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# The effect of coarse or pelleted feeds on feeding patterns in pigs*

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**Feed characteristics play an essential role in feed intake and utilisation. The objective of this research was to explore the effect of diet fed in the form of coarse meal (grits) and pelleted (granulated) forms on feeding behaviour, feed consumption (feed intake) and weight gain during fattening. While in Hungary feed in the coarse meal form is typical, in modern European pig farms feed is fed in the pelleted form. Our study was conducted with 16 fattening pigs divided into two groups of equal size. The Hungarian Large White x Hungarian Landrace pig types were involved in the investigation. Numerous research papers discussed the relationship between the two studied feeding types and the fattening effect. However, feed intake time and feeder visiting frequency have not been extensively studied for these feeding methods.**

**According to our study, there were no significant differences in feed intake and weight gain between the two feeding groups; however, pigs fed coarse meals spent 41.9 minutes more per day on average for feed intake than those fed with a pellet form feed. In contrast, pigs fed the pellet diet visited the feeder 9.4 times more often on a daily average than those fed the coarse meal feed. These results suggest that pelleted feed is recommended in pig farming, as this allows the animal to consume the required amount of feed sooner and allows more animals to feed at the same feeder.**

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Achieving maximum feed efficiency while keeping production costs and adverse environmental impacts as low as possible is one of the main challenges facing the pig sector nowadays [Pomar *et al.* 2019]. The nutrients needed by the animals can be provided by the feed, which is used for maintenance and production functions [Kiarie and Mills 2019]. Since feeding represents a significant part of the costs in pig farms, profitability can be notably increased by improving the feed conversion ratio [Rauw *et al.* 2006].

Several factors influence feed intake and feeding behaviour, such as the age and physiological condition of the animal, feed and feeding traits, environmental conditions [Nyachoti *et al*. 2004], diseases and social interactions [Putz *et al.* 2019], dominance ranking within the group [Sołtysiak and Nogalski 2010] or even the group size [Nielsen 1999]. More complex monitoring and analysis of pigs' feeding process may provide insight into the role of feed intake, growth performance, feed utilisation and social relationships between individuals [Colpoys *et al.* 2016, Bus *et al.* 2021].

Pig feeding uses several types of feed. Dry feed is fed to the animals in the pellet or coarse meal form without the addition of water, while wet feed (or liquid feed) is formulated as a mixture of water, feed and other ingredients [Santonja *et al*. 2017]. In conventional Hungarian fattening farms coarse meal feeding is commonly used, making it possible to feed by-products and mass feeds [Horn *et al*. 2011, Nyíri *et al*. 2018]. Therefore, Hungarian pig farmers prefer to use coarse meal feed, even though pelleted feed has been documented to have several advantages [Solà-Oriol *et al.* 2009]. These benefits include reducing feed wastage and dust formation, as well as increased nutrient density and starch gelatinisation, reduced time and energy spent on eating, and increased feed intake while improving the specific feed conversion efficiency [Patience *et al.* 1995, Santonja *et al*. 2017]. In contrast to pig feeds in Hungary, Vukmirovic *et al.* [2017] described the pelleted meal as more common in modern pig farms.

In general, next to the obvious benefits of increased feed efficiency and growth performance, higher processing also increases feed cost.

Next to feed composition, structure and form are critical factors in feed conversion. Several authors have examined various aspects of this problem, such as the effect of particle size and pelletisation [Wondra *et al*. 1995, Ball *et al.* 2015], dry and liquid feeding on weight gain [Choct *et al.* 2004], or simply the effect of grinding processes [Lucht 2011]. Researches are often inconsistent concerning the definition of optimal feed particle size and form. Numerous scientific papers [Healy *et al.* 1994, Wondra *et al.* 1995, Ball *et al.* 2015, Bao *et al*. 2016, Vukmirovic *et al*. 2017] have shown that because of the increased specific surface area of the feed particles reduced feed particle size can enhance pig performance by providing easier access to digestive enzymes. However, over-fine preparation should also be avoided due to the negative effect on the gastrointestinal tract. The nearly flour-like form is the only one that all researchers reject regarding particle size [Healy e*t al*. 1994]. Switching to this feed form can realise a significantly lower feed conversion ratio and bodyweight gain than the rough variant. Early experiments focused on feeding whole or grinding cereal feeds where the feed conversion ratio and daily weight gain of the ground form were significantly higher. Wondra *et al.* [1995] reported that pelleted feed has a more positive impact on feed utilisation.

In terms of pig health, Betscher *et al*. [2010] demonstrated the preventive effect of a coarsely ground diet in pigs with regard to gastric ulcer and salmonella infection, similarly as it was reported by Santonja *et al*. [2017]. Similarly, Hedemann *et al.* [2005] stated that the consumption of pelleted feed better promotes the binding of Salmonella, probably due to more significant damage to the gastrointestinal mucosa.

Considering previous animal behaviour studies, in which Hyun and Ellis [2001] showed that feed intake should also be considered, because the proportion of feeding places is suboptimal for fattening pigs, competition for feeding places may occur. Smith *et al*. [2004] also concluded that poorly designed feeders have a detrimental effect, because they can reduce feed intake and feeder service capacity due to the extended eating times. Additionally, Vargas *et al.* [1987] described that increasing feed intake time may affect production performance through individuals' social behaviour.

