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Effects of Using Farm-Grown Forage as a Component in ad Libitum Liquid Feeding for Pregnant Sows in Group-Housing on Body Condition Development and Performance

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Abstract: When feeding pregnant sows, optimal body condition at birth is sought to avoid the effects of a deviant nutritional condition on health and performance. Various feeding concepts exist but mainly have a restriction in quantity and renunciation of farm-grown forage in common. An ad libitum liquid feeding system based on farm-grown forage in combination with a sow sorting gate (according to body weight—using mechanical scales) was realized on a commercial swine farm. The sorting gate coordinated access to two feeding areas with rations based on whole plant wheat-silage (WPWS) differing in energy content. In this study with a total of 183 pregnant sows, effects of restrictive dry feeding (System I) were compared with ad libitum liquid feeding based on farm-grown forage (System II). Sows were monitored regarding body condition development during pregnancy by measuring body condition score (BCS), body weight (BW), and back fat thickness (BFT) on different time points. Sow and piglet health (vaginal injuries of sows, rectal temperature during the peripartal period, vitality of newborn piglets) and performance data regarding litter characteristics were also recorded. Body condition development of the sows was absolutely comparable. Performance indicators and the course of birth were also similar but with significantly higher scores for piglet vitality in System II ($p < 0.05$). The tested concept offers opportunities for more animal welfare and sustainability but remains to be further investigated regarding the repertoire of possibly applied farm-grown forage and the effects of the concept in the transit phase of sows.

Keywords: forage; liquid feeding; gestation; lactation; sow; ad libitum feeding; sorting gate; feed self-sufficiency

1. Introduction

Developments regarding improvements in animal welfare in pig farming and feeding are being discussed throughout Europe [1,2]. Gestating sows must be kept in groups from the 29th day of pregnancy until 7 days before the determined farrowing time in accordance with the EU Council Directive 2008/120/EC of 18 December 2008.

In the feeding of pregnant sows, the aim is to achieve optimal body condition of the animals at birth to avoid the effects of an obese or very lean nutritional status on health and performance. This is because overconditioning can favor the occurrence of postpartum dysgalactia syndrome by prolonging the farrowing duration [3,4], and severe body weight (BW) losses can have negative effects on fertility and longevity [5,6].

To maintain optimal body condition in group-housed sows, only a limited number of housing concepts are suitable. For example, sows can be kept in small groups and fed restrictively according to condition. If the sows are kept in a large group, individual feeding can be used, for example, on automatic feeders [7]. To the best of our knowledge, there is as yet no management system of sows in large groups with ad libitum feed supply based on roughage and separation solely for feeding according to body condition.

The choice of feed components is varied in sow feeding. In the past—up to the second half of the last century—pigs were often fed roughage, silages, and beets, supplemented with concentrates and mineral feeds [8]; as pigs in far smaller production units were often housed outside and after the second world war, cereal-based feeds were very expensive [8]. In the intensified pig farming of the last few decades up to now, "combined feeding" has little significance because pigs are being expected to grow as efficiently and fast as possible [9]. Additionally to production performance, the labor and time requirements of the respective feeding system and problem-free manure removal are the basis for the commercial use of a husbandry system [10].

The current concentrate-based supply of feed meets the sows' nutritional needs, but not their desire for continuous foraging and voluntary feed intake [11–13]. Animals often show increased manipulation of housing equipment or stereotypic behavior due to an unfulfilled feeding and foraging motivation and hunger [14,15]. To ensure that the supply of crude fiber to pregnant gilts and sows is adequate, different crude fiber carriers and feeding concepts are available to pig farms [16–18]. Technologically advanced liquid feeding systems facilitate the safe provision of liquid diets from chopped whole plant silage in combination with other forages [19]. A basic forage-based and fiber-rich ration can meet nutrient requirements while as well meeting the sows' distinct food intake needs when an ad libitum diet is provided [13,20,21]. The gestating sows can consume an individual amount of feed together at any given time. Additionally, using higher amounts of farm-grown forage instead of imported concentrates can lead to higher feed self-sufficiency of farms [22,23]. Farm-grown forage used for ad libitum feeding of pregnant sows can therefore offer an option for animal nutrition and welfare in a sustainable production system.

The aim of the present study as part of the "SWOF" project (sow welfare optimized feeding) was to compare two feeding systems for group-housed sows in order to achieve ad libitum feeding in larger groups of sows while maintaining body condition during gestation, sow and piglet health in the peripartal period and performance data. The comparison included one conventional concentrate based and restricted dry feeding regime and one roughage-based ad libitum liquid feeding regime.

2. Materials and Methods

In a field trial, ad libitum feeding based on whole plant wheat-silage (WPWS) was implemented for pregnant sows in group housing using an automated sorting gate to give sows access to rations with either high or low energy content depending on their BW (System II). This was compared with a conventional feeding system (restrictively a dry complete pelleted feed, System I).

