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Maize for Silage

Chop Length as a Function of DM Content

High demands are placed on the energy content and material composition of the silage used for animal feeding and energy production in biogas plants. Low loss forage preservation requires dense compression, which has a decisive influence on silage stability during the feed-out period ('long-term stability'). The influence of chop length on the compressibility of chopped maize with various DM contents was examined on a laboratory scale.

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Keywords

Maize silage, chop length, dry matter content, compactibility, ensiling, secondary fermentation

There are general recommendations regarding the practical compression work at the time the fresh plant material is placed in the silo. Timely control of the compression work even before storage requires prompt information on the relevant parameters and process factors, e.g. the DM content and the chop length distribution (e.g. proportion of oversize material) of the chopped maize, and on the corresponding measures to be combined in a control loop (*Fig. 1*).

Recent technical developments for online measurements using NIR sensors to determine the moisture content or using photo-optical sensors to determine the stage of maturity have made it possible to adjust the chop length in accordance with the current DM content [2]. However, the decision-making process lacks the corresponding measure that would guarantee optimum compression on the basis of such measurements.

In biogas production, greater particle size reduction accelerates biological decomposition, but it does not necessarily lead to a higher gas yield [3]. Accordingly, from a process engineering viewpoint, it seems reasonable to use greater chop lengths because of the resulting increase in field capacity. From an animal nutrition point of view, greater chop lengths are being discussed as a means of reducing the risk of acidity in heavy maize rations.

In comprehensive examinations of the influence of chop length on the compression and ensiling characteristics of chopped maize, the bulk density of material with a chop length of 21 mm was 20 % lower than in the 5.5 mm variant [4]. The tests were performed at DM contents between 38 and 47 % so that interaction between maize variety and dry matter content cannot be ruled out entirely. The aim of the present study has been to obtain information on the influence of chop length on the compression characteristics of silage maize with different DM contents.

Materials and methods

In 2005, a high-quality and high-yield variety of silage maize with a strong greening effect was cultivated at the 'Haus Riswick' agricultural centre. Samples were taken with a three-row forage harvester (Kemper Champion 2200) at two-day intervals. When reaching the different desired DM contents (32 %, 35 %, 37 %, 39 %, 41 %), the maize was ensiled with theoretical chop lengths of 8.4 and 22 mm. The focus of the laboratory work was on fractionation tests with a sieve stack (5 min sifting, interval switch, operating/ rest time = 30 sec/ 1 sec) and on compression tests with a materials testing machine (compression: three times in a cylinder

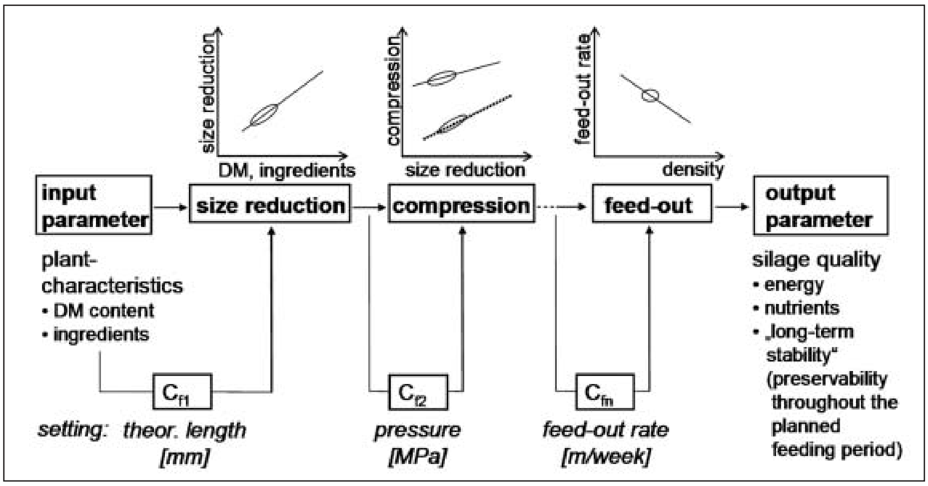

Fig. 1: Control loop for quality assurance of silage (c = control, f = factor) [1]

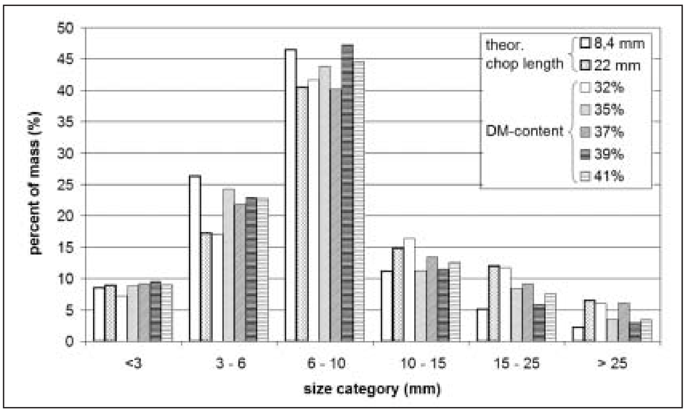

Fig. 2: Size class distribution of different dry matter content and different theoretical chop lengths