An essential aspect of these feeding considerations is that the pig is highly efficient at converting the feed, yet excretes significant amounts of undigested nutrients in manure, thus reducing production efficiency [Urriola *et al.* 2012]. In addition, researchers as Wondra *et al*. [1995] and Ball *et al*. [2015] found that feeding pellets are associated with lower nitrogen excretion.

In contrast to their role in pig performance and health, less specified experimental data are available on the two different feeding procedures (coarse meal and pelleted feed) in terms of feed intake time and feeder visiting frequency. Therefore, in this study the feed intake time and the feeder visiting frequency are assessed, paying particular attention to comparing the feeding mentioned above solutions.

It is important to examine from the point of view of the influencing factors described whether the additional cost of granulation is recouped during the fattening of the pig.

## Material and methods

This research was designed and conducted under the regulations of the Porcine Fattening Performance Test Station (PFPT) in Herceghalom (Hungary) and approved by the Scientific Council of the National Agricultural Research and Innovation Center (NARIC) (project code: ID 057).

### Experimental animals

In the experiment 16 fattening **pigs** were divided into two groups of equal numbers and placed in pens of the same size. Hungarian Large White x Hungarian Landrace

(MNF x *ML F1)* paternal half-sibs were studied**.** The sex ratio was the same in both groups (four barrows and four gilts). According to the Hungarian Pig Performance Testing Code [Pig Performance Testing Code Committee 2017], porcine fattening performance tests initiate at 80 days of age and last until a bodyweight of 105±5 kg is reached in individual and group housing. In the current study, we analysed pigs from 90 days of age to 146 days of age.

#### Feed preparation method and nutrient composition

Fattening was performed under the conditions defined by the Hungarian Pig Performance Testing Code except for the physical requirements of the feed forms. Feed was prepared in a disc grinder with a four mm sieve and homogenised with a Himel type counterflow feed mixer of 500 kg in capacity. The content values of the feed fed in both forms were identical, as the pellet was created from the milled material using a three mm hole size sticker prepared in a DS-4 type granulating machine. The nutrient composition of the diet is shown in Table 1.

**Table 1.** Nutrient composition of the applied diet

| Property, unit of measurement | Value | Property, unit of measurement | Content |
|---|---|---|---|
| Dry substance (%) | 87.8 | % of leucine | 1.5 |
| Raw protein (%) | 18.5 | % of valine | 0.8 |
| Raw lipids (%) | 2.6 | Ca (%) | 0.9 |
| Raw fiber (%) | 2.9 | P (%) | 0.7 |
| Raw ash (%) | 5.9 | % of utilisable P | 0.4 |
| Digestible energy-pig (MJ/kg) | 13.5 | Na (%) | 0.2 |
| Metabolizable energy-pig (MJ/kg) | 13 | Mg (%) | 0.1 |
| Lysine (%) | 1 | Fe (mg/kg) | 137 |
| Digestible lysine-pig (%) | 0.9 | Mn (mg/kg) | 65 |
| % of methionine | 0.4 | Cu/Cu sulfate p.h. (mg/kg) | 17 |
| % of digestible methionine-pig | 0.2 | Zn (mg/kg) | 114 |
| Methionine and cystine (%) | 0.7 | Se (mg/kg) | 0.4 |
| % of digestible methionine and cystine-pig | 0.5 | vitamin A (IU/kg) | 17500 |
| % of threonine | 0.7 | vitamin D-3 (IU/kg) | 2500 |
| % of digestible threonine-pig | 0.5 | vitamin E (IU/kg) | 100 |
| % of tryptophan | 0.2 | B5 (mg/kg) | 34.2 |
| % of digestible tryptophan | 0.2 | B3 (mg/kg) | 61.8 |
| % of arginine | 1.1 | colin chloride (mg/kg) | 600 |
| % of isoleucine | 0.7 | linoleic acid (%) | 1.4 |

**Experimental procedure**

Measurements were carried out according to the respective method in the so-called PFPT system. The study was conducted at the PFPT Station in the NARIC Research Institute for Animal Breeding, Nutrition and Meat Science. One of the essential factors in those measurements under standard conditions shows that animals are exposed to the same environmental effects.

The effect of the two feed types was tested on two separated groups of pigs, with 8 pigs per pen. Experimental pigs were placed in 12 $m^2$ fattening pens with the same layout per group, so each was provided an area of more than roughly 1.5 $m^2$. The amount of consumed feed was appropriate for the pig breed and was sex-specific, since in the ~~crates~~ pens all fatteners were able to feed ad libitum calmly and for enough time from an IVOG brand special self-feeder for 8 pigs. This type of system has been used by several research groups [de Haer *et al*. 1993, Fernandez *at al*. 2011]. The automatic feeding system was manufactured by Hokofarm Group (Netherlands). The station design prevents more than one pig from accessing the feed at the same time. This system was used for the measurements, which continuously measured the required parameters using an electronic identification system. Nipple drinkers are not part of the feeding system. They are located separately in the pens about 1.5 m from the feeding space. The feeding station is equipped with a full ISO RF electronic identification system, for which ALLFLEX (New Zealand) ID tags were used in the test.

These electronic feeders have been used for decades in pig breeding and monitor pigs' social behaviour, which can improve production efficiency [Hoy *et al*. 2012, Wallenbeck and Keeling 2013, Wenshui *et al*. 2016, Bus *et al.* 2021].

