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The Influences of Grain Species on Physical Parameters of Moist Grain

Due to increasing energy costs, interest in utilising moist grain is increasing. Experiments with grain species have shown that there are significant differences in physical parameters, which are important for maintaining the quality of the preserved moist grain.

In Central Europe grain is rarely harvested with a moisture content exceeding 20 %, whereas in regions with less favourable climatic conditions, such as Great Britain or Scandinavia, it regularly has a moisture content of more than 30 % at harvest. Without appropriate measures, it is impossible to store grain with moisture contents higher than only 14 % without an increased risk of spoilage.

The most widely used approach in connection with cash crops is to dry the grain to a moisture content below 14 %. In the last five years, however, the resulting costs have increased by more than 20% as a result of rising energy costs so that the drying costs are approximately 10 €/t for grain with a moisture content of 16 % and as much as 25 €/t at 20 %. Storage methods allowing grain preservation without prior drying are therefore becoming increasingly attractive. It is basically possible to ensile whole grains as well as crimped or ground grains. While densities after compression of 1,000 kg/m^3 are practicable with the latter, a minimum of 6 litres of propionic acid per tonne is required for stable storage of grains with a moisture content exceeding 16 % [1].

The silage bag method, where freshly harvested grain with a high moisture content is crimped, optionally sprayed with a silage additive and pressed into a silage bag, all in one operation, promises lower storage costs while maintaining the quality of preserved moist grain [2].

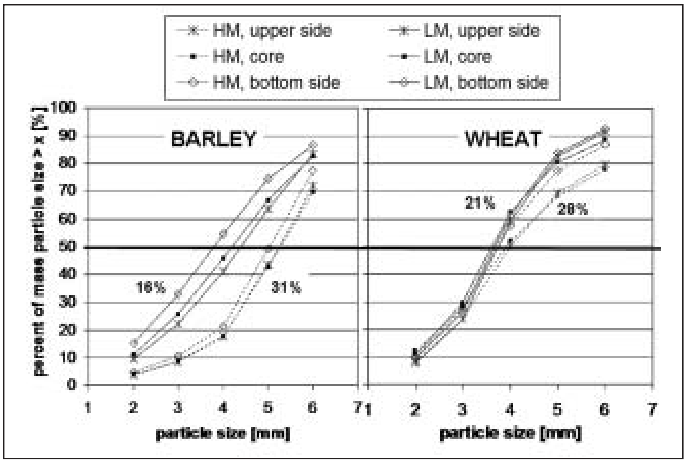

Fig. 1: Particle size of crimped grain versus moisture content (W.B.) at storing and position of extraction at the silage bag

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Keywords

Moist grain, physical parameters, silage bag, aerobic stability

Laboratory and practical experiments were carried out to analyse several quality relevant factors.

Material and Method

During the 2006 harvest, barley with moisture contents of 16 and 31 % and wheat with moisture contents of 21 and 28% were harvested with a rotary combine harvester (John Deere, CTS 9780).

Subsequently, around 13 tonnes of each moist grain type were pressed into silage bags with a length of 7-8 m, using a bagging machine with an integrated grain crimper (Murska 2000 2x2 crimper-bagger).

In order to achieve maximum size reduction in the crimper, the clearance between the rollers of the crimper-bagger was set to 0.1 mm, which is smaller than the minimal clearance of 0.3 mm recommended by the manufacturer. To assess the influence of a chemical silage additive for improved aerobic stability, one silage bag of each grain type and moisture content was treated with 4 litres of KOFA GRAIN-pH 5 per tonne, whereas a second bag was prepared with an untreated control variant. The amount of silage additive used was based on experiments carried out in the year before [3].

In variation of the buried bag method, bags containing temperature loggers were placed in the silage to determine the fermentation quality, the fermentation losses and the temperature development inside the silage bags throughout the storage period [3]. The bags were buried lengthwise in four replications at intervals of 1 m. After storage for approximately two months, the silage bags were all opened at the same time at the end of September. In the following 18 days, approximately 30 cm of silage were removed with a silage cutter every other day. After reweighing, samples from the buried bags were analysed for germ content and for fermentation quality parameters.

After removal of the last bags on the nineteenth day after the bags were first opened, pictures of the silage face were taken with a thermographic camera.

The density of the stored material was determined with a core probe (10 cm diameter,

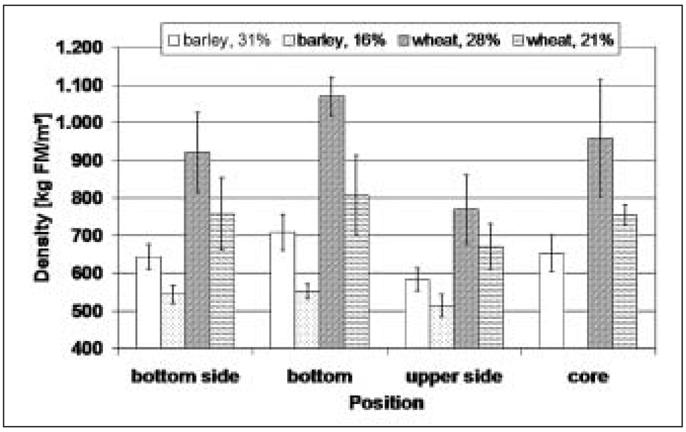

Fig. 2: Density of crimped barley and wheat with different moisture contents (W.B.) at various positions within the silage bag

