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Demands of pigs on the construction of tube feeders depending on gender

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During 12 consecutive test runs, 1814 intact male, castrated male and female fattening pigs were reared at four differently designed tube feeders. The tube feeders used differed in the number of eating places, in feed consistency, and the mechanism for food ejection. A shallow trough and easy food ejection combined with a design where the food and water bowl are not too strictly separated led to significantly better growth performance of the castrates in the first half of the fattening period. More important for sows and boars is a perfect balance of food consistency or quantity of feed and food hygiene in the trough. High competition by low feed ejection with the help of a bell mechanism also led to better feed utilization by lower feed losses. This feeder design principle led to higher animal losses, probably due to stress. Growth performance and animal welfare are less influenced by the animal-feeding place ratio than by structural design and the function of the tube feeders.

Keywords:
fattening pigs, construction of tube feeders, boars, sows, castrated male pigs

Tube feeders are an important part of dry feeding systems, which are going to keep their practical relevance in the future thanks to their robustness and low susceptibility to malfunctions. Their integration into the housing and feeding system varies greatly and is therefore a critical issue in pen design. At the same time, animal behaviour focuses on these issues. Due to the great adaptability of the pigs‘ feed intake behaviour (day rhythm, time spent at the trough, eating speed) to the feeding technique, average group performance often remains constant in trials which address the feeding place design or the animal/feeding place ratio of mash dispensers or sensor feeding systems (Schopfer et al. 2006, Kircher 2001, Nielsen et al. 1995, Walker 1991). If competition becomes too strong due to few feeding places at the tube feeder, large pigs in a fattening group gain more weight while smaller ones gain less. Thus, the groups grow apart even though average group weight increase remains constant (Georgsson and Svendsen 2002).

As a result of product development, a large number of tube feeders with very different designs are available today (Meyer 2015). However, it is more or less unknown whether the described adaptation mechanisms of the animals apply in all these cases. While many manufacturers design the feed and water bowl as more or less separate units in order to improve feed hygiene, others entirely or partially return to the basic functional principle of the classic mash feed dispenser (Meyer 2015). The design of the dispensers has consequences for the number of feeding places, the quantity of feed offered, and the resulting dry matter content of the feed. These changes must be reevaluated as part of the development of livestock management techniques, such as boar fattening. The present study was intended to describe significant design differences using common tube feeder models as examples and

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to examine them with regard to the biological performance of the ‚three genders' (male ♂, female ♀, male castrated ⚥).

Material and methods

The studies were carried out on the instructional and experimental farm (LVG) Köllitsch in one single fattening compartment with 8 group pens measuring 21 m² each. In this fattening compartment, a total of 1,814 fattening pigs were kept on a fully slatted concrete floor during 12 consecutive trial periods. 18.9 pigs were housed in one pen (min. 15, max. 22). The genders were mixed (sows and castrates or sows and boars). Unavoidable differences in housing density only occurred between the individual trial periods. On average, almost 1.1 m² of available space were provided per fattening pig. In 7 trial periods, mostly male castrated and female fattening pigs were housed. During the 5 following trial periods, largely male and female time mates were examined. Of the housed animals, 3.4% did not reach the end of the trial, which meant that they had to be removed from the trial due to injuries or diseases. All pigs were weighed on the 50th trial day and one week before the first animals were stalled out (91st fattening day) as well as before the second (105th fattening day) and the third group (120th fattening group) left the compartment. The average fattening period lasted 109 days. With the aid of so-called precision water meters, (ALLMESS; Aquadis ¾ 1.5 m³/h), water consumption was measured at the tube feeders and the additional drinkers. Since the tube feeders were installed in the partition wall between the pens, feed consumption was measured in one double pen and one housing period each. Fresh air was supplied via airflow channels, whereas exhaust air was sucked off.

Feed dispensers and feeding

The animals were fed ad libitum with floury, self-produced feed dispensed by tube feeders from four different manufacturers (Figure 1).

