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Maize Silage – The Influence of Chop Length on Compactibility, Ensiling and Secondary Fermentation

Quality losses in maize preservation due to undesirable rise in temperature and hence secondary fermentation still cause considerable practical problems in dairy cattle feeding. Presumably this problem will become even more severe in the future. Therefore, the goal of this study was to determine the quantitative interrelationships between maize breed, chop length, and the degree of mechanical processing.

Quality losses in maize preservation due to undesirable rises in temperature still cause considerable problems in the practice of dairy cattle feeding. The consequences of undesirable rises in temperature due to increased plant respiration in the silo are losses in palatability, mycotoxin infestation and especially energy losses. As a result of the following developments, the problem of undesirable rises in temperature must be assumed to grow even more severe in the future:

- The demands made on the long-term stability of silage are still on the rise due to an increasing tendency towards round-the-year indoor keeping and due to the resultant feeding of livestock with silage throughout the year.
- The compaction of silage, an important measure to avoid undesirable rises in temperature, is becoming a bottleneck in the ensiling chain because of the increasing field capacities of forage harvesters.
- Greater chop lengths, which are currently being discussed as a means of improving the structural value of silage [1], are another impediment to adequate compaction.

The objective of the present study has been to arrive at quantifiable findings concerning the influence of maize breed, chop length, and the degree of mechanical processing on the ensilability of maize. Accordingly, the following questions are to be settled:

- How can compaction be optimised without unreasonable effort?
- Provided satisfactory compaction is possible at chop lengths of 20 mm or more, what is the additional packing effort required?

Materials and Methods

In cooperation with the Chamber of Agriculture North Rhine-Westphalia, two maize breeds were cultivated on the fields of the agricultural training and research station "Haus Riswick" in the year 2003. These maize breeds were chopped at three different chop lengths (5.5, 14.0 and 21.0 mm) and two different clearance settings (1.0 and 2.0 mm) and subsequently ensiled in surface silos and tube silos. The resulting variants were analysed for chopping and processing quality, compactibility, and the course of the temperature curve of the silage from ensiling to feed-out.

The maize was harvested with a self-propelled forage harvester with a 24-blade chopping cylinder (constant number of revolutions per minute). The chop length was set via the speed of the pick-up.

To include surface silos in the comparison, one maize breed was chopped at chop lengths of 5.5 mm (1 mm clearance) and 21.0 mm (2 mm clearance) respectively. These two variants were ensiled separately in surface silos and compacted conventionally with a fore-loader (15 t).

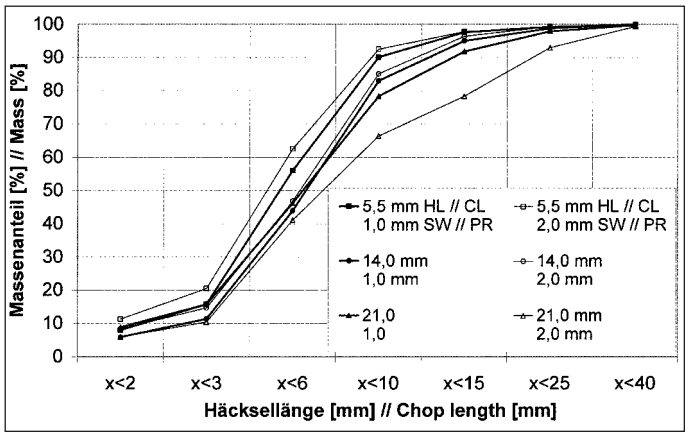

Fig. 1: Influence of theoretical chop length (CL) and distance between processing rolls (PR) on cumulative frequency of the chop length

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Keywords

Forage maize for silage, chop length, compactibility, ensiling, secondary fermentation

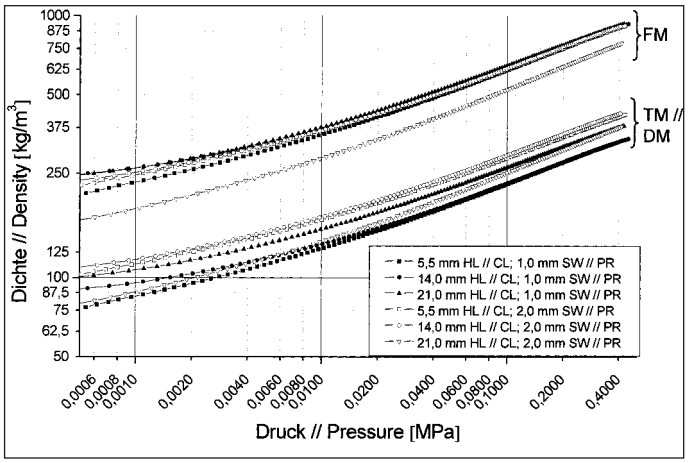

Fig. 2: Influence of the theoretical chop length (CL) and distance between processing rolls (PR) on the density of chopped whole plant maize. Fresh matter (FM) in comparison to dry mass (DM) density

