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Chopped Forage Maize Compactibility

Effect of Repeated Compression, Increasing Pressure and Chop Length

Chopping longer lengths of forage maize to improve structure efficiency in silage has increasingly become a topic of discussion. Besides the effects of the longer pieces on rumen physiology, the question arises on whether there could be negative effects on the feed quality. At the Institute of Agricultural Engineering in Bonn, this influence was investigated.

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Keywords

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Increased chop lengths lead to lower dry matter density in silos [1; 2]. With increased chop lengths calling for more effective compression work [3], the question arises as to how the effectiveness of compression can be increased.

It is not clear if a significant improvement of the density in silos can be achieved by an increased number of compression passages alone, or if the material must be compressed at a significantly higher pressure.

An attempt to answer this question was made in cooperation with Syngenta Seeds and the Chamber of Agriculture North Rhine-Westphalia; three maize varieties (A, B and C) were cultivated on the fields of the Haus Riswick agricultural training and research station and chopped at two lengths (5 and 21 mm). Variety C was chopped only to a length of 5 mm, but with variations in cutting height, which resulted in one variant with a conventional cutting height (C) and another with increased cutting height (70 cm cutting height, C*).

Description of the chopped forage

With the aim of describing the physical properties of forage particles, a sieve stack was used to grade the particles into eight fractions from x>2 mm to x<40. This standardized method has already been described in some detail [4].

As regards the composition of the material, this paper shall concentrate on dry matter content, which has a crucial influence on the density that can be achieved [2].

Compactibility tests

The compactibility tests were carried out with a materials testing machine (Zwick 1445). Compression tests of this kind have been widely used since the 1960s [5, 6, 7]. For the present investigations the chopped forage was compressed with a plunger at the given rate of 90 mm/min. What is of special interest apart from the maximum compression achieved is material relaxation, measured one minute after the pressure on the material is released. „Density after relaxation" can be calculated on this basis. These values provide information on the behaviour of the material under the load of the tractor and on material relaxation after the compression passage.

In the present investigations, the material was first compressed at the maximum pressure of 0.45 MPa. By comparison, in a second series of tests the pressure was lowered to the common-practice value of 0.2 MPa, but the material was compressed three successive times.

Results of the sieve analysis

The results of the sieve analysis are presented in terms of a size class distribution in *Figure 1*.

In the smallest fractions (x<2 to 3≤x≤6 mm) the percentages by weight of the 5 mm variants are greatest. Depending on their shape, maize grains or grain fragments can be found in the size categories between x<2 and 6≤x≤10 mm. The higher relative density

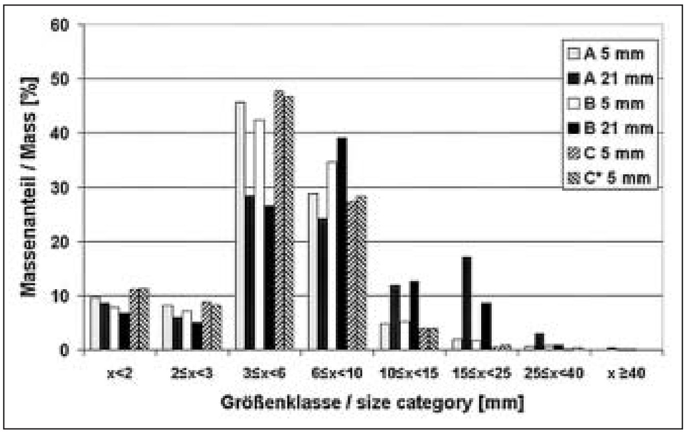

Fig. 1: Size class distribution of the variants

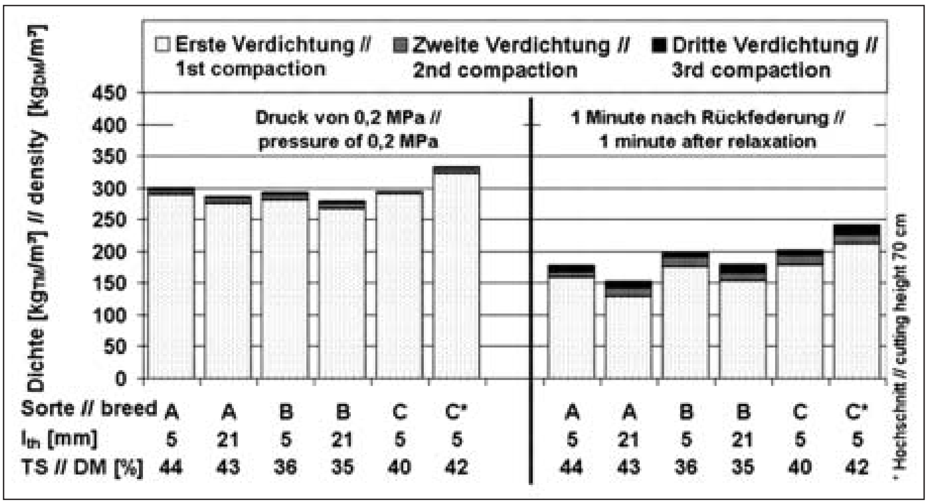

Fig. 2: Effect of repeated compression on dry matter density at a pressure of 0.2 MPa and one minute after relaxation

of maize grains compared to the rest of the plant explains the relatively high mass percentages of all variants in the range from x<2 to 6≤x≤10 mm. Due to the fact that the material under consideration is dried material, grains may constitute up to 45 % by weight [8].