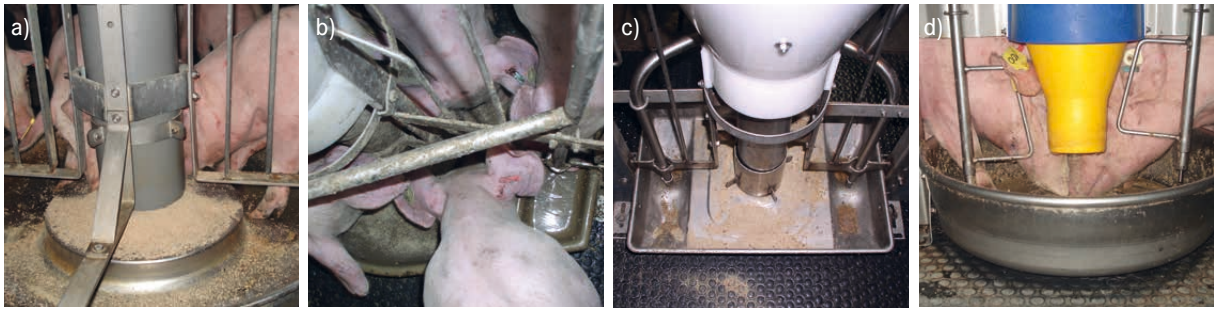

Figure 1: Tube feeders from different companies
a) ‚Ecomat' (Schauer), b) ‚3 in1 Feeder' (ACO Funki), c) ‚Pig Nic' (Big Dutchman), d) ‚AP Swing' (AP-Company) (Photos: E. Meyer)

The automatic feed dispensers were installed in the pen partition wall and differ with regard to the theoretical number of feeding places offered (Table 1), possible feed consistency, as well as the work required from the animals for feed ejection (Figure 1). The ‚Ecomat' (Schauer company) and the ‚AP Swing' represent two extreme designs. The ‚Ecomat' is characterized by a relatively large feeding bowl and consequently a slightly larger number of feeding places (Table 1). Since the four (2 × 2) drinker nozzles were installed outside of the trough, the floury feed ejected into the bowl by the shaking pipe and the revolving ring has the least contact with water as compared with other tube feeders.

This design represents the development of an entire range of automatic feed dispensers which combine design features of dry feed and mash dispensers in order to improve feed hygiene (Meyer 2015). The ‚AP Swing' with an integrated drinker nozzle without a separate water bowl, however, best stands for the functional principle of a classic tube feeder. Due to the relatively small trough combined with a rather small quantity of feed ejected by a bell, this automatic feed dispenser provokes stronger competition among the animals for the feed and thus also allows good performance to be achieved, as practical observations show. According to practical experiences, however, this requires healthy, stress-resistant pigs. The two other automatic feed dispensers can be classified in the middle between the two design principles described above. In order to improve feed hygiene, feed and water are supplied by more or less separate units, which influences trough hygiene and feed consistency.

Table 1: Design features of the examined tube feeders

Product name	Feed/water bowl	n feeding places[1)]	Feed ejection
‚3 in 1 Feeder' (ACO Funki)	Separate units, additional drinker nozzle in the feed trough	4,4	Shaking pipe
‚Ecomat' (Schauer)	Spatially separated, drinker nozzles above the feed trough	7,1	Shaking pipe + revolving ring
‚Pig Nic' (Big Dutchman)	Spatially separated, 2 water bowls located below	4,4	Shaking pipe + revolving ring
‚AP Swing' (AP-Company)	Not separated	3,8	Bell

[1)] Calculated by dividing the trough circumference (in cm) by 33 cm.

All tube feeders were supplied with floury feed (early fattening period: 13.2 MJ ME, 1.0% gross lysine; final fattening period: 13.1 MJ ME, 1.0% gross lysine) via the feed chain and a falling pipe integrated into the lid of the tube feeder. Soiling and feed losses on the plastic plates underneath the tube feeder and the slatted floor in front of the unit were evaluated weekly for each pen based on a self-defined assessment key ranging from 1 to 5.