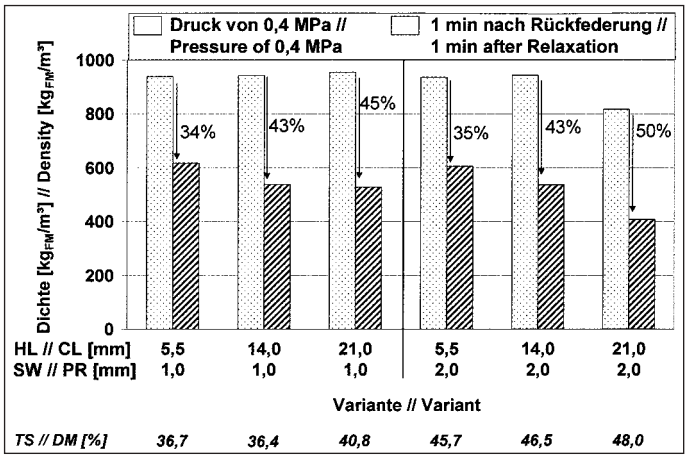

Fig. 3: Density of chopped whole plant maize after a pressure of 0.4 MPa and after one minute of relaxation

The chop length distribution was determined by a standardised method with a sieve stack (circular holes) [2].

Compactibility was determined with a materials testing machine. Chopped silage was filled loosely into a plastic cylinder with a height of 30 cm and compressed with a plunger at a rate of 90 mm/min. The height of the cylinder is the equivalent of the layer thickness of 30 cm officially recommend by agricultural advisers for the practice of ensiling [23]. The maximum compaction pressure achievable with a materials testing machine is 0.45 MPa, whereas in silos the typical pressure is 0.2 MPa. The force employed for compaction is measured and recorded continuously (with a force sensor) over the entire movement of the plunger, thus providing a basis for force/distance diagrams. The results were evaluated in pressure/density diagrams. In addition to maximum compaction, relaxation after compaction was also taken into consideration. To that purpose, the filling level in the cylinder was measured after a defined period of time after compaction. Measurements were repeated six times for each variant.

First results of experiments undertaken in 2003/04

The first experiments were undertaken in the autumn of 2003. Due to the comparatively hot and dry summer the dry matter content of the silage samples was extremely high (up to 48 % DM).

What is presented in the following are the results of sieve analyses and of compactibility tests of the maize breed Oldham with chop lengths (CL) of 5.5, 14.0 and 21.0 mm and with kernel processor clearance (PR) settings of 1.0 and 2.0 mm.

The results of the sieve analyses suggest that theoretical chop length has a considerable influence on chop length distribution. With regard to cumulative frequency (*Fig. 1*) it is evident that a clearance setting of 1.0 mm results in a mass distribution that is less varied than that resulting from a 2.0 mm setting. The mass proportion of larger particles increases as theoretical chop length increases. It is especially with the 21 mm variants that the effects of the kernel processor become apparent. At 1 mm processing roll clearance it is not only the kernels but also the other parts of the plant that are comminuted.

A comparison of the compactibility of maize silage samples on a dry mass basis (*Fig. 2*) shows that only a relatively low degree of compaction (275 kgDM/m^3) can be effected for 37 % DM silage with theoretical chop lengths of 5.5 or 14 mm (1.0 mm PR) and compacted with a pressure of 0.2 MPa. While the DM density difference between 5.5 and 14.0 mm CL with the same degree of mechanical processing decreases, the difference between the degrees of processing increases for these chop lengths. This does not apply to the 21.0 mm variant: In this case the difference between the degrees of mechanical processing, which is 16 % initially, disappears completely as the pressure increases.

Because of the great variations in dry matter content, the differences in compactibility cannot be attributed exclusively to the chop length or the degree of mechanical processing. The fresh matter/density results show that with increasing pressure the variant with a theoretical chop length of 21.0 mm and a 2.0 mm processing roll clearance has a lower density than the other variants, with the difference decreasing as pressure increases.

A pressure of 0.4 MPa effects densities of up to 954 kgFM/m^3, but due to material relaxation (elasticity) these values are reduced by up to 50 % (21.0 mm CL, 2.0 mm PR) (*Fig. 3*). For both degrees of mechanical processing, relaxation increases with increased chop length. Thus, at the end of the compaction process, after material relaxation, the variant with the highest degree of mechanical processing (5.5 mm CL and 1.0 mm PR) has a density of 227 kgDM/m^3, whereas the variant with the lowest degree of mechanical processing (21 mm CL and 2.0 mm PR) has a density of 196 kgDM/m^3.

Discussion and conclusions

The effect of the kernel processor on chopped forage is a reduction in size. The compactibility tests undertaken with a materials testing machine provided no evidence that the chop length of material processed at 1.0 mm roll clearance has a clear influence on compactibility at maximum compaction. However, a roll clearance of 2.0 mm clearly has an influence in the case of chop lengths between 5.5 and 21 mm.

It may be due to differences in dry matter content that material with a theoretical chop length of 5.5 mm and a processing roll clearance of 1.0 mm has lower compactibility than material with a theoretical chop length of 14.0 mm or 5.5 mm and a 2.0 mm processing roll clearance. In addition, differences in density might be attributable to a roughening or splicing of the silage at a tight 1.0 mm roll clearance, which makes a tight packing of the particles impossible.

Density after relaxation decreases with increasing chop length. A high degree of mechanical processing reinforces this effect.

Literature

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