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Mechanical dewatering of silage

The use of screw presses for dewatering of silage is energetically more efficient than thermal drying. Tests with two types of screw presses show that on dry matter flow rates of more than 1.0 t_{DM}/h the specific energy consumption is less than 30 kWh/t_{DM}. The water content of the silage is decreased by 5 to 20 % and the share of undesired ingredients by 2 to 30 %. Besides press design and plant species, in particular moisture content, chip size and density of silage are essentially for the dewatering success.

Keywords
Silage, dewatering, screw press, energy, ingredient

Abstract
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Pressing vegetable materials out for dewatering and/or making juice is well established. New, however, is the use of silage from greenery. The process, propagated by Prof. Scheffler from the Kassel-Witzhausen University, facilitates the generation of fuels from stalk cutting. In this process both, the solid phase (pressed cake) as well as the liquid phase (pressed out juice) is used. The former is processed to solid bio fuels, e.g. pellets, which can be fired or gasified, and the latter can be added as co-substrate in a biogas plant. The advantages of the (partly) dewatering of the silages are the reduction of energy demand for thermo drying as well as in the reduction of environmentally damaging, emission relevant substances of solid fuel.

Since only few confirmed results for the pressing out of silage were published, the process has been examined within the scope of a joint project promoted by FNR for analysis and evaluation of the entire process chain from the field to the synthesis gas. The objective of the examinations demonstrated in the following was the generation of confirmed data for throughput, energy consumption, effectiveness of pressing, and reduction harmful substances in dewatering various fuel plant silages with screw presses. Since directly usable results could be expected, the measuring was carried out with conventional screw presses under practice relevant conditions.

Material and methods

In a total of 11 series of measurement, 1 to 20 t of silage from corn, grass, rye, and barley plants, partly from 2nd stage cultivation, were processed. The test silage was stored 5 to 17 months in conventional horizontal silos. Particle lengths varied between 5 to 21 mm (median); major lengths, however, being circa 10 mm. The measuring was carried out with screw presses type Avz and DZvv by Anhydro GmbH Kassel (former Fa. Vetter) in a conventional agricultural drying plant in Selbelang as well as in the pilot plant of Amandus Kahl GmbH & Co. KG Hamburg (**table 1**).

The tested screw presses are cylindrical screws with a widening inner tube and decreasing pitch. The screw is cladded with an enhanced strainer, through which the pressed out juice can pass. The end of the screw has an adjustable congestion cone against which the material is pressed. The pressed cake is extruded through the annular gap of the cone (**figure 1**).
Conventional electronic measuring devices were used for de-

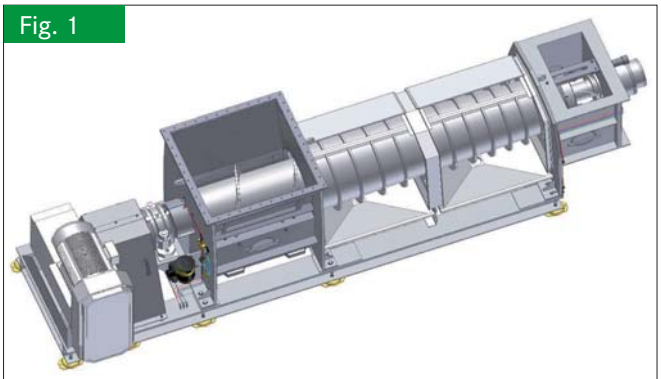
Table 1

Specifications of tested screw presses

Parameter		Pressentyp	
		Avz	DZvv
Antriebsleistung	kW	5,5	45
Eigenmasse	kg	500	6 450
Drehzahl	1/min	8	12
Kompression[1)]	-	1 : 4	1 : 3
Sieblochdurchmesser	mm	0,7	1,5; 1,2
Staukonus-Verstellung	-	mechan.	pneumat.

[1)] Verhältnis der Volumina von Ausgangs- zu Eingangsschneckengang

Fig. 1



Basic principle of the tested screw presses

termination of volume and power demands. The water content was measured with a drying oven (105°C), and the content of substances was identified according to established VDLUFA-methods. Sampling and measuring was carried out in 15 minute intervals. The measuring time was 15 to 30 seconds.