2.1. Animals

The animal housing and data collection took place in accordance with German regulations. No relevant interventions in accordance with the German Animal Welfare Act had been carried out on live animals (Approval by the Animal Welfare Officer of the University of Veterinary Medicine Hannover, Foundation, Hannover, reference: TVO-2017-V-49).

The study was carried out at a conventional farm in Germany with approximately 1200 sows (Danzucht) between January and June 2018. Sows were weaned at 1-week intervals. At a maximum of 28 days after service, sows were moved to the respective group-housing system. At day 108 of gestation, about one week before the estimated farrowing date (115 d p.c.), the sows entered the farrowing compartments. After a 28-day suckling period and weaning of the piglets, the sows again entered the service area. In two successive approaches, a total of 92 sows in System I and 91 in System II could be incorporated in the study. In the first run, 50 sows in System I and 49 in System II were included, in the second approach, 42 sows were included in each system. At the beginning of the trials, the sows have had an average of 2.86 litters in System I and 2.78 litters in System II.

2.2. Housing System

2.2.1. System I

In System I, each group consisting of 35–55 sows on the farm was housed in a compartment, which was again divided by a partition wall, where cross troughs were installed (Figure 1). Drinkers were mounted on the side walls in each compartment. Each pen in the compartments of the control group was equipped with volumetric feeders, and the cross trough extended the entire length of the compartment.

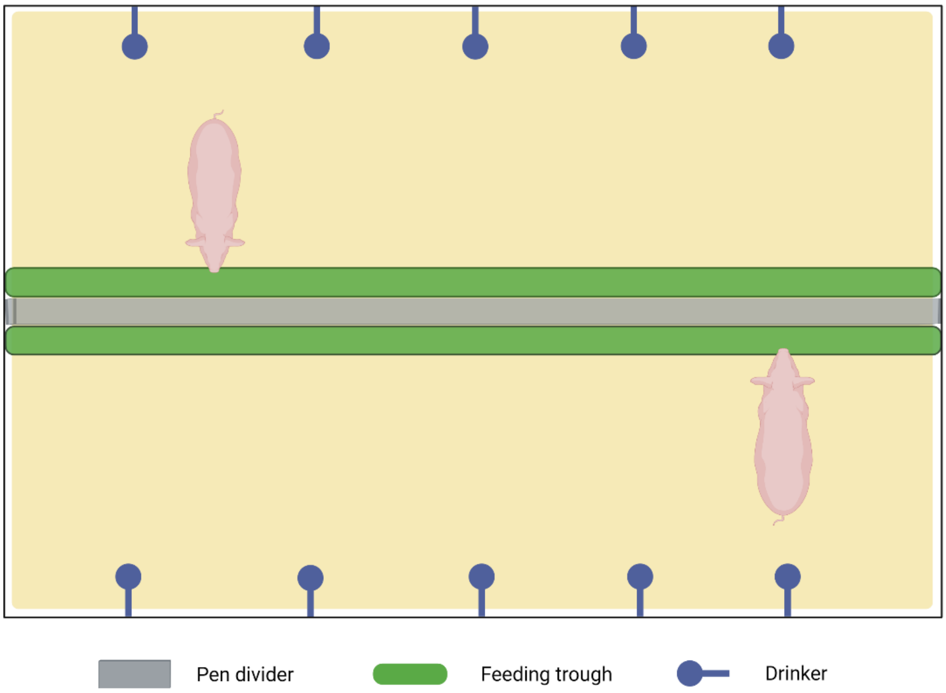

Figure 1. Housing of gestating sows in System I (Figure was created with BioRender.com) (accessed on 29 November 2021).

2.2.2. System II

In System II, the pregnant sows were kept in a large dynamic group, the size of which varied between 76 and 117 animals. Feasible group sizes in the two systems were determined by the structural conditions of the farm buildings. The sows were provided with different functional areas in the compartment—a resting/activity area and two feeding areas (Figure 2).