Apart from the daily gain, the following were continuously recorded:

– measurement of consumed feed amount (accurate to 10 gr). An evaluation program analysed the feed amount;
– time for each visit. The feeding equipment records the initial and finishing time of the feed intake accurate to seconds, comprising the full time spent eating;
– the number of visits to feeders per day and in total.

The pigs were weighed automatically on the same day once a week for ten weeks on an electronic ICONIX FX 1 (New Zealand) scale, which was lowered to the floor level. The scale was located inside the barn building, but not inside the pen, and the animal caretakers herded the animals out.

**Statistical analysis**

Data from the first nine weeks were processed. Pigs were slaughtered at different times as they reached the expected weight.

For the comparative analysis of feed intake and weight gain results, independent samples T-test was used for the two groups. We calculated the relative standard deviation (RSD) for total feed intake, weight gain and efficiency data.

Using two-way mixed ANOVAs, the feeding type and measurement time on the feeding frequency and the length of feeding intake were analysed. The interaction term into our models was also included. In the mixed ANOVA, feeding type was a fixed factor and the measurement time was a repeated-measures factor. The results were considered significant if they were significant at $p<0.05$, then a partial eta square ($\eta^2$) was calculated as an effect size indicator. Recorded fattening data were analysed by the IBM SPSS Statistics 26.0 software.

When analysing feed intake time and feeder visiting frequency data, the Mauchly test was used to check whether sphericity can be assumed in the repeated measure factor. In the case of violation of the assumption, correction of the degrees of freedom (Greenhouse-Geisser corrections) was used to make the necessary corrections. To test the homogeneity of treatment variances, Levene's test was used in the between subject factor . In the case of violation of assumption conditions, ANOVA's robustness was considered. Exploring the nature of the interaction, Simple Effect tests were also used to check the data for each week and the two types of feeding separately. Finally, we used pairwise comparisons to compare the study weeks.

## Results and discussion

### Feed intake and weight gain

Table 2 shows the average feed intake and weight gain data for the nine studied weeks.

**Table 2**. Average feed intake and weight gain data on coarse meal or pelleted diet feeding

| Period of the study (weeks) | Age of pigs (days) | Feed types | |
|---|---|---|---|
| | | coarse feed group | pelleted feed group |
| | | average weight gain (kg) | |
| 1 | 90 | 44 | 45 |
| 2 | 97 | 49 | 50 |
| 3 | 104 | 54 | 56 |
| 4 | 111 | 60 | 63 |
| 5 | 118 | 66 | 68 |
| 6 | 125 | 72 | 74 |
| 7 | 132 | 79 | 79 |
| 8 | 139 | 85 | 86 |
| 9 | 146 | 90 | 91 |
| Period of the study (weeks) | Age of pigs (days) | Average feed intake (kg) | |
| 1 | 90 | 14 | 23 |
| 2 | 97 | 23 | 33 |
| 3 | 104 | 39 | 47 |
| 4 | 111 | 53 | 63 |
| 5 | 118 | 70 | 80 |
| 6 | 125 | 89 | 97 |
| 7 | 132 | 109 | 114 |
| 8 | 139 | 137 | 142 |
| 9 | 146 | 155 | 154 |

The assumption of homogeneity of variances was tested via Levene's F test, $F(14) = 0.024$, $p = 0.880$. That means there was no difference in weight gain between the variances of the two groups referred to the final analysed week (Tab. 3). The independent samples t-test was associated with a statistically non-significant effect. There was no significant difference when comparing the coarse feed group ($M = 89.87$, $SD = 8.741$) and the pelleted group ($M = 90.50$, $SD = 9.531$), conditions; $t\,(14) = -0{,}137$ $p = 0.893$ (2 tailed) $r = 0.029$.

A similar finding was made when analysing the feed intake data of the two feeding methods. Levene's test for the equality of error variances was coming out as non-significant $F(14) = 0.930$, $p = 0.351$. Thus, we found no significant difference between the eating characteristics of the coarse feed group ($M = 154.52$, $SD = 28.05$) and the pelleted feed group ($M = 153.75$, $SD = 34.04$), $t\,(14) = 0.05$ $p = 0.961$ (2 tailed) $r = 0.013$.

Feed conversion ratio (FCR) values were also determined for both groups of pigs at 9 weeks, with a lower value found for pelleted feed, $FCR_{coarse} = 3.06$ kg/kg, $FCR_{pelleted} = 2.88$ kg/kg.

Data on feed intake and weight of the individuals in the two groups measured in the last studied week are shown in Table 3.

**Table 3.** Total feed intake and weight gain data of the last studied weeks on coarse meal or pelleted diet feeding

| Feed type | Eartag number | Total feed intake (kg)* | Weight gain (kg)* |
|---|---|---|---|
| Coarse | 8980 | 133.96 | 89 |
| | 8981 | 206.25 | 101 |
| | 9045 | 151.81 | 90 |
| | 9046 | 179.68 | 97 |
| | 9107 | 116.92 | 73 |
| | 9108 | 144.70 | 91 |
| | 9109 | 140.50 | 83 |
| | 9172 | 162.40 | 95 |
| Pelleted | 8905 | 137.51 | 85 |
| | 8909 | 194.49 | 101 |
| | 8972 | 167.49 | 93 |
| | 8979 | 144.80 | 95 |
| | 9013 | 113.89 | 70 |
| | 9020 | 181.10 | 93 |
| | 9049 | 103.88 | 90 |
| | 9058 | 186.84 | 97 |

*Data refer to the age of 146 days for pigs in the last week studied (week 9).