Measured properties:

- electric power consumption (kW)
- volume throughput of silage and pressed cake (t_{DM}/h)
- water content of silage and pressed cake (%)
- volume flow of juice (l/h)
- dry mass content of juice (%) as well as
- substance content of silage, juice, and press cake (%)

Volume throughput and energy consumption

The volume throughput substantially depends on the construction parameters of the screw press and the density of the materials pressed out. Thus the larger of both screw presses (DZvv) achieved higher throughputs of up to 1.2 t_{DM}/h compared to the smaller press (Avz). The dry mass throughput of corn and rye silage (bulk density 70 ... 120 kg_{DM}/m^3) is normally higher than the bulk density of grass silage (50 ... 70 kg_{DM}/m^3).

The throughput determines the demand of electric power, which is indicated in close correlation between mass throughput and specific energy consumption. Both screw presses show the hyperbolic performance characteristics typical for processing machines (**figure 2**). In materials with low humidity (< 60 %), high bulk densities (> 100 kg_{DM}/m^3), and short chaff lengths (< 10 mm) specific energy consumptions of less than 30 kWh/t_{DM} were achieved. Since in this respect there is hardly any difference between the two screw press types used, it can be assumed that by constructional optimization of the larger press type DZvv the specific energy consumption could be reduced further.

Pressing effectiveness

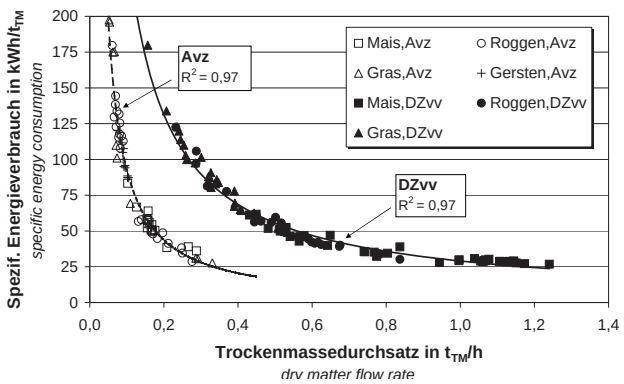
The effectiveness of pressing of screw presses is not only characterized by the reduction of water content but also by the loss of dry mass, resulting from solid particles passing through the strainer. As far as the pressed out juice and the pressed cake are used for energy generation, like in the present case, this is not a real loss, though. For the tested materials and screw presses is the loss through the strainer in the range of 5 to 15 % (DM) of the incoming silage with the loss through the strainer increasing with higher mass throughputs.

Using the DZvv screw press, the water content of silages with high humidity (> 80 %) can be reduced by up to 20 % (absolute). In silage with lower humidity the difference is reduced accordingly and is circa 5 to 15 % in silages with usual humidity of 60 to 70 %. Shorter particle lengths, however, improve pressing effectiveness and there are as well other differences between the materials, since corn silage has proved more suitable under the similar conditions than other tested silages. The results point to a required minimum humidity of 40 to 50 %. Below that acceptable dewatering effects cannot be achieved with screw presses (**figure 3**).

Reduction of harmful substances

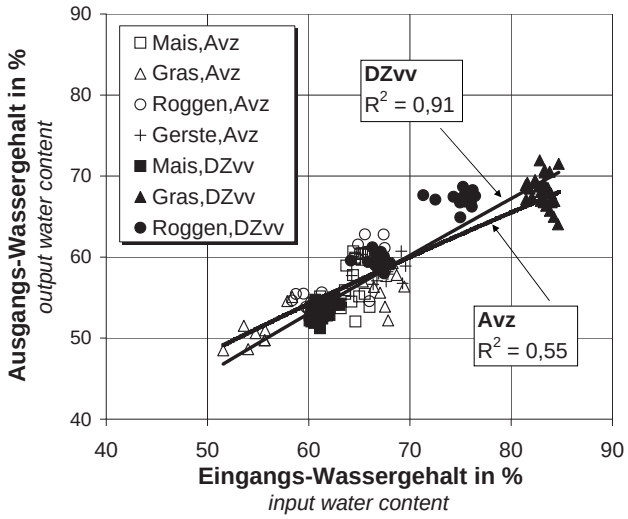
The pressed out juice, consisting of a watery solution with solid particles, contains substances which can be of advantage when returned to the field and/or in fermentation processes, but are

