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Evaluation of the functional capability of a feeder with pneumatic conveying

The functional capability of the feeder can play a pivotal role in providing essential nutrients for animals according to the requirement. Therefore, the functional capability of the feeder in a commercial pig farm was evaluated using the error of dosage, the error of adjustment, the error of mixing, the repeatability and the carry over of the feeder. The error of dosage and the error of adjustement did not exceed 6 %. Dosing 300 g and 600 g of feed, for calcium an error of mixing of 33 and 15 % was found respectively. Dosing 4 000 g of feed the error of mixing was reduced to 8 %. For the carry over of calcium 30.53 % were found. For magnesium and phosphorus the error of mixing and the carry over indicated an almost homogenous mixing process and a minimized contamination of the feed.

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Mixing and pneumatic conveying of feed using a feeder is a technical challenge for the manufacturers of such systems with respect to the physical properties of the feed [1]. The functional capability of the feeder affects the proper nutrient consumption of the animal according to the requirement. [2]. The functional capability of the feeder in a commercial pig farm was evaluated using the error of dosage and the error of adjustment. Additionally for calcium, magnesium and phosphorus the error and the repeatability of mixing and the carry over was determined.

Material and Methods

The tested feeder with pneumatic conveying (Spotmix, Schauer Maschinenfabrik GmbH & Co. KG) consists primarily of a batch mixer, an air generator, a piping system with switch points and rotation distributors, cyclones at the different feeding points and a process computer. The feeder is used under practical conditions at the Baden-Württemberg State experimental station for pig breeding in Boxberg.

Error of dosage and error of adjustment

300 g, 600 g, 1 000 g, 2 000 g and 3 000 g of feed (61 % wheat, 17 % barley, 19 % soybeanmeal, 3 % mineral- and vitamin-premix) were used as target quantity for the transport from the batch mixer to a feeding point. Conveying of feed was repeated 10 times.

The error of adjustment in percent is the absolute difference from the target quantity and the amount dosed at the feeding point. For the error of dosage the coefficient of variation was calculated for the amounts dosed at the feeding point:

$$\text{absolute difference \%} = \frac{\text{target quantity - amount dosed at the feeding point}}{\text{target quantity}} \cdot 100$$

$$\text{coefficient of variation} = \frac{\text{standard deviation}}{\text{mean}} \cdot 100$$

Error of mixing and repeatability of the mixture

The error of mixing and the repeatability of the mixture was determined using a target diet consisting of 77 % wheat, 20 % soybeanmeal and 3 % mineral- and vitamin-premix. Calcium (Ca), magnesium (Mg) and phosphorus were analysed in the single components of the mixture. Using the analysed values and percentage amounts of the components in the mixture, a target concentration for each element in the mixture was calculated. Afterwards 300 g, 600 g and 4 000 g of the mixture were produced. Samples were collected from each mixture and analysed for Ca, Mg and P. The analysed values were compared to the calculated target concentrations.

The error of mixing was calculated for each element from the absolute difference between the analysed concentrations and the target concentrations. The repeatability of the mixture is the coefficient of variation of the analysed values.

Carry over

For the determination of the carry over of Ca, Mg and P 1 kg of feed (77 % wheat, 20 % soybeanmeal, 3 % mineral- and vitamin-premix) was transported to a feeding point, followed by a 10 time repeated transport of 1 kg of wheat. Ca, Mg and P were analysed in wheat before and after conveying. The concentration of the elements before conveying were used as reference values. The carry over for each element was calculated from the difference between the element concentration after the transport and the reference value and is expressed in percent (average of the 10 samples).

Chemical analysis

Mineral and trace elements were analyzed according to the method of Naumann and Bassler [3]. Analysis error is expressed as coefficient of variation from 5 repeated determinations.

Results

The error of dosage and the error of adjustment is presented in **table 1**. An error of 5 % was only exceeded by the error of adjustment at the target quantity of 300 g. Both errors were not controlled by the target quantity.

Table 1

Error of dosing and error of adjustment

Sollmenge ***Target quantity*** **g**	**Dosierfehler** ***Error of dosage*** **%**	**Einstellfehler** ***Error of adjustment*** **%**
300	5,39	3,90
600	4,12	3,48
1000	3,29	4,69
2000	2,06	2,08
3000	3,45	3,42

Table 2

Error and repeatability of mixing [%]

Sollmenge ***Target quantity*** **g**	**Mischfehler und Reproduzierbarkeit** ***Error and repeatability of mixing***	**Ca** **%**	**Mg** **%**	**P** **%**
300	Mischfehler *Error of mixing*	33,23	9,35	5,25
	Reproduzierbarkeit *Repeatability*	33,66	11,65	4,27
600	Mischfehler *Error of mixing*	15,48	6,95	5,18
	Reproduzierbarkeit *Repeatability*	20,95	9,30	6,04
4000	Mischfehler *Error of mixing*	8,14	5,79	1,94
	Reproduzierbarkeit *Repeatability*	6,35	2,21	2,69

The error of mixing and the repeatability of mixing for the single elements are presented in **table 2**. For Ca at target quantities of 300 g and 600 g the highest errors of mixing and the poorest repeatability was found. However increasing the target quantity resulted in lower errors of mixing and a better repeatability. Compared to the other elements the error of mixing was the lowest for P.