In the fractions from 10≤x≤15 to x>40 mm the 21 mm variants make up the greatest mass percentages, with the dry matter share possibly influencing the size class distribution in this case as well (*Table 1*).

The drier 21 mm variant has greater weight percentages in the range of 15≤ x ≤25 and 25 ≤ x ≤ 40 mm, which may be a sign of the size reduction of very dry material being more difficult. The relevant research literature, too, has pointed out that there is a relationship between dry matter content and size class distribution [9].

Results of the compactibility tests

The results of the first compaction test are presented in *Figure 2* (three compression passes at a pressure of 0.2 MPa).

At a pressure of 0.2 MPa, the 5 mm variants tended to have a higher density than the 21 mm variants.

The different variants achieved densities between 267 and 320 kg DM/m³, which may be interpreted as an indicator of effective compression. However, the increases in density resulting from repeated compression were only around 4 %.

With relaxation varying between 31 % (C*) and 50 % (variety A, 21 mm), the absolute density values ranged between 153 (variety A, 21 mm) and 242 (C*) kg DM/m³. Thus, the main problem lies in the great extent of material relaxation. Repeated compression lowered relaxation by up to 19 %. In the second investigation the material was compressed only once, but at a considerably higher pressure (0.45 MPa).

Figure 3 presents the results of the compaction test.

The densities of 287 to 334 kg DM/m³ at the maximum pressure (0.45 MPa) were 31 to 38 % higher than the densities at a pressure of 0.2 MPa. However, material relaxation was significantly higher as well, ranging from 45 % (C*) to 63 % (A, 21 mm). Thus, this method of compression seems to be unsuitable particularly for long-chopped material with a high dry matter content. Ranging from 145 (variety A, 21 mm) to 241 kg DM/m³ (C*), density after relaxation was on the same scale as after triple compression at a pressure of 0.2 MPa.

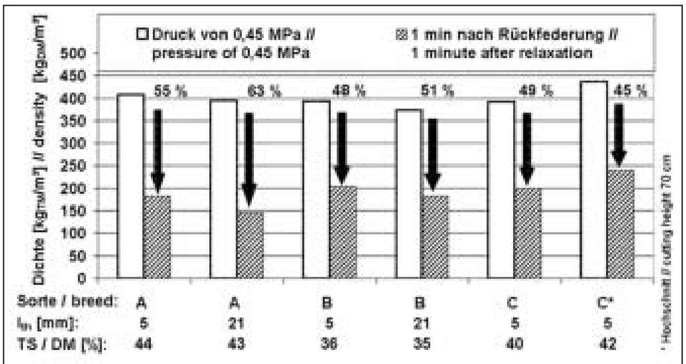

Fig. 3: Influence of a single compression path on dry matter density, at a pressure of 0.45 MPa and one minute after relaxation

Table 1: Dry matter contents of the variants

Influencing variable	Variant					
Breed	**A**	**A**	**B**	**B**	**C**	**C***
chop length [mm]	5	21	5	21	5	5
dry matter [%]	44	43	36	35	40	42

Conclusion

Theoretical chop length has a clear effect on the percentages of the fractions from 2 to 6 and larger than 15 mm. An increase in chop length from 5 to 21 mm leads to a decrease in compactness of up to 17 %.

Neither by compressing the material three times at a pressure of 0.2 MPa, nor by compressing it once with increased pressure (0.45 MPa) was it possible to achieve sufficient density after relaxation. Accordingly, it must be assumed that under practical conditions, too, it is only by a combination of repeated compression and increased pressure (higher weight of the vehicle used for compression) that sufficient compactness can be achieved.

Literature

Books are identified by •

[1] *Hoover, L.L., D. R. Buckmaster, A. J. Heinrichs and G. W. Roth*: Particle size and compaction characteristics of mechanically processed corn silage at varying lengths of cut. Paper no. AETC98-103 from 1998 Agric. Equip. Tech. Conf. Louisville, KY.9-11 Feb. 1998, Am. Soc. Agric. Eng., St. Joseph, MI, 1998

[2] *Zimmer, E. und H. Honig*: Die richtige Häcksellänge bei Silomais. Mais (1979), H. 4, S. 8-10

[3] *Thaysen, J.*: Wer bezahlt, der bestimmt. Lohnunternehmen 58 (2003), H. 9, S. 16-20

[4] *Leurs, K., A. Wagner und W. Büscher*: Nacherwärmung von Maissilage. Landtechnik 59 (2004), H. 2, S. 100-101

[5] *Fürll, C.*: Spannungsrelaxation und Rückdehnungsverhalten von angewelktem Wiesengras bei Verdichtungsvorgängen. Deutsche Agrartechnik 22 (1972), H. 12, S. 566-568

[6] • *Kutzbach, H.D.*: Die Grundlagen der Halmgutverdichtung. Dissertation, TU Braunschweig, VDI-Verlag, Düsseldorf, 1972

[7] *Mewes, E.*: Verdichtungsgesetzmäßigkeiten nach Presstopfversuchen. Landtechnische Forschung 9 (1959), H. 3, S. 68-75

[8] *Kromer, K.H. und O. Schmittmann*: Die Maishäckselqualität optimieren. Land und Forst (1999), Nr. 38, S. 22-23

[9] *Schurig, M., G. Rödel und K. Wild*: Schnittlängenqualität. Landtechnik 51 (1996), H. 3, S. 146-147