Fig. 2



Energy consumption and dry matter flow rate during dewatering of corn, rye, barley and grass silage by means of the screw presses Avz and DZvv

Fig. 3

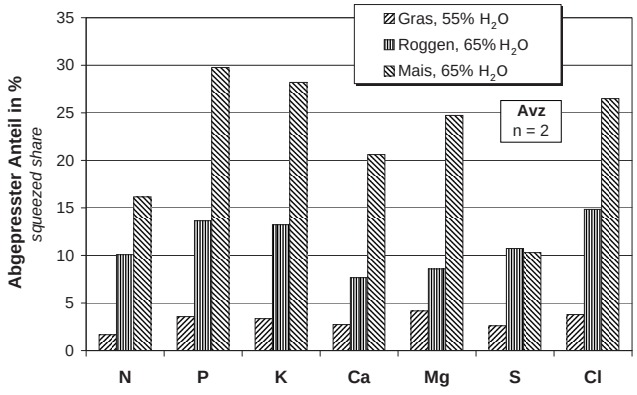


Dewatering success of screw presses depending on water content of silages

rather of disadvantage for burning or gasification. Inter alia, these are specifically the micro and macro nutritive substances nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), and chlorine (Cl). These substances potentially cause technical problems (corrosion, slagging) and/or noxious emission (NO_x, SO_2, dioxin), thus a high proportion of it should be pressed out.

Although the concentrations of these substances in the pressed out juice are 1 to 4 times higher than in the silage, the relative reduction can be kept within the limits and is lower than 30 %. The reduction particularly depends on the water content of the silage at the beginning. Whilst in the relatively dry grass silage only 2 to 4 % of these substances are pressed out, in the humid corn silage it is about 20 to 30 % (**figure 4**).

Fig. 4



Relative reduction of selected ingredients during dewatering of silages with different water contents

Conclusions

The carried out tests allow for the following conclusions:

- The throughput of screw presses substantially depends on the kind of material, particle length, bulk density, and water content. The larger of the two screw presses can achieve dry mass throughputs of 0,8 t_{DM}/h, and with extremely short particle lengths (5 mm) even 1,2 t_{DM}/h. Higher throughputs can certainly be achieved with constructive changes.
- The specific energy consumption, which is potentially determined by the throughput, is under optimal conditions between ca. 30 kWh/t_{DM} (corn silage) and 70 kWh/t_{DM} (grass silage). This is equivalent to a primary energy demand of ca. 0.3 to 0.7 GJ/t_{DM}.
- The water content of the silage can be reduced up to 20 %, relative to the humidity of the silage. With usual water contents of the silage of 65 %, the water content of the pressed cake is reduced to 55 ±5 % (median).
- Besides water there are ca. 5 to 15 % dry mass pressed out from the silage. In the case of fermentation of the pressed out juice in biogas plants (0.55...0.62 m^3/kg_{DM}) ca. 0.6 ... 2.0 GJ per 1 t_{DM} silage could be generated (based on respective calculation), thus compensating widely for the energy loss of the pressed cake due to mass losses (0.8 ... 2.5 GJ/t_{DM}).
- The contents of (nutritive) substances (N, P, K, Ca, Mg, S, Cl) in the silage, which may cause technical problems and unwanted emission when being burned or gasified are reduced by 2 to 30 %, relative to the effectiveness of pressing of the pressed cake.

Summarizing, it can be concluded that the tested screw presses are suitable for (partial) dewatering of stalk silage, and are of advantage in connection with the generation of dried solid bio fuels. The primary energy demand for the extremely energy intensive thermo drying (ca. 8 GJ/t_{DM}) can thus be reduced with screw presses by up to 25 %, already considering the energy consumption of the screw presses.

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