Also the carry over and the error of analysis showed the highest values for Ca as compared to the other elements (30,53 % and 6,88 % respectively). Lowest values were observed for P (**table 3** and **4**).

Table 3

Mean of the carry over [%]

Ca	Mg	P
30,53	3,81	3,06

Table 4

Error of analysis [%}

Ca	Mg	P
6,88	3,04	2,23

Discussion

The range of values found for the error of dosage and the error of adjustment provides an adequate feed supply to the animals. An error of adjustment below 5 % was also estimated to be sufficient for an adequate nutrient supply in earlier studies [4]. Both values are primarily dependent of the feeder itself and the amount of feed to be conveyed into the mixer. Thus the error of dosage and the error of adjustment is mainly determined by the scales weighing to the nearest 10 g, and the inaccuracy of the screw conveyer providing the feed components for the mixing process.

Furthermore components to be mixed and conveyed may vary greatly in characteristics and their nature may influence the errors of dosage and adjustment [5]. As only one mixture was used in our study, this effect can not be discussed here. The same is true for the error of mixing and the carry over.

An influence of the amount of feed to be conveyed on the error of adjustement can also be assumed. With increasing amounts of feed the error of adjustment should decrease as the relative part of an absolute deviation decreases with increasing amounts to be conveyed. In our study this effect could not be observed.

In contrast to the error of adjustment and the error of dosage, the error of the chemical analysis is a substantial part of the error of mixing and of the carry over of the single elements.

For Ca and Mg the errors of mixing exceeded the errors of analysis at all target quantities. For P the error of mixing fell below the error of analysis only at the target quantity of 4 000 g.

A considerable excess of the error of analysis was observed for the error of mixing of Ca at the target quantity of 300 g. This indicates together with the low value for the repeatability that a homogenous mixing result can only be achieved with difficulty for Ca at a target quantity of 300 g.

For Ca also the highest carry over was found (30,53 %) and the error of analysis was markedly lower (6,88 %).

The high values of the error of mixing and the carry over observed for Ca may not only be due to the feeder itself. Particle size of the mineral- and vitamin-premix may be an important factor influencing the mixing result [6]. Furthermore the error of mixing is reduced at a target quantity of 4000 g. This indicates that the error of mixing is also a function of the target quantity.

As the error of mixing and the carry over for Mg and P was only slightly higher as compared to the error of analysis, a homogenous mixing process with a minimal carry over at conveying can be assumed for these elements.

Conclusion

The error of dosage and the error of adjustment seem to be satisfactory for a nutrient supply of the animals according to the requirement. At a practical target quantity of 4000 g the mixing process for Ca, Mg and P is almost homogenous. With the exception of Ca the carry over of the elements is low. But the high carry over of Ca might be caused also by the properties of the mineral- and vitamin-premix used.

Literature

[1] Cui, H.; Grace, J. R. (2006): Pneumatic conveying of biomass particles: a review. China Particuol. 4, S. 183–188

[2] Groesbeck, C. N.; Goodband, R. D.; Tokach, M. D.; Dritz, S. S.; Nelssen, J. L.; Derouchey, J. M. (2007): Diet mixing time affects nursery pig performance. J. Anim. Sci. 85, S. 1793–1798

[3] Naumann, K.; Bassler, R. (1976): Verband deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten. Methodenbuch III. Die chemische Untersuchung von Futtermitteln. Verlag J. Neumann-Neudamm, Melsungen, Berlin, Basel, Wien

[4] Hepherd, R. Q.; Randall, M. J.; Lightfoot, A. L.; Armsby, A. W. (1982): Field trials of an automatic conveying and dispensing system for pelleted pig feeds. J. Agric. Engng. Res. 27, S. 455–463

[5] McKendry, P. (2002): Energy production from biomass (part 1). Overview of biomass. Bioresourc. Technol. 83, S. 37–46

[6] Friedrich, W.; Jansen, H. D. (1974): Mischgüte und Mischstabilität als Qualitätsmerkmale von Mischfutter. Übers. Tierernährung 2, S. 239–257

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