blending with the lucerne concentrate mixture first started at farrowing due to a misunderstanding of the feeding system. This abrupt change, combined with the stress of farrowing, likely intensified the negative effects on the palatability of the lucerne

Table 3 Analyzed nutrient composition of the lactation concentrates (arithmetic mean $\pm$ SD; as-fed basis) ^a

Item	Control concentrate		Lucerne concentrate	
Dry matter	896	± 5.44	905	± 1.89
Crude ash	56	± 0.82	60	± 0.82
Crude protein	157	± 5.72	186	± 6.02
Crude fiber	52	± 4.90	59	± 3.30
Crude fat	44	± 2.45	69	± 0.82
Starch	422	± 6.24	340	± 12.75
Sugar	39	± 3.27	54	± 0.47
Lysine	8.43	± 0.19	9.67	± 0.37
Methionine	2.13	± 0.47	2.47	± 0.21
ME (MJ/kg) ^b	13.0	± 0.08	13.3	± 0.09

^a mean values from three samplings

^b ME: metabolizable energy calculated according to GfE (2008)

feed. The daily feed intake of all sows was below the recommended level (GfE 2006). The animals in the lucerne group consumed lower daily feed quantities compared to the control. These sows consumed more of the supplementary concentrate. The daily feed intake for the observation period of day 1 to 42 is also given in MJ ME. All measured feeds (lactation concentrate mixture, supplementary concentrate and milk) were included here to compare the energy input with the performance.

Sows with a significantly low ME and nutrient intake showed a slightly faster decrease in backfat

Table 4 Characteristic parameters for the sows selected for the trial (least square means and standard error)^a antepartum^b calculated live weight after farrowing: live weight a.p. minus litter weight minus 3 kg birth by-products

Item		Control group		Lucerne group		<i>p</i>
Number of litters	<i>n</i>	11		11		
Live weight 1 week a.p. ^a	kg	273.0	(± 7.51)	264.2	(± 7.27)	0.38
Live weight day 1 ^b	kg	247.8	(± 7.29)	241.5	(± 7.05)	0.51
Backfat thickness at farrowing	mm	26.7	(± 1.63)	29.3	(± 1.58)	0.22
Litter weight	kg	22.2	(± 1.35)	19.8	(± 1.31)	0.19
Liveborn per litter	n	14.3	(± 0.98)	13.8	(± 0.94)	0.73
Deadborn per litter	n	1.2	(± 0.67)	1.2	(± 0.65)	0.99

Table 5 Diet effects on the performance of sows in the lactation period (least square means and standard error)^a contains lactation concentrate mixtures, supplementary concentrate and other feedstuff (like milk)^b in each group, two gilts weaned before day 42

Item	Control group	Lucerne group	p	
Feed intake				
Day 1 to 28, kg lactation mixture/d	5.7 (±0.31)	4.0 (±0.30)	<0.001	
Day 28 to 42, kg lactation mixture/d	6.7 (±0.29)	5.6 (±0.27)	0.01	
Day 1 to 42, kg lactation mixture/d	6.2 (±0.24)	4.8 (±0.23)	<0.001	
Day 1 to 28, kg supplementary concentrate/d	0.09 (±0.13)	0.22 (±0.12)	0.42	
Day 28 to 42, kg supplementary concentrate/d	0.01 (±0.01)	0.02 (±0.01)	0.55	
Day 1 to 42, kg supplementary concentrate/d	0.02 (±0.09)	0.14 (±0.09)	0.35	
Day 1 to 42, MJ ME/d ^a	81.4 (±2.83)	65.8 (±2.68)	<0.001	
Backfat thickness, mm				
Day 28	20.9 (±1.90)	22.2 (±1.84)	0.60	
Day 42 ^b	17.7 (±2.47)	20.5 (±2.33)	0.40	
Losses (day 1 to 28)	−5.8 (±0.94)	−7.1 (±0.91)	0.29	
Losses (day 28 to 42) ^b	−2.1 (±0.55)	−2.2 (±0.52)	0.89	
Losses (day 1 to 42) ^b	−7.6 (±1.38)	−8.4 (±1.30)	0.68	
Live weight, kg				
Day 28	236.3 (±8.53)	226.4 (±8.25)	0.38	
Day 42 ^b	242.4 (±9.90)	237.2 (±9.37)	0.69	
Losses (day 1 to 28)	−11.5 (±4.07)	−15.1 (±3.94)	0.50	
Losses (day 28 to 42) ^b	−5.5 (±3.45)	−7.8 (±3.26)	0.61	
Losses (day 1 to 42) ^b	−13.0 (±5.91)	−17.9 (±5.59)	0.54	

thickness. The higher backfat thickness in the lucerne group compared to the control group stayed present throughout the lactation, but the backfat losses were greater than in the control group. The development of the backfat decrease seems to have flattened out in the last two-week interval of the lactation period. The live weight of the lucerne group stayed under the level of the sows in the control group throughout the lactation period, and the losses were higher here. The development of the live weight regarding a two-week interval seems to have decreased linearly. In all observations regarding the last third of the lactation period, it must be noted that two gilts from each group got weaned before day 42 for management reasons.