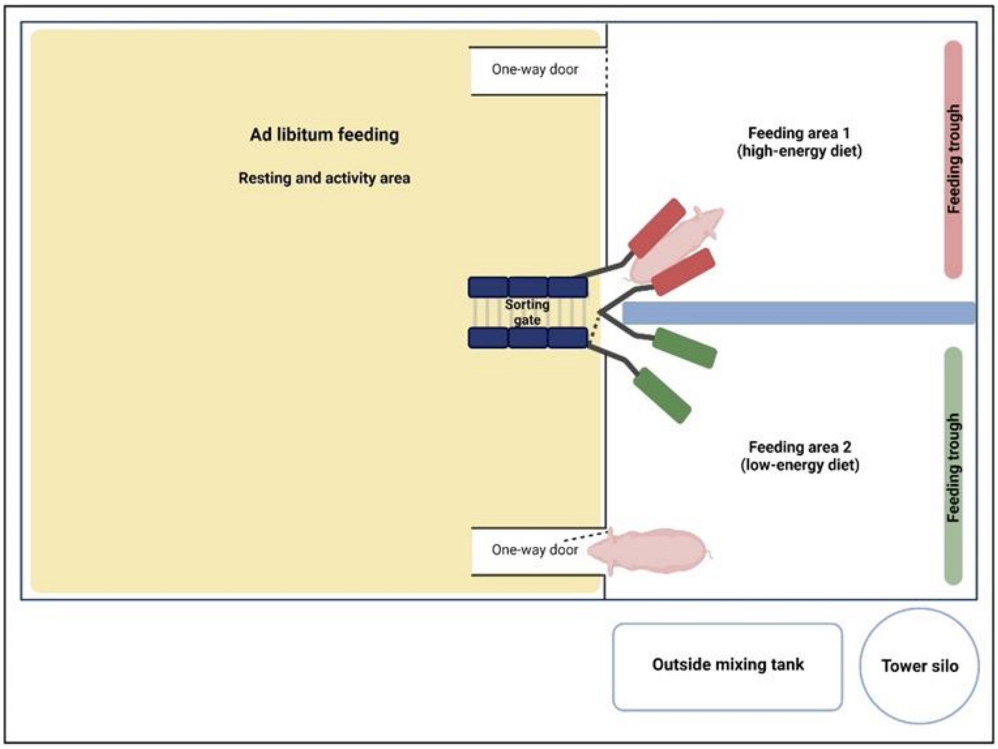

Figure 2. Housing of gestating sows in System II (Figure was created with BioRender.com) (accessed on 29 November 2021).

The resting/activity area was built with pen construction elements and had alternating perforated and paved areas. This functional area contained the drinkers and centrally the access to the feeding areas through a sorting gate (Hölscher + Leuschner GmbH & Co. KG®, Emsbüren, Germany). The sorting gate separated the feeding area from the activity and resting area (Figure 3).

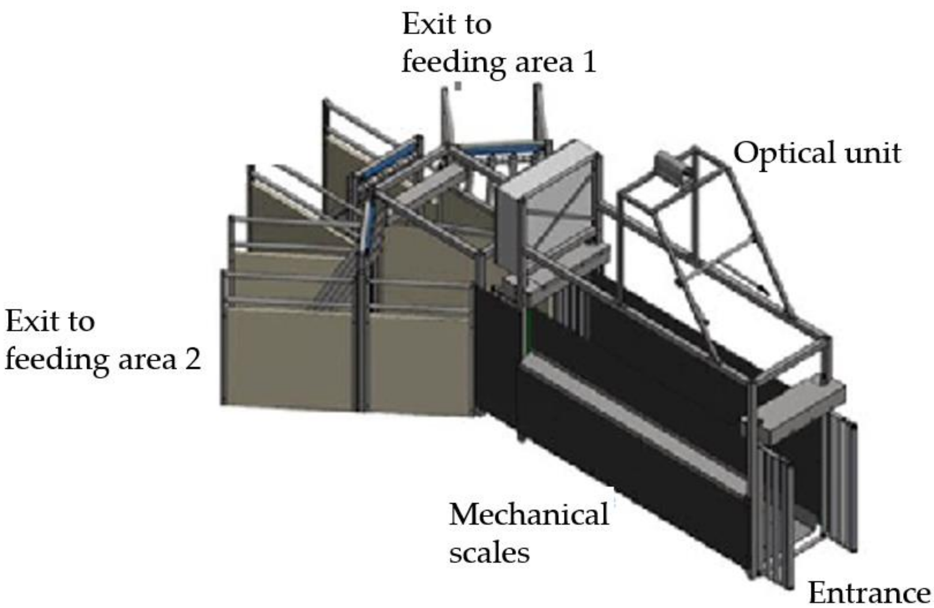

Figure 3. Design of the sorting gate for group-housed pregnant sows.

Transponder ear tags of the sows enabled automatic identification and storage of individual animal data. In addition to the optical unit (measuring height and width of the animals), the gate also contained mechanical scales for documenting BW. Sows could only enter the feeding areas through the gate, allowing access to one of two feeding areas with different feed ratios depending on body condition.

2.3. Diets and Feeding Technique

The sows in System I were fed restrictively using a chain feeding system with crumbled pellets (Tables 1 and 2). The amount of feed was manually adjusted on the volumetric feeders. Sows received feed twice daily. The complete feed used was purchased by the farm. In System II, the liquid feeding system from the company Hölscher + Leuschner GmbH & Co. KG (Emsbüren, Germany) was based on WPWS (Tables 1 and 2). The silage was taken from the silo and mixed with water in an outside mixing tank (approx. 11.5% DM). The mixture was pumped into the mixing tank of the liquid feeding system in the barn building and was completed with barley meal, soybean extraction meal, and mineral feed. Table 1 displays the botanical composition of the compound feeds used in Systems I and II. The two ad libitum rations were each pumped in stub lines to the troughs so that any ration could be fed at any time in System II. Sensors were integrated into each trough to measure the filling level. If the level in the trough was low, the feed was added automatically. Feeding was carried out in four feeding blocks and started in the morning at 03:00. A feeding break was taken from 21:00 to 03:00 to empty the trough once a day for hygienic reasons.

