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Pre-treatment of forage with microwaves and high-frequency radiation

The results of tests with plant material show that microwave application for the acceleration of the drying process results in faster drying as compared with pure convection drying.

According to the current status of research, tests of the drying behaviour of green forage after microwave- and high-frequency treatment in combination with mechanical conditioning have not yet been carried out. By courtesy of the Institute of Agricultural Engineering of Georg-August University Göttingen (director: Prof. Dr. W. Lücke), which permitted the use of its experimental installation, initial research results can be presented.

It was the goal of this study to examine the influence of the pre-treatment of forage with microwave- and high-frequency radiation on drying behaviour and quality development.

Material and Methods

The test material used was alfalfa having an initial dry matter content of 14.7%. Variants resulted from treatment

- in a stationary microwave installation (*Fig. 1*)
- in a high-frequency installation (*Fig. 2*) and
- in the microwave tunnel.

In the climatic cabinet, the drying course was recorded under controlled conditions (at ~ 40 °C and ~ 40% relative humidity). The recording of the drying curves was intended to examine the influence of the individual pre-treatment on subsequent drying behaviour. The zero variants with and without mechanical treatment served as comparative variants. Afterwards, quality was determined according to the Hohenheim feed value test. For this purpose, 11 samples were selected.

For the first part of the trial, both crushed and uncrushed material was used. For treatment in the microwave tunnel, the material was cut to stem lengths of approximately 80 mm.

Both in the stationary microwave system and the high-frequency installation, the mass of the samples examined was about 200 g. Treatment times varied between 15, 30, and 60 seconds. The power radiated by the magnetron was fixed at a uniform level of 1.2 kW.

The sample material for the high-frequency system was poured into a 100 mm tall ceramic ring having a diameter of 300 mm and subsequently placed between two capacitor plates. Treatment took place at a frequency of 27 MHz and a power of 1.2 and 2.4 kW. For 1.2 kW of radiated power, variants of 15, 30, and 60 seconds were applied. When 2.4 kW were radiated, treatment lasted 15 seconds.

The different duration of exposure during treatment in the microwave tunnel was reached by altering the belt speed. The first five variants were exposed to a radiated power of 4.8 kW. The 6th variant was carried out at a radiated power of ~ 8.4 kW. In all variants, the sample mass of ~ 500 g was evenly distributed over 1.4 m of belt length.

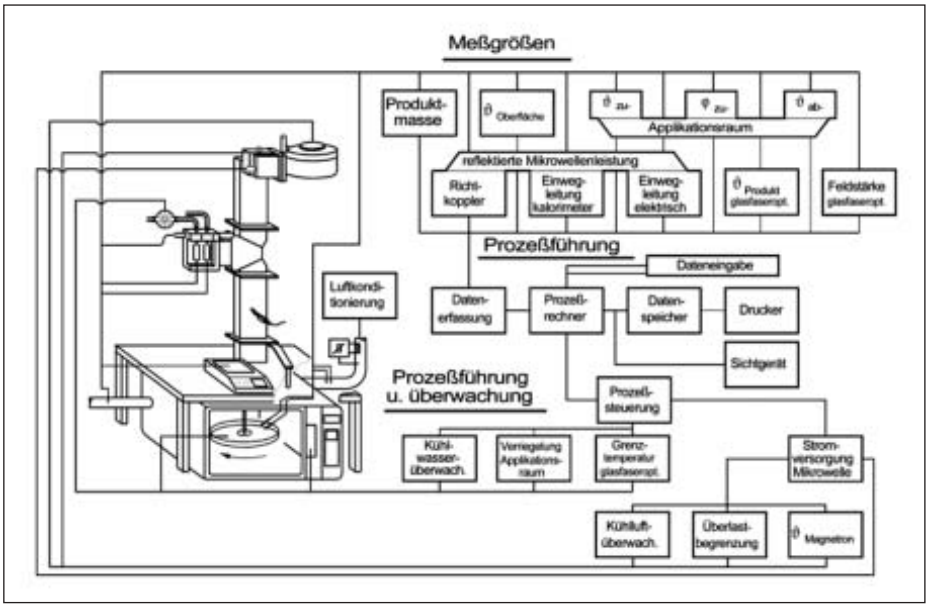

Fig. 1: Design of the stationary microwave-installation

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Keywords

Drying behaviour, forage, quality, microwave- and high-frequency treatment

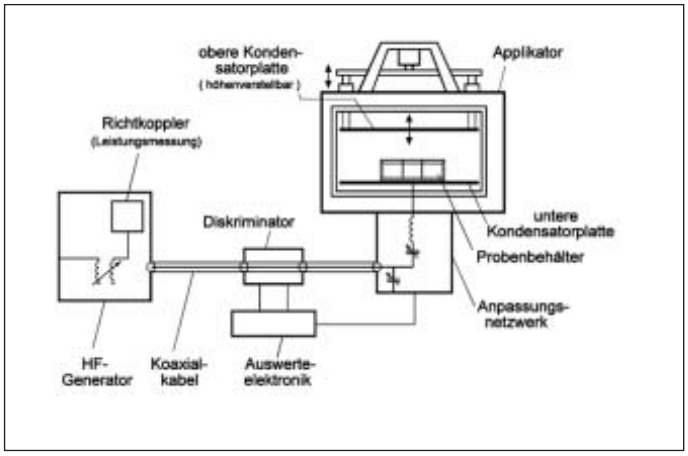

Fig. 2: High-frequency installation

Results

Pre-treatment

For both the stationary microwave installation and the high-frequency system, no significant differences with regard to moisture removal were able to be determined.