Over both groups, the mean live weight without the gilts would have been 246.9 kg (standard deviation (SD): ± 22.2) on day 28, and 243.0 kg (SD: ± 25.3) on day 42. The losses would have been more linear because day 1 to 28 would have had losses of about −10.6 kg (SD: ± 12.2).

The performance of sows regarding their piglets is shown in Table 6. The number of piglets per litter, the piglets' individual live weight, the litters' daily weight gain and the piglets' daily weight gain were at the same level in both groups. Of 320 piglets born, 32 were dead. Of the 288 liveborn piglets, 2 were given to other sows outside the trial. Of 286 piglets starting the trial, 39 were crushed by the sow

Table 6 Performance of suckling piglets regarding litter size and weight development (least square means and standard error)

Item	Control group		Lucerne group		<i>p</i>
Number of piglets per litter					
Day 4 ^a	12.4	(± 0.52)	11.4	(± 0.50)	0.169
Day 28	11.5	(± 0.47)	11.0	(± 0.46)	0.392
Day 42	9.9	(± 0.66)	9.0	(± 0.63)	0.303
Piglets live weight, kg					
Day 1	1.48	(± 0.080)	1.36	(± 0.077)	0.274
Day 28	8.84	(± 0.370)	8.16	(± 0.358)	0.169
Day 42	13.60	(± 0.546)	13.25	(± 0.517)	0.623
Litter weight gain, kg/d					
Day 1 to 28	2.94	(± 0.163)	2.61	(± 0.158)	0.134
Day 28 to 42	2.52	(± 0.286)	2.23	(± 0.280)	0.455
Day 1 to 42	2.63	(± 0.175)	2.28	(± 0.172)	0.143
Piglets weight gain, g/d					
Day 1 to 28	256	(± 11.76)	239	(± 11.37)	0.289
Day 28 to 42	275	(± 15.68)	268	(± 15.16)	0.713
Day 1 to 42	268	(± 10.88)	254	(± 10.52)	0.332

^a after litter balancing

(13.5%), 9 were euthanized because of anomalies or weakness, and 2 died. In total, suckling piglet losses amounted to 17.5%. 236 piglets reached day 28. Furthermore, 8 piglets in the control group and 6 piglets in the lucerne group were then selected for the Bavarian breed examination, so 222 piglets finished the full observation time.

Discussion

Feeding value of LTH

There is limited published research on lucerne plant tips. The LTH used in this study is comparable to the LTH from Bellof et al. (2021), who developed the first high-cut harvesting method for lucerne. LTH shows a well-balanced lysine-methionine proportion compared to other equal protein sources, for example, faba beans. Therefore, LTH shows a strong potential addressing the challenges in organic pig feeding. The feeding value of soybean cake can be reduced because of the present trypsin inhibitors. A high TIA value is directly linked to reduced digestibility of amino acids and crude protein in pigs (Chen et al. 2020). The used soybean cake showed a TIA value which is over the recommended threshold (Turner et al. 2020). When interpreting Table 1, it is important to note that all values are subject to variation due to factors such as

location, year, harvest time, and climate. The quality of the LTH depends on the leaves, as the leaves are the biggest part of the LTH. The quality of the leaves is influenced on the one hand by the harvest management (e.g. number of cuts, time of harvest or location), and on the other hand by sorts and kinds (Hoischen-Taubner et al. 2017). The saponins reduce the feeding value of lucerne products, but the amount of antinutritional ingredients in its tips is lower than in the leaves (Górski et al. 1984). Lysine and methionine are the first limiting amino acids in the feeding of monogastrics. An analysis of the nutrient composition of primary organic feed sources reveals that methionine requirements are not adequately met (Zollitsch et al. 2004). Consequently, lucerne plant tips present significant potential for organic pig production due to their ability to address the deficiency of essential amino acids (Sommer and Sundrum 2015; Weltin et al. 2014).