The efficiency of the different pigs in the utilisation of feed was between $range_{coarse} = 0.49 – 0.66$ kg/kg and $range_{pelleted} = 0.51 – 0.87$ kg/kg.

In the study of the relative standard deviation within the two feeding groups, the following not very different data were found in relation to feed intake, $RSD_{coarse}$ =

18.15 %, $RSD_{pelleted}$ 22.14 %. and weight gain $RSD_{coarse}$ = 9.73 %, $RSD_{pelleted}$ = 10.53 %. A greater difference in RSD was found only in efficiency in favor of the group consuming pelleted feed, $RSD_{coarse}$ = 9.25 %, $RSD_{pelleted}$ = 19.34 %.

We found a significant ($p<0.01$) positive correlation between feed intake and weight gain $r = 0.892$.

**Feed intake time**

Comparing the weekly measurement data of the feed intake time (Fig. 1), Mauchly's sphericity test gave significant results ($W = 0.000357$ $p<0.001$), which means that sphericity cannot be assumed. In the data series of the nine studied weeks we found only two weeks (weeks 5 and 8), where the differences between variances for the two groups were significant at $p = 0.008$ and $F (1, 14) = 7.707$ $p = 0.015$. However, the sample sizes were equal, therefore ANOVA is robust for the violation of the assumption.

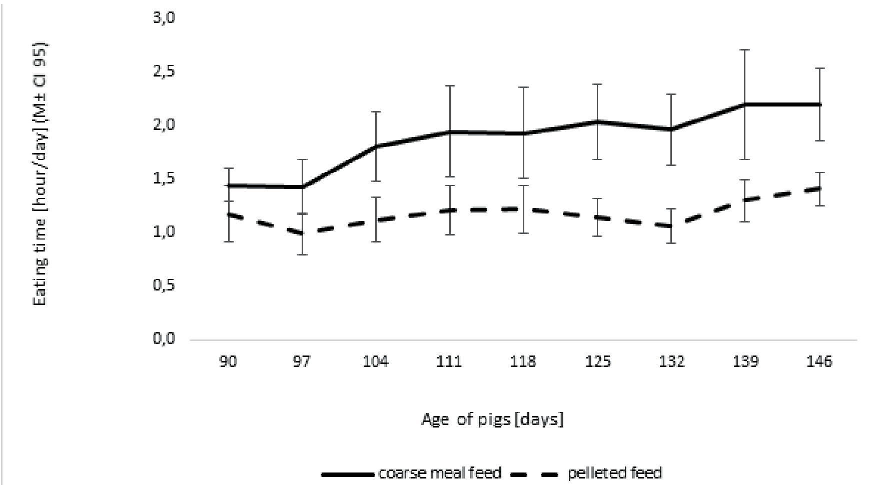


Fig. 1. Weekly changes in feed intake time for coarse meal or pelleted diet feeding.

Applying the Greenhouse-Geisser correction, the main effect of the feeding form was significant. $p = 0.001$ part. $\eta^2 = 0.547$. Pigs fed the coarse meal spend more time eating in general. The main effect of time was also significant at $p<0.001$. part. $\eta^2 = 0.368$. For both feeding types, pigs spent more and more time eating as time went by. The interaction between feeding type and time was also significant at $p = 0.0497$. part. $\eta^2 = 0.163$.

Each week's data were checked separately with the Simple Effects test to detect differences between the two feeding types. To compensate for the increased Type 1 error due to the multiple testing, a corrected significant level at $\alpha = 0.01$ was used. The series of Univariate Tests in Table 4 showed a stable trend towards the end of the feeding period (from week 6) between the two feeding types.

**Table 4**. Results of the series of Univariate Tests on feed intake time between the two feeding types

| Weeks | Partial Eta Squared | *P*-value |
|---|---|---|
| 1 | 0.170 | 0.113 |
| 2 | 0.329 | 0.020 |
| 3 | 0.464 | 0.004 |
| 4 | 0.389 | 0.010 |
| 5 | 0.380 | 0.011 |
| 6 | 0.592 | < 0.001 |
| 7 | 0.618 | < 0.001 |
| 8 | 0.418 | 0.007 |
| 9 | 0.547 | 0.001 |

Moreover, using another Simple Effect test we also examined the two types of feeding separately whether there is a difference between the weeks. The effect of time was significant for both the pelleted and coarse meal groups, and the effect size was nearly identical. For pigs on coarse meal feed it was p = 0.016. part. $\eta^2 = 0.869$ and for pelleted feed pigs it was p = 0.022. part. $\eta^2 = 0.855$.

In the Pairwise Comparisons for pigs fed the coarse meal feed the last three weeks were significantly higher than the first three weeks. However, there were no significant differences after the 4th week. For pigs fed the pelleted feed only week 2 differed from week 9 and week 7 from week 9.

#### Feeder visiting frequency

To verify this finding (Fig. 2) also a two-way mixed ANOVA was applied. In this case, it was also checked whether sphericity could be assumed by comparing the weekly measurement data of the feeder visiting frequency. It has been established that sphericity cannot be assumed by the Mauchly test (W = 0.0028 $\chi2$ (df= 35, N= 16) = 65.214 p<0.001), so for all these reasons the Greenhouse-Greiner method was applied.