Table 1. Botanical composition of the complete feed for the restrictively fed sows in System I according to feed declaration and for the two ad libitum feed rations (% of dry matter-DM) in System II.

System I	System II		
Component	**Component**	**Low-Energy Ration**	**High-Energy Ration**
Barley	Barley	30.93	48.54
Wheat bran	WPWS	51.55	25.89
Oats	Soybean extraction meal	13.40	21.04
Rapeseed cake	Mineral feed	4.12	4.53
Extracted sunflower seed meal			
Sugar beet pulp			
Soybean hulls			
Soybeans (toasted)			
Malt culms			
Sugarbeet molasses			
Brewer's yeast			
Calcium carbonate			
Monocalcium phosphate			
Sodium chloride			

Table 2. Chemical composition of the three different compound feeds used in the trials (% of dry matter—DM).

Chemical Component	Restrictive Dry Feed-in System I	Ad Libitum Liquid Feed in System II	
		Low-Energy Ration	**High-Energy Ration**
Crude protein	17.2	18.5	22.5
Crude fat	4.18	2.18	2.38
Crude fiber	8.48	12.7	9.34
Ash	5.90	5.30	5.16
Calcium	0.79	0.76	0.81
Phosphorus	0.68	0.41	0.46
Sodium	0.25	0.15	0.13
Starch	37.4	34.6	37.0
Energy (MJ ME/kg DM)	13.31	11.54	13.15

The chemical composition of the two different feed ratios as well as of the restrictive dry feed is displayed in Table 2.

Sows in System II were identified by the transponder and automatically sorted by age and weight using an algorithm. With controlled access to low or high energy and nutrient feed, those sows were able to ingest feed ad libitum together at the cross trough at any time. If the target condition could be determined for a sow, it was assigned to the feeding area with lower-energy and -nutrient feed. The target condition or weight was set according to the BW of sows under restrictive feeding (Table 3).

Table 3. Sorting gate algorithm according to body weight (BW) and parity.

Parity	Target BW (kg)	Sorting to the High-Energy Ration BW (kg)	Sorting to the Low-Energy Ration BW (kg)
0	225	<215	>235
1 and 2	270	<260	>280
3 and 4	300	<290	>310
>5	325	<315	>335

2.4. Data Collection

2.4.1. Feed Intake

Daily feed consumption was calculated for both systems. For the sows in System II, the amount of daily feed allocation per valve was recorded by the computer of the liquid feeding system every day during the study. The number of sows using the feeding area was recorded by the sorting gate. From this, the average feed intake could be calculated. Feed losses at the trough could not be taken into account. The sows in System I received feed twice daily. The volumetric feeders installed in the compartment were gauged, and the feed quantities weighed. From this, the average feed intake per animal could be calculated.

2.4.2. Body Condition Development

The BW of the sows was determined on four control days always at the same time (entry into the waiting group, 70th gestation day, exit from the waiting group at 108th day of gestation, weaning) by means of mobile individual animal scales (T.E.L.L. Steuerungssysteme GmbH & Co.KG, Vreden, Germany; weighing range: 65–500 kg). To document the development of body condition, the body condition score (BCS) of all sows was assessed on the same four control days as the BW from the same single person, according to Kamphues et al. [24]. The BCS assessment was always done before determining the BW and back fat thickness (BFT). The BFT of the sows was measured using an ultrasonic device (Logiq V2, GE Healthcare, Inc., Wauwatosa, WI, USA) on the day of entry into the waiting group, at the exit from the waiting group, and at weaning. The measurement was done when the sows were standing with their backs straight on the individual animal scales using three measurement points on the right side of the body. The mean value of the three measurement points resulted in the BFT.

2.4.3. Health Status

In the peripartal period, manual or medical birth assistance, e.g., dystocia was recorded. In the puerperium, the body temperature of sows was measured directly after parturition and 12 h postpartum. After weaning, the weaning estrus interval was documented.

Vaginal injuries were documented in the waiting group. Clinical examination and evaluation of the external genitalia were performed on the 108th day of gestation, documenting any type of injury to the vulva at the end of gestation. Depending on the size of the injury, these were classified into three categories: (score 0) no injuries were found to the vulva; (score 1) fresh bloody injuries < 4 cm; (score 2) fresh bloody injuries > 4 cm.