Calculation and analyses of the lactation concentrate mixtures

The calculated protein level of both concentrate mixtures were not be fully achieved. In particular, the control concentrate mixture contained less protein than originally intended. Given that the control concentrate mixture included a higher proportion of soybean cake, this suggests that the intended mixing

ratio was not reached during feed preparation. On the other hand, the energy level difference between control and lucerne concentrate mixture was bigger than calculated. This could be due to the inaccuracy of sampling either the feedstuffs or the diets. The feed mixture for the lucerne group showed a slightly higher energy level than the control concentrate mixture. When the diets were calculated, the energy level of the LTH was estimated at 8.5 MJ ME/kg DM using digestibility values of lucerne meal since the exact values were not determined at this time. Soybean oil and a higher amount of corn were used to address the apparent need of balancing the energy level of the test concentrate mixture. Weber et al. (2024) determined the exact digestibility quotient for this new feedstuff, leading to a higher energy level (Table 1). Consequently, the daily energy intake is also shown in the present trial, besides the kg per day. The lactation concentrate mixtures correspond to the recommendations of LfL (2024).

Initial parameters in the beginning of the trial

The live weight of sows correlates with the parity (Kecman 2016). For the 4th lactation, the GfE (2006) predicts a live weight of 245 kg at the beginning of the lactation. The sows of the present trial show the expected live weight. The backfat thickness of the sows in this trial is higher than reported in the literature. In the study by Bergsma et al. (2009) the sows display 17.6 mm, and Weissensteiner et al. (2018) show a maximum of 15 mm before farrowing. Bergsma et al. (2009) had a very high range from 7.5 mm to 38.0 mm. When comparing the backfat thickness in different studies, measuring management plays an important role as measuring depends on the used device and the measuring method (for example, P2-method, ABC-method) (Hesse 2003). At least Weissensteiner et al. (2018) also used a picture-driven device with the measuring point a half width of a hand beside the spine. The P2-point measuring is comparable to the point C in the ABC-method (Hesse 2003). The hormone leptin is implicated in feed intake regulation (Estienne et al. 2000). A high backfat thickness goes along with an increasing leptin-level in serum of the sows (Estienne et al. 2000), and fat sows had a lower feed intake than thin sows (Mullan and Williams 1989).

The number of liveborn piglets in the present trial is high compared to the literature for organic pig husbandry. In the studies by Weissensteiner et al. (2018), Beyga and Rekiel (2010), Young et al. (2016) and Bergsma et al. (2009), fewer piglets were born alive. Werner and Bussemas (2021) and Bussemas and Weißmann (2009) presented a similar level of 13 to 15.3 liveborn piglets. The number of stillborn piglets lays within the range of Werner and Bussemas (2021) and Bussemas and Weißmann (2009).

Development of the condition in relation to the daily feed intake

The backfat losses are slightly higher than those in the literature. But the values given in the literature are mostly for thinner sows (< 25 mm); for example, the study by Bergsma et al. (2009) shows 14.4 mm in the average at weaning (−3.2 mm loss) with a range from 6.5 to 29.0 mm. Remember, the maximum at farrowing was 38.0 mm, so the thick sows lost 9 mm within 25 d of suckling (Bergsma et al. 2009). Sows with a high backfat thickness show greater losses in the lactation period. Mullan and Williams (1989) discovered that gilts with high body reserves at farrowing (171 kg live weight and 32 mm backfat thickness) mobilized more body reserves during lactation (−30.7 kg and −4.3 mm) than gilts with less body reserves. Also, Estienne et al. (2000) discovered that the fatter sows (backfat thickness at farrowing: 28.1 mm) had greater backfat losses than thinner sows during lactation (−6.7 mm down to 21.8 mm at weaning compared to −1.8 mm down to 13.7 mm).

However, the live weight loss is independent of the backfat thickness at farrowing, as Estienne et al. (2000) found within the range of 12.6 to 20.6 kg losses. The live weight loss is significantly influenced by the growth rate of the litter (Werner and Bussemas 2021). In the present study, the live weight losses are within the norm. GfE (2006) recommends a maximum of 10 kg losses within 25 d of suckling for the presented litter growth rate. Kirchgeßner et al. (2014) recommend a live weight loss of 5 to 7.5% and 10 to 20 kg, respectively. Kamphues et al. (2014) consider manageable losses of up to 10% of the live weight.