Based on Levene's Test in the data of the nine studied weeks, we found only two weeks (weeks 1 and 7), where the differences between variances for the two groups were significant  F (1,14) = 9.437 p= 0.008 and F (1, 14) = 5.114 p = 0.040. However, the sample sizes were equal, therefore the ANOVA is robust to the violation of the assumption.

In the Greenhouse-Greiner method the main effect of the feeding form was significant F (1, 14) = 6.146 p= 0.027 part. $\eta^2 = 0.305$. Pigs fed the pelleted diet showed more feeder visiting frequency in a day. In contrast, the main effect of time F (3.468, 112) = 2.426 p = 0.069 part.$\eta^2 = 0.148$ and the interaction between the feeding types was not significant F (3.468, 112) = 2.504 p= 0.062 part.$\eta^2 = 0.152$.

Simple Effect tests were run to examine the nature of the interaction. Within this method, the weekly data were checked to see a difference between the two diets fed.

To compensate for the increased Type 1 error due to the multiple testing we used a corrected significant level at $\alpha = 0.01$. Although significant values fluctuate over the

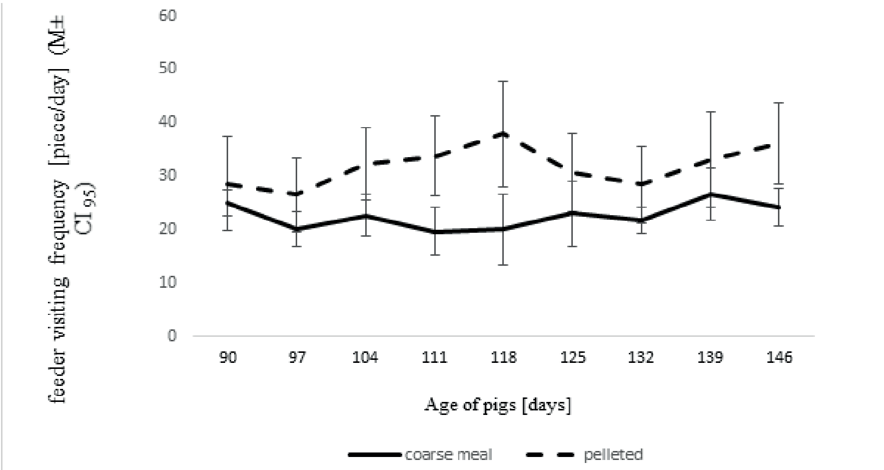


Fig. 2. Feeder visiting frequency by pigs in the case of coarse meal and pelleted diet feeding.

**Table 5.** Results of the series of Univariate Tests on feeder visiting frequency between the two feeding types

| Weeks | Partial Eta Squared | *P*-value |
|---|---|---|
| 1 | 0.041 | 0.451 |
| 2 | 0.165 | 0.119 |
| 3 | 0.295 | 0.030 |
| 4 | 0.420 | 0.007 |
| 5 | 0.377 | 0.011 |
| 6 | 0.154 | 0.132 |
| 7 | 0.181 | 0.100 |
| 8 | 0.100 | 0.234 |
| 9 | 0.356 | 0.015 |

weeks based on the Univariate Test, only data of weeks 3,4, 5 and 9 were significant (Tab. 5).

The purpose of this study was to evaluate the duration time spent with pigs fed coarse meal and pelleted feed, the number of feeding visiting frequency, as well as weight gain and amount of feed consumption.

In our study no significant difference was found in weight gain and feed intake between the two different feeding groups. These data justify, at first sight, those farmers who consider granulation unnecessary, as it results in additional costs, but it is also worth analysing in terms of animal patterns.

Our findings partly contradict the statement of Ulens *et al*. [2015] that average daily feed intake was greater in pigs consuming coarse meal feed compared to the pelleted form. Still, in daily weight growth they also found no difference between the two fed forms. Li *et al*. [2017] came to a similar conclusion that higher average daily feed intake can be expected for pigs fed a coarse diet; however, they also found no difference in the average daily gain increasing when comparing the results of the two groups. The small number of pigs involved may limit the reliability of generalisation of our results, we could not detect a difference, as Ulens and his colleagues [2015] performed experiments on 576 individuals. In his scientific work, O'Doherty *et al.* [2001] also described higher average daily feed intake with coarse meal, explained by the increased energy value resulting from pelletisation. Regarding the average daily growth, Vande Ginste and De Schrijver [1998] were also unable to show a difference in feed form comparison, in contrast to Wondra *et al*. [1995], who enhanced the positive effect of pellet use in growth parameters, leading to the stronger taste effect, lower losses and better utilisation of nutrients resulting from the heat treatment of ingredients. When analysing a study by Myers *et al*. [2010], it seems that daily feed intake was much higher for pelleted feeds in young fattening pigs compared to the coarse meal. This phenomenon was also observed in other farm animals, as in the case of broiler chickens in a study by Engberg *et al*. [2002], where in the case of mash and pelleted feed a significantly higher weight gain was achieved with the pellet form due to the higher feed intake and the enhanced feed utilisation. Overall, although it cannot be excluded that part of the higher feed consumption for coarse meal cause resulted on the one hand from switching from creep meal feed received before the start of the experiment, which was already detected with a change in the diet of turkeys from crumbs to pellets [Lecuelle *et al*. 2010]. On the other hand, it should be considered based on a study by O'Doherty *et al*. [2001] that despite the careful methodology there is potential for larger spillage of the feed, which may stick to the pig's mouth or be thrown out from the trough during eating, thus causing feed wastage on average amounting to 5% [Patience *et al*. 1995].