2.4.4. Performance Data

At farrowing, the following reproductive parameters were recorded: litter number, number of piglets born alive, stillborn, mummified piglets, litter size of piglets born alive (within the first 12 h postpartum), number of piglets after litter balancing, as well as number of weaned piglets and litter size of weaned piglets. During the births, a total of 31 sows (16 in System I and 15 in System II) were filmed with camera systems. The exact length of birth (time interval from first to last born piglet), the birth interval between piglets (including mummified and stillborn piglets), and the vitality of the piglets could be documented for these sows. The following parameters were selected to describe piglet vitality immediately after birth according to a score developed by Muns et al. [25]: The piglets' ability to move was assessed based on body posture and position change (movement or rotation around body axis). Documented were head movements of piglets that corresponded to search behavior or actual mammary stimulation. The time interval from birth to first teat contact was recorded for each piglet.

2.5. Statistical Analyses

Statistical analysis was performed using the Statistical Analysis System for Windows, SAS®Enterprise Guide®, version 7.1 (SAS Institute Inc. Cary, NC, USA). Descriptive statistics were applied to report mean and standard deviation values. The Shapiro–Wilk test and Kolmogorov–Smirnov test were used to test the normal distribution of the data and verified by visual representation. If data could be considered normally distributed, a comparison was made using one-way ANOVA and the Ryan–Einot–Gabriel–Welsch test (probability of error $\alpha = 5\%$). In the case of not normally distributed data, the nonparametric Wilcoxon's two-sample test was applied. Correlation analyses were performed by determining Pearson's correlation coefficient. Indicated by SAS®, p-values with a significance level lower than $\alpha = 0.05$ were considered statistically significant.

3. Results

3.1. Feed Intake

Daily feed intake of sows in the two feeding systems differed significantly ($p < 0.0001$). Both the diluted low-energy and concentrated high-energy rations in System II resulted in high feed intakes with very high variation in each case (low-energy ration 4.67 ± 2.14 kg dry matter (DM) per animal and day and high-energy ration 4.52 ± 2.03 kg DM per animal and day). Feed losses at the trough (during feed intake) were observed but could not be quantified. The sows in System I consumed 2.54 ± 0.23 kg DM per animal and day.

3.2. Body Condition Development

No significant differences in BW, BCS, and BFT were observed between the feeding systems during the gestation period. Interestingly, the mean BW, BCS, and BFT gain during gestation of the sows in System I were significantly higher (BW: 68.23 ± 24.92 vs. 57.03 ± 22.42, BCS: 0.54 ± 0.65 vs. 0.19 ± 0.48 and BFT: 4.30 ± 4.11 vs. 3.26 ± 6.49; $p < 0.05$, Table 4). However, at the beginning of the field study, sows in System I had a significantly lower BCS and BFT.

Table 4. Body condition development of sows during pregnancy.

Timepoint	BW (kg)		BCS		BFT (mm)	
	System I	System II	System I	System II	System I	System II
Entry into waiting group	225.43 ± 43.48 ^{a}	236.72 ± 59.84 ^{a}	3.25 ± 0.49 ^{a}	3.62 ± 0.60 ^{b}	11.49 ± 3.51 ^{a}	13.78 ± 4.56 ^{b}
Day 70 of gestation	268.86 ± 58.03 ^{a}	271.55 ± 57.49 ^{a}	3.63 ± 0.46 ^{a}	3.73 ± 0.50 ^{a}	-	-
Day 108 of gestation	295.34 ± 59.81 ^{a}	299.03 ± 61.31 ^{a}	3.79 ± 0.52 ^{a}	3.81 ± 0.55 ^{a}	15.84 ± 5.61 ^{a}	16.98 ± 5.66 ^{a}
Gain during gestation[3]	68.23 ± 24.92 ^{a}	57.03 ± 22.42 ^{b}	0.54 ± 0.65 ^{a}	0.19 ± 0.48 ^{b}	4.30 ± 4.11 ^{a}	3.26 ± 6.49 ^{b}

$^{a, b}$ different letters mark significant differences between means in a row for one parameter ($p < 0.05$).

3.3. Health Status of Sows

There were no significant differences between sows in the two feeding systems in the number of obstetric measures or in body temperature postpartum.

Significantly ($p < 0.05$) more vulva injuries at the end of gestation (day 108) were observed in System I (32.50% of sows (21.25% score 1 and 11.25% score 2) vs. 17.10% of sows (14.47% score 1 and 2.63% score 2) in System II).

3.4. Performance Data

There were no significant differences between the systems in terms of the overall performance of sows. In System I, significantly more piglets were left with a sow after litter balancing (Table 5). The crushing losses in System II were significantly reduced by one-third compared to System I. Recorded litter size of live-born piglets and calculated total litter size (with secundiae) were significantly different between feeding systems. Higher masses were recorded for sows in System II in each case. The calculated litter size of dead and live born piglets or the calculated average birth weight per piglet showed no significant differences. The individual BW of the piglets were determined at the time of weaning and were almost equal between the two systems.

Table 5. Birth and performance data of sows as well as litter sizes and weight of piglets at birth and weaning (kg).