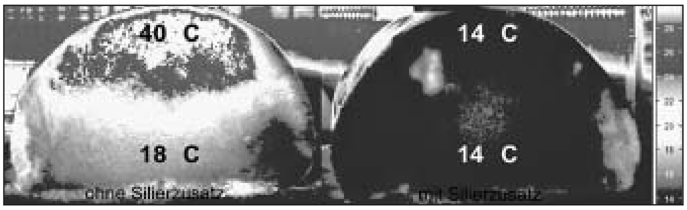

Fig. 3: Thermography picture of barley in the silage bag with 31% moisture content (W.B.). Left: Intensive secondary fermentation of the control variant; right: secondary fermentation can be decelerated significantly with a chemical additive

20 cm sampling depth) at different positions of the silo face.

In order to determine the particle sizes, 200 g of the material sampled with the core probe were dried at 105 °C and fractionated in a sieve stack into the particle size classes ≤ 2 mm, 2-3 mm, 3-4 mm, 4-5 mm, 5-6 mm und ≥ 6 mm.

In addition, the compressibility of samples taken at the time of ensilage was analysed using a materials testing machine (maximum pressure: 0.2 MPa).

Results and discussion

Harvesting moist grain with an unusual moisture content of 30 % did not pose any technical problems under the conditions prevailing in 2006. However, it is not always possible to achieve uniform moisture contents because, firstly, there were average daily moisture decreases of up to 3 % and because, secondly, there were diurnal variations of up to 5%.

The influence of the moisture content of grain on the size reduction achievable with a crimper is illustrated in *Figure 1*. In the case of barley, the average particle size increases with increasing moisture content, whereas such differences are less significant in the case of wheat. One of the reasons lies in the different structures of wheat and barley grains. With increasing moisture contents, barley glumes increasingly reduce the degree of size reduction achievable with crimping rollers so that there is less fragmentation and a greater proportion of grains is flattened, which makes them bigger. It is also evident that the average particle size also depends on the position in the silo as the proportion of particles <3 mm is slightly higher in the lower area of the silage bag. The rotation of the auger conveyor and the compression pressure further contribute to the size reduction of the grain in the exit area of the auger conveyor.

In addition to reducing the degree of size reduction, the barley glumes also bring about greater springback of the compressed material, which leads to significantly lower compressibility compared to wheat. The tests with the materials testing machine showed that after compression with 0.2 MPa the springback of the barley led to density decreases of the compressed material by 28 % (at 31 % moisture content) and 17 % (at 16% moisture content). In the case of wheat, by contrast, the density decreases were only 10 % (at 28 % moisture content) and 9 % (at 21 % moisture content), respectively.

Figure 2 shows that the achievable fresh mass densities in silage bags are around 700 kg/m^3 in the case of moist barley but that fresh mass densities of more than 1,000 kg/m^3 are achievable with moist wheat. In this case, increases in moisture content can lead to significantly higher increases in density after compression than is possible with barley. The density of the dried variants is around 300 kg/m^3 lower in both cases.

Due to its poor compressibility, the volume of voids of crimped barley is much greater than that of wheat. Consequently, contact with air leads to increased gaseous exchange and earlier spoilage.

In the case of wheat, the negative influence of the moisture content on particle size reduction is less strong. Smaller particles are easier to compress; the volume of voids decreases. Increased moisture contents lead to agglutination of the starchy wheat grains, which may reduce gaseous exchanges. In wheat, however, moisture contents higher than 25 % lead to formation of clumps, the subsequent breaking up of which may require additional work.

The investigations focusing on aerobic stability showed a significant dependence on grain type and moisture content at ensilage. Temperature measurements within the silage bags and at the silo face provided evidence of incipient spoilage. Pictures taken with a thermographic camera 19 days after opening the silo bag containing barley with a moisture content of 31% are presented in *Figure 3*.

If no chemical silage additive is used, an intensive spoilage process is likely to start, leading to temperatures > 40 °C in peripheral areas of the silage bag. Similar observations were made for a silage bag containing wheat with a moisture content of 21 °C. By applying 4 litres of a chemical additive per tonne of fresh matter, it was possible to suppress undesirable heating of the silage in all grain and moisture variants throughout the experimental period of 18 days. At the same time, untreated wheat with a moisture content of 28 % at the time of ensilage did not show any clear traces of heating over the experimental period. Likewise, at moisture contents between 15 and 18 %, undesirable heating of the silage is not always detectable. However, in analyses of the germ content (yeasts, moulds) increased values were observed in all variants not treated with the chemical additive, which shows that spoilage had taken place.

Conclusion

Grain species and moisture content at ensiling have a clear influence on the quality of conserved moist grain. In the case of barley, increases in moisture content lead to increased densities after compression, but the negative influence on size reduction entails insufficient stability when exposed to air. In the case of wheat, negative effects on size reduction as a result of increased moisture contents are small. Instead, the achievable densities in themselves can lead to high degrees of stability.

The use of chemical additives is advisable as a quality assurance measure for all types of moist grain.

Literature

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