Despite all the above, we found a significant difference between the two different feeding groups for such a small number of pigs, only in the frequency of feeding visits and the time spent on feed intake, which factors were analysed in more detail. A combined analysis of feed intake time and feeder visiting frequency data suggests that pigs on the coarse meal diet spent considerably more time eating, but the feeder visiting frequency was significantly higher in pigs fed pelleted feed. A shorter eating time for pelleted feed has been confirmed by several authors [Laitat *et al*. 2004, Li *et al.* 2017]. It can be said that pigs consuming feed consisting of small grains ate more slowly, but more continuously than the other group.

In the details of our study, pigs spent almost half of their time eating only in the case of pelleted diets than did pigs fed coarse diets, so the efficiency of eating increased significantly. However, they visited the feeder several times, as the group consuming coarse meal feed averaged 22.5 times a day, while the pellet group consumed pelleted form 31.9 times. As body weights increased, so did the amount of consumed feed, fatteners who ate the coarse form spent more time eating. In the 9th week of fattening there was already a 64% difference in daily feeding time, favouring pigs consuming coarse meal with 131.5 minutes compared to those consuming pelleted with 84.5 minutes feed.

After reviewing the relevant literature on feeding patterns [Hyun and Ellis 2002, Rauw *et al.* 2006, Guo *et al.* 2015], we found that longer meal times predicted higher feed intake. This result contradicts the studies we conducted, just as a lower feeding frequency results in a higher intake indicated by some researchers [Nielsen *et al.* 1995, Carco` *et al*. 2018]. Rauw *et al*. [2006] were unable to show a correlation in their study, examining 104 Duroc barrows on an ad libitum standard diet, those more frequent feeding visits did not mean more time spent with eating. A recent survey by Santiago *et al*. [2021] also concluded that in Duroc pigs more frequent feeder visits were coupled with faster growth and longer duration of time spent consuming feed resulted in a lower average daily gain.

The results suggest that stocking density needs to be chosen correctly, considering available feeding sites and the form of feed used. Most feeders in Hungary are designed to feed coarse meal feed and animals consuming coarse meal feed have a much longer feed intake time**.** It may also be worthwhile to go around the issue discussed in this experiment for the number of places recommended per feeder, as in general higher-ranking animals stay longer at the trough compared to lower ones and consume more food per visit [Hoy *et al*. 2012]. This is especially recommended in places where the proportion of feeding places compared to fattened animals is below optimal to prevent competition for feeding places. Based on Li *et al*. [2017], an 80% utilisation of the feeder is recommended to maintain growth performance and allow the required eating time for pigs.

Overall, the cost of granulation pays off, as our herd will not grow unevenly, so the required amount of feed can be consumed sooner, therefore more pigs can be fed with the same feeder.

The study results should be viewed with some limitations. First, generalisability of our results is limited due to the smaller pig numbers (two groups of 8 pigs) compared to recent studies with higher numbers of pigs. However, the uniqueness of our study is connected with the standard nature of the test parameters, as the environmental conditions of the two groups compared were identical owing to the strictly regulated performance testing principles. Another important highlight of the study was the study of pigs with the same genetics. A majority of recent literature also showed no difference in average daily weight gain when comparing the two diets. Therefore, we believe that this may partly confirm the differences in the studied eating behaviour parameters (feed intake time and feeder visiting frequency), which could be detected even with such a small number of pigs.

## Conclusions

The cost of feeding in pig farms is the most critical factor in terms of efficiency. Therefore, every producer wants to reduce the high cost of feeding, which often goes to the detriment of the content. This research aimed to examine the choice of coarse meal or pelleted feed form in pig production in terms of the effect of the duration of time spent on feed intake and the number of feeder visiting (i.e. frequency).

The present research showed that feeding of pelleted feed is recommended, as the individuals consuming pelleted feed spent less time feeding than the group members consuming coarse meal feed. In the Hungarian large-scale pig production, the maximum utilisation of fattening farms is typical, coupled with overcrowding and high stocking densities. These results could be a technological advantage and could be considered in the development of feeding systems.

