Effects of Different Bio-Parameters for Colorimetric Evaluation of Grain Damage

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STANDING in the field, unhusked corn is undamaged and can last almost indefinitely in that state without diminishing its food value. Deterioration begins with the mechanical process of harvesting, and practically every subsequent operation in drying, transporting, and handling further decreases the quality of the grain. The rate of deterioration is dependent on the initial injury sustained during such mechanical processes, particularly the harvesting operation. During harvesting, the kernels are subjected to damaging impact and compressive forces that result in breaches of the seed coat or cracks in the pericarp of the kernel.

Currently, practically no measurements are made concerning mechanical damage of grain at the initial selling point, and no discounts are applied, therefore, for mechanical damage. Hence, there is little or no incentive for the producer of the crop to minimize mechanical damage. Further, there is no commercial apparatus or method available that is economical, reliable, and administered without skilled help for measuring mechanical damage to corn as it is being harvested. If such a method were available, farmers could adjust their combines to minimize the mechanical damage, which would result in great savings that could be passed on to consumers.

A number of indices or tests have been proposed for measuring mechanical damage, but these have been primarily of theoretical or academic interest (refs. 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13). It is believed that much of the waste due to mechanical damage could be reduced or eliminated if, for example, grain elevators or markets could establish a purchase price based, at least in part, on discounts for mechanical damage of corn as it is delivered. This would add some incentive for the farmer who properly adjusts his combine to minimize mechanical damage.

We have devleoped a simple, economical, and reliable test for quantitative and qualitative measurement of mechanical damages of grain (Chowdhury and Buchele 1975). With this test, mechanical damage to grain is measured by taking a small sample of the grain and applying a solution of a substance that selectively adheres only to the exposed surfaces of the interior of the damaged grain and not to the seed coat. Excess solution is rinsed away; thereafter, a solvent is applied that dissolves the substance adhering to the exposed internal parts of the grain. The amount of recovered material brought back into solution is then measured, and the measurement is representative of the mechanical damage to the grain. The test may be performed within a few minutes (2 to 3) by selecting the right concentration of the dye and the right normality of the recovery solution.

The objective of the research reported herein was to study the effect of different bio-parametes and to develop design parameters for a grain-damage meter that can be used in the grain (corn) trade.

EXPERIMENTAL PROCEDURE

Mechanical damage occurs on a continuous scale, from hairline cracks and tiny spots of pericarp missing to complete breakage, but it is very difficult to control the damage level for experimental purposes (to observe the effect of other parameters). Hence, artificially damaged corn kernels were used for this study. The mechanical damage can occur on any part of the kernel; for example, on the tip, seed coat, embryo, endosperm, horny endosperm, crown, or a combination. Artificially damaged corn kernels were prepared by cutting the kernel longitudinally so that all such parts of the seed were exposed to the dye. A single-edge razor blade was used for cutting the seeds.

Any dye that can adhere to the damaged part of the grain and is soluble in the solvent used will serve the purpose. There are a number of dyes and solvents that can be used. In these experiments, Fast Green FCF dye and sodium hydroxide solution were used as the dye and solvent, respectively, for the evaluation of grain damage.

In this experiment, a Beckman DB-G grating spectrophotometer was used to read the concentration of the dye in the NaOH solution. The cell thickness was 1 cm, and the wavelength used was 610 nm. Distilled water was used as the reference solution in the reference cell. The spectrophotometer was calibrated for zero absorbency with distilled water in both the cells. Care was taken while pouring the sample solution in the cell so that the sides of the cell were clean and no bubbles were left inside. The dye to be used should follow the Lambert-Beer Law, when dissolved in the desired solvent.

$$\text{Absorbency} = \log I_o/I = a_s bc$$

where

I_o = Intensity of light when $x = 0$
I = Intensity of light when $x = b$
b = Cell thickness
c = Concentrations
a_s = Absorbency index

The Beckman DB-G grating spectrophotometer was used to read the absorbency of the dye in the solvent. The Fast Green FCF dye was dissolved into 0.01 N NaOH solution according to the required ppm (parts per million). The relation between dye concentration and absorbency is

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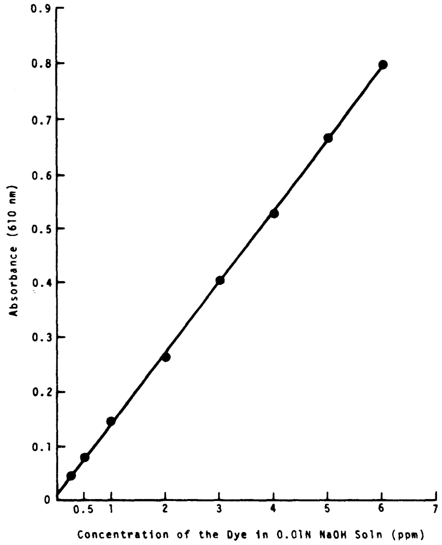

FIG. 1 The effect of dye (fast green FCF) concentration (ppm) on absorbency.

shown in Fig. 1, which shows a linear relation and, hence does follow the Lambert-Beer law.

