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NEAR INFRARED SPECTROSCOPY (NIR) –SPECTROSCOPY, COLOUR MEASUREMENT AND SINGLE KERNEL CHARACTERIZATION IN RYE BREEDING

ABSTRACT

Breeding relevant methods were developed or adapted for a comprehensive characterization of rye quality. In addition to classical chemical methods, necessary for calibration of NIR–spectrometer, a single kernel characterization system (SKCS) and a colour measuring instrument was used. NIR calibrations are calculated for yield, weight, size, shape and hardness (toughness) of rye grains, composition (protein, starch and arabinoxylans), colour and sprouting parameters.

Key words: arabinoxylan, NIR, protein, rye, sprouting, starch, yield,

INTRODUCTION

Besides wheat, rye is among the grains most commonly used in bread production. In the "rye belt" rye is an important component in mixed animal feed. Kernel size and shape, moisture content, intrinsic density, packing of grains, chemical composition as well as impurities, and possible sprouting damages determine the rye quality for all uses. A low test weight, a low kernel weight, a long shape, toughness, and a high content of pentosans in rye kernels reduce milling quality, flour yield and colour, feeding value for animals, and industrial use of rye (FLAMME, W. *et al.*, 1997). Baking and bread quality are dependent on content of pentosans. The desirable properties are subdivided in a high swelling power of insoluble pentosans and a high viscosity of soluble rye slimes. As a result of those water absorption, dough volume, and finished loaf of bread are increased, including a low rate of bread stailing. Rye has a valuable amino acid composition of protein, however, a high content of protein is disadvantageously for milling and baking. In breeding of varieties and in production and marketing falling number,

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water content, test weight and thousand kernel weight are used for evaluation of quality. The aim of our quality research on rye is to develop and to use breeding relevant methods for all characters mentioned above with regard to NIR–spectroscopy, colour measurement, and single kernel characterization (FLAMME, W. *et al.*, 1999).

MATERIAL AND METHODS

Rye samples of the actual German collection of rye varieties grown in field trials and harvested in steps (yellow and full ripeness, overripeness), were used for these investigations. Kernels, whole meal, and flour were applied as substrates for analyses.

A continuous flow analyser with computer–assisted data acquisition and evaluation (Flow Solution, Perstorp Analytical Ltd.) was employed for colourimetric determination of pentosans. A high–performance anion–exchange chromatography (HPAEC) system with fluorescence detector (Fa. Jasco and Shimadzu) was used for chromatographic analysis. SKCS 4100 (Fa. Perten Instruments), classifying wheat samples as either soft, hard, or mixed, was adapted for rye. The Farinograph (Brabender Instruments Inc.) is used to determine hardness and (or) toughness of cereal grains. Colour measurements were performed at Luci 100 (Fa. Lange). NIR–spectroscopy calibrations were executed at NIRS–5000 (Perstorp Analytical Ltd.).

RESULTS AND DISCUSSION

Several methods are used concurrently for the determination of pentosans in cereal flours. When applying colorimetric methods a coloured complex, formed with sugar derivatives obtained by hot concentrated acid treatment of the sample in the presence of orcinol or phloroglucinol is measured. Interferences can occur from glucose, resulting from hydrolysis of starch. Therefore these methods are qualified for screenings with a continuous flow analyzer. In gas chromatographic methods the preparation procedure is often complex and time–consuming, but the results are precise and specific for arabinose and xylose. A simple and rapid HPAEC method was developed for routine–like analysis of pentosans, characterized by derivatization of released reducing saccharides and fluorescence detection.

SKCS provides a rapid, objective assessment of class and uniformity using measurements on 300 individual kernels within the sample. SKCS automatically singulates kernels and determines individual kernel weight, diameters, moisture, and crushing force profile. The single kernel data collections as histograms in connection with elapsed time, average, and standard deviation are stored or printed out. Manual determined kernel weight, moisture and kernel diameter were closely cor–

related with SKCS–dates. The SKCS was used successfully for characterization of rye kernels.

For the hardness test of rye kernels the structure tester take the place of the dough mixer of Farinograph. Besides the milling time, the length, high, and areas of diagram and the work for grinding were evaluated. Grinding (Nm) of one sample (50 g rye kernels) is realized gradually in three intervals of time.

The results of wet analytical procedures are used for calibration of NIR– (reflectans) spectrometer. The content of proteins, starches and moisture are determined by NIR–analysis with high precision. In addition the weight, diameter and hardness index of rye grains are possible to classify, however only rye forms with low or high pentosan contents can be selected.