The following parameters were measured for the evaluation of biological performance:

- Weight increase per fattening day (WID) per animal and day in g
- Feed requirements (FR) per group (1 : x)
- Water consumption at the tube feeder per animal and day in l
- Animal losses in relation to the total number of pigs housed in %
- Start weight and Live weight at the end of fattening period per animal, dressed weight per animal in kg
- Classification and carcass quality, percentage of muscle meat (PMM) in % and index points (IP) per animal
- Sensor measurement of boar taint in the neck fat layer using androsterone, skatole, and indole as indicators in μg/g per sample
- Subjective evaluation of boar taint in the neck fat layer with the aid of a panel (3 persons, scale 1–4) per sample

The assessment values which were not distributed normally were evaluated using the chi-squared test (χ^2 test). All other measurement values of biological performance were assessed with the aid of variance analysis. The fattening period was considered in the model as a fixed effect. Average group feed intake was not tested statistically.

Results and discussion

Given an absolute daily weight increase of approximately 800 g (variation coefficient VC = 20.5%) in the first 50 fattening days and 825 g (VC = 17%, VC last weighing weight = 9%) over the entire fattening period, performance was satisfactory. All manufacturers indicate 30–40 pigs as the maximum capacity of their tube feeders. This figure is based on the size of animals which have almost reached their final fattening weight. If the legally required animal per feeding place ratio of 8:1 is assumed, one tube feeder allows approximately 30 (‚AP Swing') to more than 50 (‚Ecomat') pigs to be fed if the number of feeding places corresponds to the figures shown in Table 1. In practice, the necessary feed outlet showed that the design capacity of all tube feeders used was rather small for the size of the groups housed during the trial (from 26 to 46, average size 38.8 pigs) if floury feed was used. Group size varied exclusively between the fattening periods as a result of a different number of piglets housed. Following the order of the trough sizes shown in Table 1, the setting of the tube dispensers had to be adjusted relatively quickly within 2 weeks to reach full outlet capacity (the ‚AP Swing' first, the ‚Ecomat' last). Starting at an initial value of almost 39 pigs per tube feeder, each additional animal statistically reduces weight increase per fattening day by a group average of 12 g (regression analysis). This shows that this relatively large group size tends to overtax the adaptability of the pigs due to their feed intake behaviour (Schopfer et al. 2006, Kircher 2001, Nielsen et al. 1995, Walker 1991) described in the literature even if the group average is considered. This significant correlation between group size and weight increase per fattening day (-0.4) is approximately equally strong in the ‚AP Swing', which has the smallest trough, and the ‚Ecomat', which is equipped with the largest trough. The variability of live weight on the 50th fattening day is identical (17.6%) for the two tube feeders. In the two other automatic feed dispensers, it is almost 1% lower, which confirms the established correlation (-0.3). Thus, not only the animal/feeding-place ratio may play a role, but also other design differences. These include in particular the dry matter content, which depends on the design of the tube feeder. This is confirmed indirectly by water consumption at the tube feeder. As compared with the ‚Ecomat', about 20% more water is consumed at the ‚AP Swing' and the ‚3 in 1 Feeder' while water consumption at the ‚Pig Nic' tube feeder is more than 30% higher. Practical experience shows a correlation with resulting feed consistency. Judging by mean weight increase per fattening day (Table 2), the more mash-like feed dispensed by the ‚AP Swing' compensates for the disadvantage of the smaller trough surface. The large trough of the ‚Ecomat' is obviously unable to provide this compensation because it rather features the described characteristics of dry feed dispensers (Gonyou and Lou 2000, Bergstrom et al. 2012, Myers et al. 2013). Apparently, feed consistency, which depends on the design of the tube feeder, is rather the limiting factor. Feed consistency determines the time that the pigs spend at the trough (Gonyou 1998, Gonyou and Lou 2000) as well as the quantity of feed consumed (Bremermann 2003). While the ‚AP Swing' features a classic design without separate feed and water bowls and the ‚3 in 1 Feeder' as well as ‚Pig Nic' provide two separate units with transition zones between feed and water, the drinker nozzles of the ‚Ecomat' are situated above the trough at the pigs' eye level. The feed is moistened only by water which runs back from the pigs' mouths while they are drinking. This is obviously too little in order to exploit the advantages of a tube feeder.