Parameter	System I	System II
Piglets born alive per litter	$16.71^{a} \pm 5.32$	$18.49^{a} \pm 3.52$
Still born piglets per litter	$1.80^{a} \pm 1.97$	$1.47^{a} \pm 1.83$
Mummified born piglets per litter	$1.01^{a} \pm 2.06$	$0.79^{a} \pm 1.42$
Piglets after litter balancing	$15.93^{a} \pm 1.47$	$15.47^{b} \pm 2.21$
Crushed piglets per litter	$1.20^{a} \pm 0.91$	$0.80^{b} \pm 0.80$
Dead piglets (cause unknown) per litter	$1.16^{a} \pm 1.09$	$1.05^{a} \pm 1.12$
Weaned piglets per litter	$12.75^{a} \pm 1.58$	$12.75^{a} \pm 1.40$
Litter weight (dead and alive piglets)	$23.84^{a} \pm 6.11$	$25.55^{a} \pm 4.18$
Litter weight (piglets born alive) [1]	$21.83^{a} \pm 5.56$	$23.52^{b} \pm 3.96$
Average birth weight of piglets born alive [2]	$1.24^{a} \pm 0.22$	$1.31^{a} \pm 0.23$
Total litter size (with secundiae) [3]	$28.16^{a} \pm 8.02$	$30.61^{b} \pm 5.01$
Average weight of piglets at weaning	$6.38^{a} \pm 0.10$	$6.38^{a} \pm 1.01$

[a, b] Different letters indicate significant differences between the mean values in one row ($p < 0.05$). [1] Calculated assumption: same mean birth weight of piglets born alive and dead. [2] Calculated, from litter size and number of piglets born alive. [3] Calculated, as the sum of litter size and placental mass (placental mass = 19.8% of litter size [26]).

The sows (n =75) from System I could be inseminated after an average of 5.89 ± 5.35 days after weaning. Animals (n = 70) from System II had a comparable weaning estrus interval (5.87 ± 3.17 days).

3.5. Farrowing

For the duration of birth from first to last piglet, the individual time intervals between the birth of two piglets and the time until complete expulsion of the placenta after the last-born piglet, no significant differences were found between the sows of the two systems. Regarding the duration of birth and the mean birth interval, the sows in System II tended to take longer (06:49:45 ± 04:57:21 and 00:21:47 ± 00:47:22 in System I vs. 07:08:42 ± 04:35:33 and 00:24:24 ± 01:08:50 in System II), while the time interval between the birth of the last piglet until complete expulsion of placenta tended to be shorter (05:10:24 ± 06:02:55 in System I vs. 03:37:29 ± 03:08:30 in System II).

3.6. Piglet Vitality

The recorded video footage was examined for each piglet regarding the time interval until the first head and body movement and until the first contact with the teats of the respective piglet. The newborn piglets of sows from feeding System II took significantly less time to show head movement and to reach the teat (Table 6).

Table 6. Mean time interval until first body movement, first head movement, and first contact of piglets with teats [hh:mm:ss].

Time	System I	System II
Until body movement	00:01:16 ^{a} ± 00:01:06	00:01:13 ^{a} ± 00:01:08
Until head movement	00:00:31 ^{a} ± 00:00:47	00:00:27 ^{b} ± 00:00:36
Until contact with the teats	00:22:16 ^{a} ± 00:24:18	00:21:11 ^{b} ± 00:28:48

$^{a, b}$ Different letters mark significant differences between means in a row (p < 0.05).

Of the sows from System II, significantly (p < 0.05) more piglets (System I: 70.79%; System II: 81.15% of piglets) showed head movements analogous to mammary stimulation in the first 30 seconds after birth. In the first 10 minutes after birth, significantly more piglets from the sows in System II reached the teats in comparison to piglets from System I sows (43.35 vs. 32.79%).

3.7. Body Condition at Weaning

BW of the sows was recorded on the 108th day of gestation and on the day of weaning (day 28 postpartum). BW postpartum was calculated based on the determined litter size. The weight loss of sows from both systems during lactation and BW at weaning did not differ significantly from each other (Table 7). The display of the change in BW was only based on the animals for which the calculation of the weight postpartum was possible. At the end of gestation, the sows of the two feeding groups reached an almost identical mean BCS. The calculation of the mean BCS difference was based exclusively on the animals that had also been assessed on the 108th day of gestation. After lactation, there was no significant difference in the BCS values of the sow groups. During lactation, sows in feeding System II lost numerically more back fat; this difference was not significant.

Table 7. BW, BCS, and BFT change during lactation of the sows in both systems.