– Fig. 1– In most cases the NIR–calibration are not useable for prediction of sprouting damages. Only increase in enzyme activities gives a measurable NIR–signal.

– Fig. 2– At beginning of autolysis in rye kernels changes of components are correlated with α–amylase activity and other sprouting parameters. A monitoring of latent and visual sprouting of rye kernels during provocation by image–analyses in combination with NIR–spectroscopy will give information about dormancy and sprouting resistance of rye.

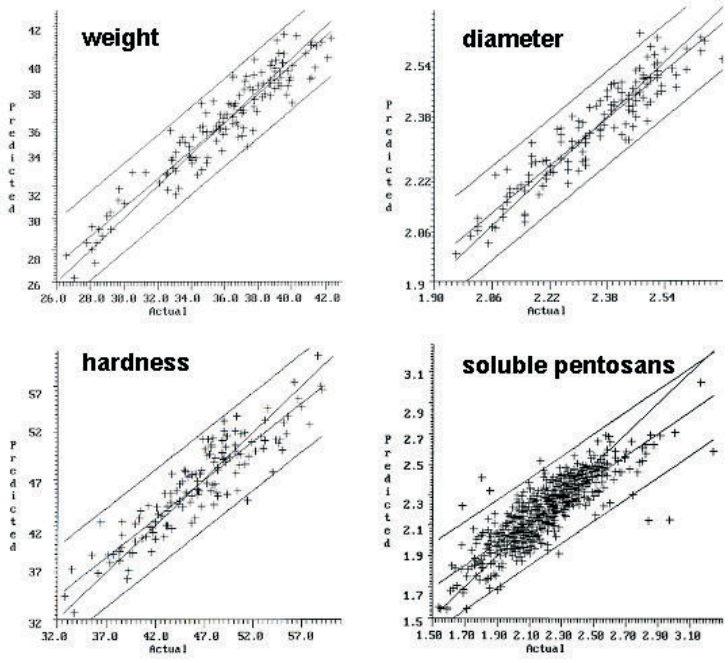

Fig. 1 NIR–Calibrations plots for weight, diameter, hardness index (SKCS–data) and soluble pentosans of rye kernels

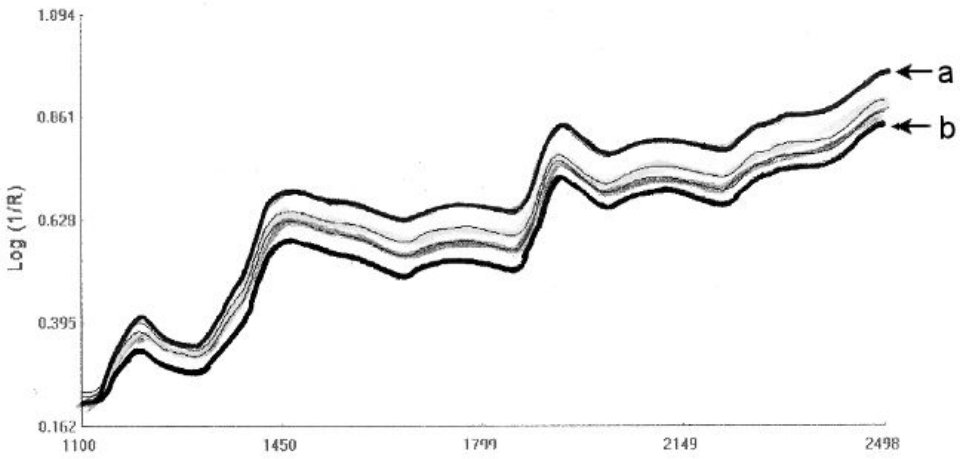

Fig. 2 Detection of sprouting damages with NIR. a – sprouting, b – no sprouting

The colour of rye kernels has (negative) influence for milling and industrial use. Rye kernel colour ranges from pigmentless over yellow to green and blue. Anthocyanins and flavonoids are responsible for colour of rye caryopses. Stuffed cups for determination of colour in a colour instrument are used to take spectra in visual and NIR–region, too. This complex matrix allows to determine differences of rye samples in content and distribution of colour.

CONCLUSIONS

In the last years wet standard procedures were developed or modified for analysis of rye grain, whole meal, flour, and starch. NIR–spectroscopy, image analysis, single kernel characterization, and colour measurement were adapted to determine content of protein and starch, sprouting damages, weight, shape, size, hardness (toughness), and colour of rye grains. For characterization of pentosans GC, HPLC, Flow solution, and NIR in connection with rheology (Poster Jansen and Flamme) of rye slimes and swelling substances are used.

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