Table 2: Biological performance of different genders

Parameter	Unit	Tube feeders												Significance		
		‚3 in 1 Feeder' (ACO Funki)			‚Ecomat' (Schauer)			‚Pig Nic' (Big Dutchman)			‚AP Swing' (AP-Company)			p < 0,05		
Gender		♀	♂	♂	♀	♂	♂	♀	♂	♂	♀	♂	♂	♀	♂	♂
Number of pigs		224	131	87	235	123	87	245	105	86	227	128	84	931	487	344
Start weight	kg	31.7	30.8	34.5	31.1	31.3	33.7	31.0	31.2	32.9	31.4	31.0	34.0	n. s.	n. s.	n. s.
Start weight SE[1)]	kg	0.31	0.54	0.86	0.30	0.54	0.87	0.29	0.69	0.68	0.30	0.41	0.87			
Weight_50[2)]	kg	69.2	74.6	70.1	67.6	75.8	68.1	68.2	77.2	67.5	68.3	77.3	69.4	n. s.	n. s.	n. s.
Weight _50 SE*	kg	0.5	0.9	1.4	0.5	0.9	1.4	0.5	1.2	1.1	0.5	0.7	1.4			
Weight increase per fattening day_50	g/d	780	874	820	759	894	791	771	929	803	768	887	814	n. s.	a,a,b,a	n.s.
Weight increase per fattening day_50 SE	g/d	7	12	21	6	12	21	6	16	17	6	9	21			
Weight increase per fattening day	g/d	807			790			807			801			ab, a, b, ab		
Quantity of feed dispensed_50		1 : 1.95			1 : 1.9			1 : 1.9			1 : 1.85					
Last weighing weight	kg	112	111	110	111	109	108	112	110	109	112	110	111	n. s.	n. s.	n. s.
SE last weighing weight	kg	0.5	0.9	1.4	0.5	0.9	1.4	0.5	1.1	1.1	0.5	0.7	1.4			
Weight increase per fattening day	g/d	778	895	840	758	905	800	775	927	830	776	906	827	n. s.	n. s.	a,b,a,ab
SE weight increase per fattening day	g/d	6	11	17	6	11	17	6	14	13	6	8	17			
Weight increase per fattening day	g/d	828			812			834			825			a, b, a, a		
Water consumption at the tube feeder	l/d	3.7			3.0			4.1			3.6					
Feed intake		1 : 2.67			1 : 2.66			1 : 2.63			1 : 2.52					
Percentage of muscle meat	%	56.4			56.7			57.3			57.4			n. s.		

1) SE: Standard error
2) Measurement at day 50

The functional principle of the ‚Ecomat' leads to significantly lower weight increase per fattening day (30 to 40 g less), which in particular affects boars. The castrates, however, reach similarly good results at both types of tube feeders. For them, an advantage from the first half of the fattening period at the mash dispenser ‚Pig Nic' tends to be predominant. Given the same trough size, this type provides significantly higher weight gains for castrated male pigs during the first half of the fattening period than any other feed dispenser. Here, two drinker nozzles instead of one are installed on a relatively flat trough bowl with a very low barrier and feed ejection is supported by a soft-running revolving ring. Obviously, the young castrates, which tend to consume a lot of feed, are stimulated by this design difference. According to practical observations, feed carried into the water bowls is rather an optical than a practical problem for the fattening of castrates. In boar fattening, however, this is not the case. During the sensitive pre-fattening period, boars gain slightly less weight than animals

fed with the aid of dry feeders featuring clear separation (‚3 in 1') or ejecting a smaller quantity of feed (‚AP Swing').