Timepoint	BW (kg)		BCS		BFT (mm)	
	System I	System II	System I	System II	System I	System II
Day 108 of gestation	295.34 ^{a} ± 59.81	299.03 ^{a} ± 61.31	3.79 ^{a} ± 0.52	3.81 ^{a} ± 0.55	15.84 ^{a} ± 5.61	16.98 ^{a} ± 5.66
Postpartum	265.67 ^{a} ± 56.44	267.49 ^{a} ± 61.64	-	-	-	-
Weaning	237.11 ^{a} ± 48.41	236.90 ^{a} ± 52.74	2.95 ^{a} ± 0.45	3.00 ^{a} ± 0.51	11.18 ^{a} ± 4.03	11.45 ^{a} ± 4.59
Difference	−28.20 ^{a} ± 19.17	−31.17 ^{a} ± 18.67	−0.83 ^{a} ± 0.38	−0.84 ^{a} ± 0.43	−4.38 ^{a} ± 3.29	−5.54 ^{a} ± 2.97

$^{a, b}$ Different letters mark significant differences between means in a row for one parameter (p < 0.05).

4. Discussion

The investigations in this field study within the "SWOF" project (sow welfare optimized feeding) aimed to compare two feeding systems for pregnant group-housed sows (restricted dry feeding, System I vs. ad libitum liquid feeding based on farm-grown forage, System II) in terms of body condition development during gestation, sow performance data and sow and piglet health in the peripartal period and lactation. System II was equipped with a sorting gate to give sows access to two different feeding areas with rations either high or low in energy and nutrients according to their body condition. In particular, this ad libitum system was expected to enable sows a natural feed intake rhythm with regard to their voluntary feed intake behavior as well as maintain the weight development, health status, and litter performance characteristics, and therefore improving overall animal welfare. In this study, data were collected on the farm from two systems diverging with regard to feeding access (restricted vs. ad libitum), feed composition ("conventional" vs. based on WPWS) and type (dry vs. liquid), group size (35–55 sows vs. 76–117 sows) and management (small stable vs. large dynamic group) with a total of 183 sows. Manifold factors have therefore to be considered when interpreting the results.

During pregnancy, the sows gained body mass regardless of the feeding system in the group. No significant differences could be detected at the three measurement time points during pregnancy. A comparable body condition development of sows during pregnancy between these two feeding concepts (restrictive vs. ad libitum) was not described by Hoy et al. [27], Steffens [28], or Ziron [29], who all found a higher body mass gain in the group of ad libitum fed sows. Feed consumption in System II was almost twice the amount of System I (low-energy ration 4.67 ± 2.14 kg DM per animal and day and high-energy ration 4.52 ± 2.03 kg DM per animal and day vs. 2.54 ± 0.23 kg DM per animal and day), but a major uncertainty in energy and nutrient supply that cannot be calculated remains the obvious feed losses in feeding areas of the ad libitum feeding system as the design of the troughs and the feeding technique was a prototype and has to be adjusted and improved regarding the use of fiber-rich liquid feed. The same extent of the standard deviation of BW over all measuring times is an indication that the sow groups did not grow apart depending on the ad libitum feeding system. A growing apart of the sow groups due to the different feed intake of the animals in an ad libitum feeding system was described by different authors [27,29,30], whereas Steffens [28] could not document any growing apart of the sows during pregnancy under ad libitum feeding when comparing the feeding systems. Peltoniemi et al. [31] found no significant difference in BW and BFT of sows at the beginning of their study, which investigated the effect of ad libitum feeding on body condition development and fertility in comparison with a conventionally fed group. After the third lactation, the ad libitum fed sows were significantly heavier and had a significantly higher mean BFT. Steffens [28] and Schade [30] also documented lower BFT at the beginning of gestation than after lactation in ad libitum fed sows. Consequently, the ad libitum fed sows could start the next pregnancy with a higher BFT. This finding could not be confirmed in the present study. Unfortunately, the sows could not be analyzed over several reproductive cycles, so that a statement about performance development is not possible. Several studies have shown that BW and BFT of sows at the end of gestation are directly related to ME and nutrient intake during gestation [32,33]. In the present study, the average energy consumption of sows in System I was higher than in System II (low and high-energy ration, Energy (MJ ME/kg DM); 13.31, 11.54, 13.15, respectively), which might be a possible reason for this result.

When looking at our results, considering both systems, a lower occurrence of vulva injuries was observed in System II at the end of gestation (day 108; 32.5% vs. 17.1% of sows in System I and II, respectively). A likely explanation, according to Rault et al. [34], is that pigs are a gregarious species, and when housed in groups, they establish dominance hierarchies. Consequently, group-housed sows are required to share resources and compete for feed [34]. Vulva biting is thereby a potent method of expelling sows without being in danger of being attacked in return [35]. Thus, the higher occurrence of vulva injuries found in sows in System I in our study might result from the feed restriction that could have been related to the competitive behavior in sows and which was the main cause of this injury [36]. According to Angermann et al. [36], the use of controlled entrance doors in the ad libitum liquid feeding system could explain the lower occurrence of vulva injuries as the automatic entrance door at the sorting gate was designed to protect the animals from being attacked by other sows.

In the present study, the reproductive performance was on a generally high level with litter sizes between 16.71 ± 5.32 and 18.49 ± 3.52 piglets born alive. Other recent studies reported lower litter sizes under different conditions: depending on different energy levels during late gestation, Rooney et al. [37] found litters with 13.5 to 15.3 piglets born alive, and Li et al. [38] fed different ratios of soluble to insoluble fiber and reported between 11.2 and 12.8 piglets born alive.