The feed intake is mainly defined through body condition and litter size and increases throughout the lactation period (Weissensteiner et al. 2018). The daily feed intake of all sows was below the

recommended level of GfE (2006). The feed intake of the control group is comparable to the feed intake from Werner and Bussemas (2021), who used a concentrate of 13.1 to 13.3 MJ ME/kg FM requiring 6.2 to 6.6 kg/d per sow. Weissensteiner et al. (2018) had slightly higher daily feed intakes though less weaned piglets (6.9 to 7.4 kg/d). Mullan and Williams (1989) discovered that gilts with high body reserves at farrowing had a lower food intake than sows with a low level of body reserves. Estienne et al. (2000) discovered a leptin increase for fat sows (> 25 mm), which went along with a lower feed intake. Besides the influence of the backfat thickness on the daily feed intake, a low feed intake also leads to a greater backfat loss.

The low ME and nutrient intake of the present sows could have contributed to an increased decrease in backfat thickness. A sow can often not cover her energy requirements from feed alone (NRC 1987). The sow's body reserves are made available for further milk production. Low feed intake results in greater body condition loss (Sulabo et al. 2010; Young et al. 2016). The significant difference regarding the feed intake of the lucerne group could be reasoned by the saponins and their negative influence on palatability (Sen et al. 1998). An adaptation to the reduced palatability is possible and necessary as Lauer et al. (2023) have shown. In this trial, the sows were given just a short time to adapt to lucerne tips, as the lucerne tips were not part of the gestation diet. For further research, LTH should be part of the gestation feed mixture to improve feed acceptance during the subsequent lactation period. It is possible for fattening pigs to consume hot-air dried lucerne leaves up to 20% in the feed mixture without performance problems (Messinger et al. 2021). Hot-air dried lucerne leaves were successfully used up to 10% in the lactation concentrate mixture of lactating sows in the studies of Werner and Bussemas (2021). They fed 1% of the gestation concentrate mixture with lucerne leaves for adaptation. LTH was used up to 20% in the concentrate for rearing piglets by Lauer et al. (2023). Though the piglets showed an adaptation period in the form of slowing down in growth, the feed utilization was on the same level as in the control group.

Besides the importance of adaption time, lucerne plant tips could more enrich the feeding of lactating sows if they are ensiled before. Ensiled lucerne products have a different saponin composition which

probably leads to more acceptance (Szumacher-Strabel et al. 2019). The silage would have to be presented separately to the lactation meal, as most feeding systems used in farrowing stable do not support silage within a grounded meal.

Litter size and weight gain performance

Prior to the experiment, the average number of weaned piglets per sows and litter was 10.9. The lower number of weaned piglets (on day 42) observed during the experiment can be attributed to the removal of piglets on day 28 for the country's genetic examination. No piglet died after day 28. Therefore, the number of piglets recorded on day 28 reflects the actual number of weaned piglets. Piglet losses during the lactation period were on the same level for similar farrowing systems (Nicolaisen et al. 2018; Werner and Bussemas 2021).

Piglet growth performance tends to decline as litter size increases (Auldist et al. 1998). In the present study, piglet weight gain during the lactation period was at the same level in both groups but lower than in the studies by Werner and Bussemas (2021) and Baldinger et al. (2017), though these studies documented larger litter sizes at weaning. Weissensteiner et al. (2018) registered similar daily growth rates for the piglets in litters smaller than those in the present study. However, despite the smaller energy input in the lucerne group, both groups showed a similar piglet growth performance. This was also discovered by Mejia-Guadarrama et al. (2002). These authors showed a negative impact of low protein intake regarding the body weight loss of sows. Still, a low protein intake did not influence the piglets' growth rate. In the studies of Weissensteiner et al. (2018), there was also no negative influence of dietary protein levels (low vs. high) on litter weight gain. Besides that, Noblet and Etienne (1989) correlated milk production with the piglets' growth. So even when the feeding does not contain sufficient energy for the milk production of the sows, the sows will be able to mobilize their body reserves to ensure the piglets grow well.

Conclusion

In this trial the lactation concentrate mixture with 20% LTH was compared to a control concentrate mixture. The high initial backfat thickness of the sows is presumed to be a contributing factor to the low feed intake observed in both groups relative to the recommendations (GfE 2006). Due to the reduced palatability, the lucerne-containing concentrate mixture was less accepted than the control concentrate mixture, and sows of this feeding group showed lower feed intakes. Nevertheless, there were no significant differences in the mobilization of body reserves or in piglets' growth. For further feeding recommendations, early acclimatization is advisable to improve acceptance of LTH. LTH must already be included in the gestation diet for successful use. LTH could therefore be a useful protein feed for organic sow feeding delivering a meaningful part of protein and essential amino acids.

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Data availability The data that are used in this study are available from corresponding author, on request.

Declarations

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