Proceedings Talk

Duane Bernhardson[1], Elke Hilscher[2], Heiko Narten[2], Stefan Meldau[2].
[1]KWS Innovations, 1500 S 40th St Grand Forks, ND 58201
[2]KWS SAAT SE, PF 1463, 37555 Einbeck.

Heterogeneity of sugarbeets- challenge for recoverable sugar analysis of grower's field samples

The most error-prone process in sugarbeet quality analysis is the preparation of brei with the subsequent analysis. Investigations of more than 50 years show that the quality components not only vary within one beet, but also between beets. In 1961 H. Lüdecke analyzed the content of sucrose, dry matter and ash in sugarbeet by separating each sugarbeet in 16 segments. The variations between the analyzed segments of a sugarbeet where considerable high, indicating a heterogeneity in the quality components.

In 2001 K. Mahn et al determined a decrease in quality components of a sugarbeet from the root to top. Furthermore, the increase of shoot material in a sugarbeet sample led to a decrease in the quality. In 1972 M. Burba analyzed 250 randomly taken samples, each consisting of 20 beets, from a regular population. To ascertain the optimum sample size for a representative determination of quality components, a statistical analysis was made. The optimal sample size for reliable detection of recoverable sugar was determined to be at least 50 sugarbeets.

During this period, the average sugar content in sugarbeet increased from 15 % to 18 % in Germany, due to progress in breeding, which may have influenced the distribution of the quality components within the beet. To study the distribution of several quality components within beets, 2 varieties (higher tonnage variety and higher sugar content variety) were investigated. From every variety, 100 uniform beets were selected and sorted by size to process homogenous groups of 5 to 7 beets. In average 16 replications per variety were produced. Every beet was divided into 6 horizontal sections. The slices were cut along specified circular vascular bundles to produce 11 segments in total (Figure 1). The corresponding segments (same segments of all beets) were pooled and processed by grinding and homogenization with ceramic knives in a mill (Grindomix).

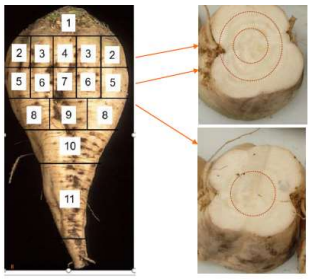


Figure 1 Definition of beet segments

The so produced brei samples were analyzed using different analytical methods to determine the quality components as Polarisation, Sodium; Potassium; Amino-

Nitrogen; soluble Nitrogen; total Nitrogen; Dry Matter; Glucose. Standard molasses loss (SML), calculated according to Buchholz et al (1995) was used for evaluating recoverable sugar in the different beet segments (Formula 1):

$$SML = 0{,}12(w' K+Na) + 0{,}24\ (w'AmN) + 0{,}48 \quad (1)$$

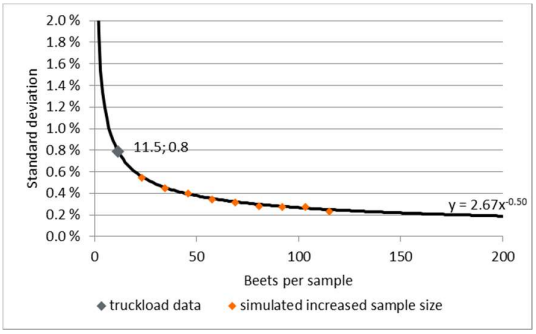
For the evaluation of the distribution of the quality components in beet segments different analysis were performed:

- comparison of values with average beet weight,
- outlier check in raw data based on residuals of an ANOVA
- Comparison of segments with ANOVA and Tukey HSD

The results show significant differences between segments for all components. In general, the concentration of recoverable sugar increased from root tip to upper root. In the central marc the content of recoverable sugar is lower compared to the root tissue outside. The highest content of recoverable sugar was determined in the middle root tissue. The distribution of quality components within the sugarbeets was comparable in both varieties. The results indicate a higher heterogeneity for recoverable sugar in sugarbeet in comparison to previous investigations

An additional trial was performed to check for a possible decrease in beet to beet heterogeneity due to the improved field management during the past 50 years. One truckload of sugarbeet was divided in 459 individual samples. Each sample was processed and analyzed in a quality lab. The results for the recoverable sugar content show the huge heterogeneity in one growers truckload. Recoverable sugar content ranged from 11.9 % up to 16.2 % with an average of 14.5 % and standard deviation of 0.79 %. To evaluate the effect of sample size, random sample results were joined to virtually larger samples. **Error! Reference source not found.** shows the expected decrease of the standard deviation by increasing the simulated sample size. The original average sample size was 11.5 beets per sample. By merging two samples the standard deviation decreased from 0.79 % to 0.56 % and by merging four samples it decreased further to 0.39. Even when increasing the sample size to 200 beets per sample the standard deviation remains at 0.19 % and is still multiple times higher than the analytical error (<0.05 %). The results of this calculation indicates the importance of sampling and specifically choosing of the right sample size, that match to the desired accuracy limit.

Chart 1: Influence of sample size on sample heterogeneity



All results emphasize the importance of sampling, sample size and sample preparation for reliable quality analysis of sugarbeets.

The conventional method in sample preparation and analysis requires a central lab, a logistics system for samples and trained employees. Furthermore it causes chemical waste and is a time-consuming process. The overcome these high requirements, an innovative approach to analyze the full heterogeneity of sugarbeet in 20 seconds is presented. This technology is based on a diode array- NIRS- spectrometer, which works automatically, is mobile and can be implemented with less effort in sugar factories.

The method consists of a chopper, which chops the 20-40 kg of sugarbeet in few seconds in small, uniform pieces. A conveyor belt, equipped with a pressure roll, produce a homogenized and uniform stream of chopped beets. A NIR- spectrometer in wavelength range 850-1650 nm scans in diffuse reflection the surface of the chopped beets in distance of 200 mm (7,9 inch), every 40 ms a spectrum is scanned. The spectrometer records on single spectrum every 40 ms, leading to 400 spectra (measurements) per sample, depending from sample size. Using this approach, the whole heterogeneity of a beet sample is captured. Chemometric methods were used to analyze the spectral data and correlate it with reference data from conventional methods of sugarbeet analysis in the quality laboratories of KWS. Multivariate calibration models were developed to predict recoverable sugar (**Error! Reference source not found.**).

Table 1: NIRS calibration statistics for recoverable sugar content of sugarbeets

Trait	Reference	calibration				validation					
		N_{cal}	min	max	SD	N_{val}	min	max	SD	R	SEP
Recoverable sugar [%]	**calculated from Polarisation, Na, K and α-amino-N (ICUMSA)**	1756	9.0	20.6	1.65	8411	9.5	20.6	1.43	0.95	0.43

Additional calibrations for sugar, dry matter and marc content were also developed and can be used simultaneously. The NIRS calibration models have proven their predictive performance in worldwide breeding activities of KWS SAAT SE for 10 years.

The heterogeneity in sugarbeet has the largest impact in the estimation of the beet quality. To receive reliable and comparable analytical results, good sampling and sample preparation is crucial. Combining an optimized sample with NIRS measurements can lead to a reduced global estimation error.

The presented BEETROMETER™ provides a fully automated sample preparation and NIRS measurement system of grower's field samples.

References

H. Lüdecke Zuckerrübenbau (1961); p.20-29
K. Mahn et al Europ.J.Agronomy 17(2002); p.29-39
Burba, M. et al Z.f.d.Zuckerind. 22(1972); p.75 – 80
Buchholz, K. et al Zuckerindustrie120(1995); p.113-121