Even though the drying effect of the high-frequency system increased with growing radiated power and longer duration of treatment, it is smaller as compared with the stationary microwave installation at the same level of radiated power.

During treatment in the microwave tunnel, the drying effect increased with growing radiated power and longer duration of treatment. The achieved drying effect was greater than in the two first-mentioned trials.

Drying in the climatic cabinet

Virtually all samples treated in the stationary microwave installation showed greater moisture reduction than the comparative variants. The best result was reached at a duration of treatment of approximately 60 seconds. As the duration of treatment decreased, drying speed diminished as well. As compared with unconditioned samples, those samples which had undergone additional mechanical treatment showed the same or better results.

Moisture removal from samples treated in the high-frequency installation was at the same or at a lower level than in those samples which were only treated mechanically. A difference between mechanically treated and unconditioned samples was able to be observed in only two cases (1.2 kW, duration of treatment: 30 s; 2.4 kW, duration of treatment: 15 s). In those samples which had undergone additional treatment, no disadvantage was able to be established. Doubling the radiated power provided better results. In addition, the variant exclusively based on mechanical treatment dried faster.

Treatment in the microwave tunnel speeded up the drying process significantly in some cases. The variants characterized by the shortest duration of treatment showed virtually no difference as compared with the variant exclusively based on mechanical treatment.

A comparison of two variants (4.8 kW, duration of treatment: 66.6 s and 8.4 kW, duration of treatment: 20.8 s) is interesting. Even though almost twice as much power was radiated in the second variant, the drying effect provided by the first variant was virtually identical because the duration of treatment was three times longer (*Fig. 3*).

Quality analysis

All samples treated with microwaves showed good colour- and odour quality. Samples from high-frequency treatment, however, noticeably smelled like burned material, and their coloration also showed signs of burning during treatment. After the evaluation of the feed value test, all samples are in the same quality class. Negative effects on nutrient contents and energy density were not confirmed.

Summary

By drying all samples in the climatic cabinet at an air temperature of 40°C and a relative humidity of approximately 40%, comparable conditions were created. If the air does not circulate, however, the absolute quantity of moisture removed is comparatively small. Nevertheless, the comparative values are meaningful for the drying acceleration effect caused by pre-treatment with microwave and high frequency.

With growing exposure times and increasing power radiated by the microwaves, considerably better results are achieved. Mechanical treatment also led to the expected acceleration. The combination of mechanical conditioning and microwave treatment proved useful and advantageous for moisture removal.

Given the drying results, treatment with high frequency is no practicable alternative to the mechanical conditioning of green forage. The fact that the green forage has an unpleasant smell and looks burned after treatment makes this technique appear questionable as a means of feed preparation.

The results in the microwave tunnel are interesting. Here, virtually the same acceleration of the drying process was achieved in two variants at different levels of radiated power. The decisive factor proved to be the duration of treatment rather than radiated power.

Under real harvesting conditions, both techniques hardly seem appropriate due to their great energy requirements and the necessary long duration of treatment. Under real harvesting conditions, significantly more radiated power would be required in order to achieve a comparable effect. This would result in a large energy demand.

According to the results of the Hohenheim feed value test, all examined variants were assigned to the same quality class. The sensorically determined burning of the material was not confirmed by the values. After microwave treatment, no negative effects on feed quality were established.

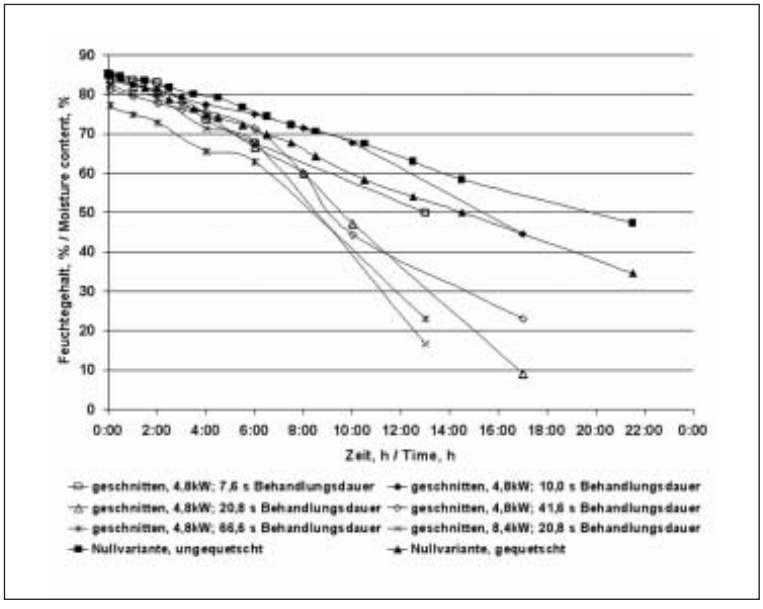

Fig. 3: Drying curves of the samples treated in the microwave tunnel as compared with zero variants