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**REFERENCES**

1. BALL M.E.E., MAGOWAN E., MCCRACKEN K.J., BEATTIE V.E., BRADFORD R., THOMPSON A., GORDON F.J., 2015 – An investigation into the effect of dietary particle size and pelleting of diets for finishing pigs. ***Livestock Science*** 173, 48-54.
2. BAO Z., LI Y., ZHANG J., LI L., ZHANG P., HUANG F.R., 2016 – Effect of particle size of wheat on nutrient digestibility, growth performance, and gut microbiota in growing pigs, ***Livestock Science*** 183, 33-39.
3. BETSCHER S., BEINEKE A., SCHÖNFELD L., KAMPHUES J., 2010 – Effects of diet's physical form (grinding intensity; meal/pellets) on morphological and histological parameters (e.g. ratio of neutral to acid mucins) of the gastrointestinal tract in weaned piglets. ***Livestock Science*** 134, 149-151.
4. BUS J.D., BOUMANS I.J.M.M., WEBB L.E., BOKKERS E.A.M., 2021 – The potential of feeding patterns to assess generic welfare in growing-finishing pigs. ***Applied Animal Behaviour Science*** 241, 105383.
5. CARCO` G., BONA, M.D., CARRARO L., LATORRE M.A., FONDEVILA M., GALLO L., SCHIAVON, S., 2018 - Influence of mild feed restriction and mild reduction in dietary amino acid content on feeding behaviour of group-housed growing pigs. ***Applied Animal Behaviour Science*** 198, 27-35.
6. CHOCT M., SELBY E.A.D., CADOGAN D.J., CAMPBELL R.G., 2004 – Effect of particle size, processing, and dry or liquid feeding on performance of piglets. ***Australian Journal of Agricultural Research*** 55, 237-245.
7. COLPOYS J.D., JOHNSON A.K., GABLER N.K., 2016 – Daily feeding regimen impacts pig growth and behavior. ***Physiology & Behavior*** 159, 27-32.
8. DE HAER L.C.M., LUITING P., AARTS H.L.M., 1993 – Relations among individual (residual) feed intake, growth performance and feed intake pattern of growing pigs in group housing. ***Livestock Production Science*** 36, 233-253
9. ENGBERG R.M., HEDEMANN M.S., JENSEN B.B., 2002 – The influence of grinding and pelleting of feed on the microbial composition and activity in the digestive tract of broiler chickens. ***British Poultry Science*** 43, 4, 569-579.
10. FERNANDEZ J., FABREGA E., SOLER J., TIBAU J., RUIZ J.L., PUIGVERT X., MANTECA X., 2011 – Feeding strategy in group-housed growing pigs of four different breeds. ***Applied Animal Behaviour Science*** 134, 109-120.

11. GUO Y.M., ZHANG Z.Y., MA J.W., AI H.S., REN J., HUANG L.S., 2015 – A genomewide association study of feed efficiency and feeding behaviors at two fattening stages in a White Duroc × Erhualian F2 population. ***Journal of Animal Science*** 93, 1481-1489.
12. HEDEMANN M.S., MIKKELSEN L.L., NAUGHTON P.J., JENSEN B.B., 2005 – Effect of feed particle size and feed processing on morphological characteristics in the small and large intestine of pigs and on adhesion of Salmonella enterica serovar Typhimurium DT12 in the ileum in vitro. ***Journal of Animal Science*** 83, 1554-1562.
13. HEALY B.J., HANCOCK J.D., KENNEDY G.A., BRAMEL-COX P.J., BEHNKE K.C., HINES R.H., 1994 – Optimum particle size of corn and hard and soft sorghum for nursery pigs. ***Journal of Animal Science*** 72, 2227-2236.
14. HORN P., PÁSZTHY G., BENE SZ., 2011 – Pig Breeding Online: https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0059_sertestenyesztes/index.html (accessed 30 May 2020). In Hungarian.
15. HOY S., SCHAMUN S., WEIRICH C., 2012 – Investigations on feed intake and social behaviour of fattening pigs fed at an electronic feeding station. ***Applied Animal Behaviour Science*** 139, 58-64.
16. HYUN Y., ELLIS M., 2001 – Effect of group size and feeder type on growth performance and feeding patterns in growing pigs. Journal of Animal Science 79, 803-810.
17. Hyun Y., Ellis M., 2002 – Effect of group size and feeder type on growth performance and feeding patterns in finishing pigs. ***Journal of Animal Science*** 80, 568-574.
18. KIARIE E.G., MILLS A., 2019 – Role of feed processing on gut health and function in pigs and poultry: conundrum of optimal particle size and hydrothermal regimens. ***Frontiers in Veterinary Science*** 6, 19.
19. LECUELLE S., BOUVAREL I., CHAGNEAU A.M., LESCOAT P., LAVIRON F., LETERRIER C., 2010 – Feeding behaviour in turkeys with a changeover from crumbs to pellets. ***Applied Animal Behaviour Science*** 125, 132-142.
20. LI Y.Z, MCDONALD K.A., GONYOU H.W., 2017 – Determining feeder space allowance across feed forms and water availability in the feeder for growing-finishing pigs. ***Journal of Swine Health and Production*** 25, 174-182.
21. LUCHt T., 2011 – Stage grinding with hammer mill and crushing roller mill. ***Feed Compound***er 31, 22-26.
22. MYERS A.J., BERGSTROM J.R., TOKACH M.D., DRITZ S.S., GOODHAND R.D., DEROUCHEY J.M., NELSSEN J.L., 2010 – The effects of diet form and feeder design on the growth performance and carcass characteristics of growing-finishing pigs. Conference Paper, Swine Day, Manhattan, KS, November 18, Kansas State University. Agricultural Experiment Station and Cooperative Extension Service. 209-215.
23. NIELSEN B.L., LAWRENCE A.B., WHITTEMORE C.T., 1995 – Effects of group size on feeding behaviour, social behaviour, and performance of growing pigs using single-space feeders. ***Livestock Production Science*** 44, 73-85.
24. Nielsen B.L., 1999 – On the interpretation of feeding behaviour measures and the use of feeding rate as an indicator of social constraint. ***Applied Animal Behaviour Science*** 63, 79-91.
25. NYACHOTI C., ZIJLSTRA R., DE LANGE C., PATIENCE J., 2004 – Voluntary feed intake in growing-finishing pigs: A review of the main determining factors and potential approaches for accurate predictions. ***Canadian Journal of Animal Science*** 84, 549-566.
26. NYÍRI A., FENYVESI L., RÓZSA L., NAGY I., ZSOLNAI A., ANTON I., 2018 – Effect of pelleted and ground diet on feeding behaviour of Hungarian Landrace x Hungarian Large White pig. ***Hungarian Journal of Animal Production*** 67, 92-98.
27. O'DOHERTY J.V., MCGLYNN S.G., MURPHY D., 2001 – The effect of expander processing and pelleting on the nutritive value of feed for growing and finishing pigs. ***Journal of the Science of Food and Agriculture*** 81, 135-141.