The reproductive performance characteristics, e.g., live-born, stillborn, mummified piglets as well as weaned piglets or the calculated average birth weight per piglet of sows, were not significantly influenced by the different feeding systems. Previous studies [39,40] as well reported no difference in the litter performance, the litter weight, or the number of born, born alive, stillborn, or mummified piglets between the restrictively vs. ad libitum fed group-housed pregnant sows. Van der Peet-Schwering et al. [41], for example, reported with 13.6 total born piglets in restricted feeding vs. 13.5 under ad libitum feeding conditions very similar results, and Martí et al. [42] reported 13.5 total born piglets with restricted feeding and 13.6 total born piglets with ad libitum feeding during late gestation. However, this is not in accordance with Cools et al. [43], who found a higher number of total born and born alive piglets to restrictively fed sows during the peripartal period compared to ad libitum fed sows (total born 11.5 vs. 10.5 piglets, live-born 11.1 vs. 10.2 piglets.

Compared to restricted dry feeding (System I), ad libitum liquid feeding (System II) led to a significantly higher litter size of live-born piglets and calculated total litter size (with secundiae) for sows in System II. This is in accordance with Li et al. [44], who reported an increased placental weight in sows fed a high-fiber diet. The crude fiber content in the dry compound diet fed to sows in System I was lower than in the feed in System II (low- and high-energy ration, crude fiber (% DM); 8.48, 12.7, and 9.34, respectively), which might be an explanation for our finding. Moreover, fiber-rich feeding of the sows during pregnancy has an effect on the ingesta passage (faster) and thus lowers the risk of prolonged farrowing due to constipation [19].

Interestingly, the farrowing duration and the birth interval were longer in sows from System II, while the time interval between the birth of the last piglet until complete expulsion of the placenta tended to be shorter (05:10:24 in System I vs. 03:37:29 in System II). However, in our study, due to technical reasons, the respective system could not be continued in the farrowing crates. Thus, at farrowing, the sows of both systems had already been fed the same feed for some days. A possible long-term effect of the respective feeding system can therefore be discussed but not be explained.

It has been observed that a longer farrowing duration is associated with an increased piglet stillborn rate [45,46]. However, there was no evidence for a difference in the stillborn rate in this study, regardless of the feeding system. In contrast, Feyera et al. [47], who observed an influence of the timing of the last meal prior to parturition on the farrowing duration and stillborn rate, concluded that when sows had been offered a meal less than 6 h before parturition, sows had a shorter farrowing duration and a reduced stillborn rate.

With increasing litter size and performance selection, the piglet vitality or the viability of the piglets is also a relevant criterion for piglet production [48]. Birth weight is often a decisive factor for assessing viability and selection with regard to litter compensation [49,50]. In the study by Muns et al. [25], a relation was found between the ability to move and reach the teats of sows to assess piglet vitality and its influence on piglet survival and growth during lactation. In the present study, the newborn piglets from feeding System II showed smaller time intervals until first head movements and reaching the teats of the mother sows. The head movements analogous to mammary stimulation were a reliable indicator of the piglets' vitality and were correlated with their BW [25]. After evaluating the recorded video material, more piglets from the sows from System II showed head movements analogous to mammary stimulation in the first 30 seconds after birth (70.8% vs. 81.2%), and in the first ten minutes after birth, significantly more piglets from System II sows reached the teats in comparison to piglets from System I sows (43.4 vs. 32.8%). According to the evaluations by Muns et al. [25], mammary stimulation is a reliable indicator of piglet vitality. Nonetheless, ad libitum liquid feeding did not affect lactating and weaning sow performance. In accordance with van der Peet-Schwering et al. [41], it is possible to feed group-housed gestating sows a liquid diet ad libitum without negative effects on reproductive performance.

Unfortunately, due to technical reasons, the respective feeding system could not be continued during lactation, which could also have had effects on performance and health [43]. When using an ad libitum feeding system based on whole plant silages, higher feces masses are produced in combination with lower digestibility. These should be taken into account when designing stables and optimizing manure management [51]. Further studies are, therefore, ultimately necessary and useful to examine the effects of forage-based ad libitum feeding in an optimized housing system, since in terms of comprehensive animal welfare, the target is full feeding of sows.

5. Conclusions

In summary, it can be said that the tested group-adapted ad libitum feeding system in combination with a sorting gate had no negative impact on the body condition development and sow's performance. If anything, the piglet vitality was positively affected. The feeding concept evaluated in this study offers opportunities for more animal welfare, and due to the use of farm-grown forage, it also enhances sustainability and farm self-sufficiency. Nevertheless, this will require further research in the future regarding the repertoire of possibly applied farm-grown forage, the effects of the concept in the transit phase of sows, and the optimization of floor design and manure management.

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