In boar fattening, it seems that the barriers between the feed and the water bowl should not become too flat if they are designed as separate units. Otherwise, the problem of low feed intake by the boars (Bünger et al. 2011) is aggravated by non-optimal feed consistency or feed hygiene. Larger troughs or more feeding places as described in the literature cannot compensate for non-optimal feed consistency in any gender because a mash dispenser without water provides worse results than a dry feed dispenser (Bergstrom et al. 2012). When male animals reach puberty, their feed intake and weight increase grow beyond the level of the castrates (Meyer und Alert 2013). Apparently, the ‚3 in 1' tube feeder (ACO-Funki) provides the feed quantity and consistency that best suits the needs of the sexually mature animals. In this tube feeder, one drinker nozzle is installed at the bottom of the trough, which is situated lower, while another nozzle is located in the drinking bowl designed as a (clearly) separate unit. Obviously, this principle is the best compromise between trough hygiene and feed supply for the sensitive fattening boars. The only limiting factor is that sticky feed tends to clog the rather narrow slit of the shaking pipe especially at the edge of the feeder seal.

Measured feed utilization in principle follows weight gain performance and is also influenced by feed losses. These losses are mainly caused by feed being dug out (Gonyou 1998), which is provoked by excessive feed quantities in the trough and a rather flat trough form without clear edges. Due to the bell mechanism, the ‚AP Swing' ejects only very small feed quantities, which are eaten rather hastily by the pigs and cannot be dug out of the rather deep trough, as practical observations show. This leads to slightly better feed utilization. Due to the group trial setting, feed utilization was not examined statistically. Considered over the entire fattening period, however, feed utilization is significantly (0.13) better. Obviously, this potential advantage comes at a price. In these housing groups, 3.5% of all animals housed died or had to be removed from the trial due to diseases or injuries, while losses in other housing groups were approximately 0.5% lower. The larger part of these losses occurred among the more sensitive female and intact male animals (5.5% and 3.7%) (Meyer and Alert 2013), while the castrates even had the smallest losses at this tube feeder (1.2%). In the weekly evaluation of moisture and feed losses in the area in front of the trough, the ‚AP Swing' achieved the best average value (1.9), whereas the ‚Ecomat' reached the lowest mark (2.4). This confirms the described correlation with the functional principle. In a repetition at the end, a sample of boars was examined for the boar odorants androsterone and skatole.

Table 3: Tube feeders and boar taint

Parameter	Unit	Tube feeders				Significance
		‚3 in 1' (ACO Funki)	‚Ecomat' (Schauer)	‚PigNic' (Big Dutchman)	‚AP Swing' (AP-Company)	
n boars		66	69	68	65	
Androsterone	µg/g	0.996	1.186	1.081	0.929	n. s.
Skatole	µg/g	0.185	0.237	0.183	0.151	n. s.
Indole	µg/g	0.038	0.050	0.04	0.036	n. s.
Percentage of carcasses with skatole > 0,25 µg/g	%	22	24	19	16	

The measured skatole concentrations in the boar fat tend to reflect the results of pen cleanliness. In 65 fattening boars reared with the aid of the ‚AP Swing', 0.15 µg of skatole per g of boar fat were found, whereas 0.24 µg of skatole per g of boar fat were measured in the 69 boars fed at the ‚Ecomat'. From a statistical viewpoint, however, these values are not different. The data were not transformed.

Conclusions

Different designs of common tube feeder models influence fattening performance and animal welfare. The genders react differently to the different designs. The dry matter content of the mash produced which is correlated with the water supply as well as feed quantity in the trough which depends on the work required for feed ejection play the biggest role.

The installation of the drinker nozzles above the feed trough influences feed consistency and limits potential weight gain during the entire fattening period in all genders. The design of the feed and water bowl as separate units influences the dry matter content of the feed and at the same time also trough hygiene. The genders also react differently to these influences.

Castrated male pigs show higher feed intake and significantly better weight gain performance in the first half of the fattening period if the feed ejection unit is easy to operate because the feed and the water bowl are not designed as clearly separate units. For sexually mature boars, however, in particular an optimal compromise between feed consistency, feed quantity, and feed hygiene in the trough is even more important than for sows. Hygiene improves if the feed and water bowl are designed as clearly separate units. An additional drinker nozzle at the trough bottom guarantees optimal water quantity for feed intake. If a relatively small quantity of feed was ejected by a bell mechanism, feed utilization tended to be better because feed losses were lower. However, this also meant higher animal losses, which were probably caused by stress. Only the castrates can cope with this stress without consequences.

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