28. PATIENCE J.F., THACKER P.A., DE LANGE C.F.M., 1995 – Swine nutrition guide. 2nd ed. Prairie Swine Centre, Saskatoon, SK.
29. POMAR C., REMUS A., 2019 – Precision pig feeding: a breakthrough toward sustainability. ***Animal Frontiers*** 9, (3).
30. Pig Performance Testing Code Committee 2017 – Hungarian pig performance testing code 8, 23-33, Hungarian Purebred Pig Breeders' Association. Kaposvár.
31. PUTZ A., HARDING J., DYCK M., FORTIN F., PLASTOW G., DEKKERS J., 2019 – Novel resilience phenotypes using feed intake data from a natural disease challenge model in Wean-to-Finish pigs. ***Frontiers in Genetics*** 9, 660.
32. RAUW W., SOLER J., TIBAU J., REIXACH J., GOMEZ-RAYA L., 2006 – The relationship between residual feed intake and feed intake behavior in group-housed Duroc barrows. ***Journal of Animal Science*** 84, 956-62.
33. SANTIAGO K.G., KIM S.H., LOPEZ B.I., LEE D.H., CHO Y.G., SONG Y.N., SEO K.S., 2021 – Estimation of genetic parameters for feeding pattern traits and its relationship to feed efficiency and production traits in Duroc pigs. Agriculture 11, 850.
34. SANTONJA G.G., GOERGITZIKIS K., SCALET B.M., MONTOBBIO P., ROUDIER S., SANCHO L.D., 2017 – Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. EUR 28674 EN
35. SMITH L.F., PATIENCE J.F., GONYOU H.W., BEAULIEU A.D., BOYD R.D., 2004 – The impact of feeder adjustment and group size/floor space allowance on the performance of nursery pigs. ***Journal of Swine and Health Production*** 12, 111-8.
36. SOLÀ-ORIOL D., ROURA E., TORRALLARDONA D., 2009 – Feed preference in pigs: Effect of cereal sources at different inclusion rates, ***Journal of Animal Science*** 87, 562-570.
37. SOŁTYSIAK T., NOGALSKI Z., 2010 – The effects of social hierarchy in a dairy cattle herd on milk yield, ***Polish Journal of Natural Science*** 25, 22-30.
38. ULENS T. DEMEYER P. AMPE B. VAN LANGENHOVE H., MILLET S., 2015 – Effect of grinding intensity and pelleting of the diet on indoor particulate matter concentrations and growth performance of weanling pigs. ***Journal of Animal Science*** 93, 627-636.
39. URRIOLA P.E., STEIN H.H., 2012 – Comparative digestibility of energy and nutrients in fibrous feed ingredients fed to Meishan and Yorkshire pigs. ***Journal of Animal Science*** 90, 802-12.
40. VANDE GINSTE J., DE SCHRIJVER R., 1998 – Expansion and pelleting of starter, grower and finisher diets for pigs: Effects on nitrogen retention, ileal and total tract digestibility of protein, phosphorus and calcium and in vitro protein quality. ***Animal Feed Science and Technology*** 72, 303-314.
41. VARGAS J.V. CRAIG J.V., HINES R.H., 1987 – Effects of feeding systems on social and feeding behavior and performance of finishing pigs. ***Journal of Animal Science*** 65, 463-674.
42. VUKMIROVIC D., COLOVIC R., RAKITA S., BRLEK T., DJURAGIC O. SOLÀ-ORIOL D., 2017 – Importance of feed structure (particle size) and feed form (mash vs. pellets) in pig nutrition – a review. ***Animal Feed Science and Technology*** 233, 133-144.
43. WALLENBECK A., KEELING L., 2013 – Using data from electronic feeders on visit frequency and feed consumption to indicate tail biting outbreaks in commercial pig production. ***Journal of Animal Science*** 91.
44. WONDRA K.J., HANCOCK J.D., BEHNKE K.C., HINES R.H., STARK C.R., 1995 – Effects of particle size and pelleting on growth performance, nutrient digestibility and stomach morphology in finishing pigs. ***Journal of Animal Science*** 73, 757-763.
45. WENSHUI X., XINJIAN L., FENG Z., GUORONG Y., NENGSHUI D., LUSHENG H., ZHIYAN Z., 2016 – A multi-population survey on swine feeding behavior with electronic feeding devices. ***Archives Animal Breeding*** 59, 445-452.