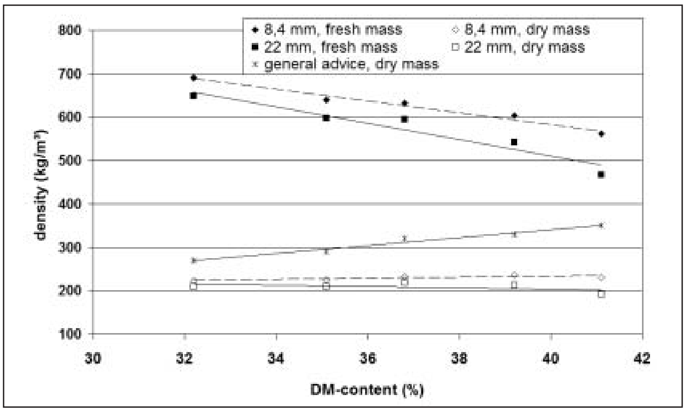

Fig. 3: Effect of dry matter content and theoretical chop length on dry and fresh matter density after repeated compression with 0.2 MPa (n = 4)

with a height of 30 cm and a diameter of 12.5 cm; density measurements: immediately after compression at 0.2 MPa and 60 seconds after release of the load). The methods are described in detail in [4].

Results of the sieve analysis

The results of the particle size distribution tests suggest that particle size depends on the DM content and maturity stage of the material and on the theoretical chop length set on the harvester. To determine the degree of dependence on both these factors, the mass distribution is analysed separately for chop length (average over all DM contents) and for DM content (average over both chop lengths) (*Fig. 2*).

A greater chop length leads to an increase in particles of the size classes > 10 mm. These size classes make up 18.5 % in the variant with the shorter chop length and 33.4 % in the longer variant. Thus, by choosing a greater chop length, it is possible to raise the proportion of large particles by approximately 15 percentage points. In investigations by [4], a chop length of 21 mm also increased the quantity of particles > 10 mm by 18 and 13 percentage points in comparison to chop lengths of 5.5 and 14 mm.

In the material with the greater chop length, an increased proportion of particles > 10 mm leads to a smaller proportion of particles in the size classes < 10 mm (*Fig. 2*).

Figure 2 illustrates the influence of increasing stages of maturity irrespective of the chop length of the material. The proportion of larger particles tends to decrease with increasing DM contents. In the process, the proportion of large particles decreases by approximately 10 percentage points. On the other hand, the proportion of material in the size classes < 10 mm increases with increasing maturity, particularly in the size classes between 3 and 6 mm and between 6 and 10 mm. With increasing DM contents, the elasticity of the material may be expected to decrease while its brittleness increases, which explains why mechanical processing produces smaller particles if the material is harvested at a later stage of maturity.

Results of the compression tests

Figure 3 shows that dry density is largely independent of DM content, whereas chop length is much more important. In the short variant (8.4 mm), the density one minute after release of the load is 21 kg DM per m^3 (or 10 %) higher, because the relaxation of the material is less pronounced in this variant. The reason why material relaxation is less pronounced in the shorter variant is probably that the proportion of large particles in the size class > 10 mm is approximately 15 percentage points smaller.

The influence of the DM content on dry density one minute after release of the load must be regarded as small. Up to a DM content of approximately 39 %, there is a slight increase in density. Above a DM content of 40 %, however, there is a clear decrease in density. The influence of chop length is greater here.

With regard to fresh density (original material), DM content clearly has a greater influence on the achievable density than does chop length (*Fig. 3*). It remains to be determined which parameter – fresh density or dry density - an assessment of the degree of compression should be based on.

In particle mixes, bulk density is an indirect measure of void content, which is a determining factor of the gas exchange at the silo face and, consequently, of undesirable temperature increases. A high proportion of combined water in the harvested crop reduces the total void content. Thus, like the solids content, it contributes to a reduction of the gas exchange. This is directly related to soil physical analyses which characterise the texture of soil on the basis of its void content. Accordingly, recommendations for the compression of maize silage say that for DM contents > 33 % the density should increase by 10 kg DM/m^3 for each percentage point, beginning at 270 kg DM/m^3. However, this recommendation implies target values of 350 kg TM/m^3, which are not reached in practical farming.

Thus, especially for dry forage, the decision to increase the chop length to 22 mm requires measures suitable to achieve higher densities. The compression values reached in the tests failed to meet the compression requirements both of dry and fresh silage. Thus, the question remains open as to how maize silage has to be compressed in order to be suitable as fodder or as a renewable resource for biogas plants..

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