EFFECT OF THE DYE CONCENTRATION:

The objective was to observe how the absorbency affects samples of the same damage level when soaked in the Fast Green FCF dye of different concentrations (i.e., different percentages of the Fast Green FCF dye) for the same amount of time.

Five 10-g samples of split kernels were soaked in different percentages of the Fast Green FCF dye solution for 10 min. After the extra dye was washed off the seed coat, the samples were resoaked in 200 ml of 0.01 N NaOH solution for 30 min. Fig. 2 shows the relation between dye concentration and absorbency.

EFFECT OF THE SOAKING TIME IN THE FAST GREEN FCF DYE:

For this study, eight 10-g samples of split kernels were used. Each one was soaked for different intervals, starting from 2 minutes to 1 hour in 0.1 percent Fast Green FCF dye solution. After the extra dye was washed off the seed coat, the samples were resoaked in 150 ml of 0.01 N NaOH solution for 1 hr. The relation between the absorbency and soaking time is shown in Fig. 3.

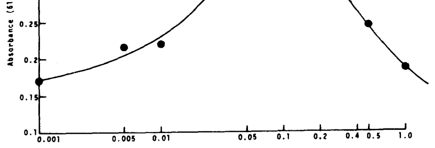

FIG. 4 The effect of the normality of the bleaching solution (NaOH) on absorbency.

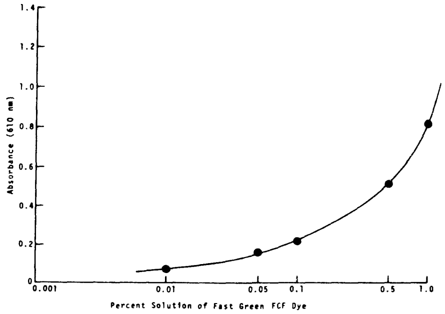

FIG. 2 The effect of the concentration (percent solution) of the fast green FCF dye on absorbency.

EFFECT OF THE NORMALITY OF THE RECOVERY SOLUTION:

The objective was to observe the effect of the different normality of sodium hydroxide in extracting the dye from the damaged part of the kernel. Seven samples consisting of 10-g of split kernels were soaked in 0.1 percent Fast Green FCF dye solution for 10 min. After the extra dye was washed off the seed coat, the samples were resoaked for 30 min in 200 ml of NaOH solution of different normality. Fig. 4 shows the relation between absorbency and normality of the NaOH solution.

EFFECT OF THE RECOVERY TIME IN NaOH SOLUTION:

Two 7-g samples of longitudinally split kernels were used. The samples were soaked in 0.1 percent Fast Green FCF dye for 14 min and washed under running water to remove the extra dye on the surface of the seed coat. The samples were resoaked in 200 ml of 0.01 N NaOH solution. Fig. 5 shows the relation between absorbency and the bleaching or recovery time.

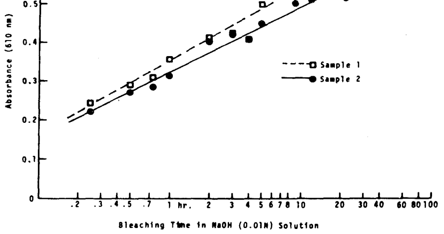

FIG. 5 The effect of bleaching time on absorbency.

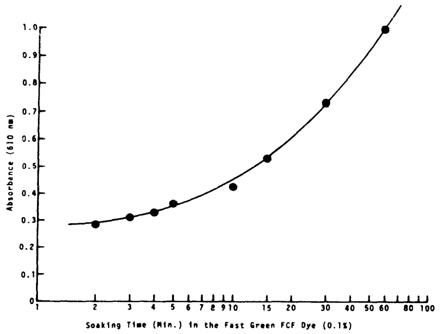

FIG. 3 The effect of soaking time in the fast green FCF dye (0.1 percent).

EFFECT OF THE AMOUNT OF NaOH SOLUTION:

Seven 10-g samples of split kernels were soaked for 10 min with 0.1 percent Fast Green FCF dye. After the extra dye was washed off the seed coat, the samples were resoaked in different amounts of 0.01 N NaOH solution. Fig. 6 shows the relation between different amounts of NaOH solution and absorbency at different time intervals.

EFFECT OF VARIETY AND KERNEL MOISTURE CONTENT:

Two varieties of corn at different moisture content were used for this experiment. The two varieties are Pioneer 3388 and Black's B73XM017. For each variety and at each moisture content, the experiment was repeated thrice.

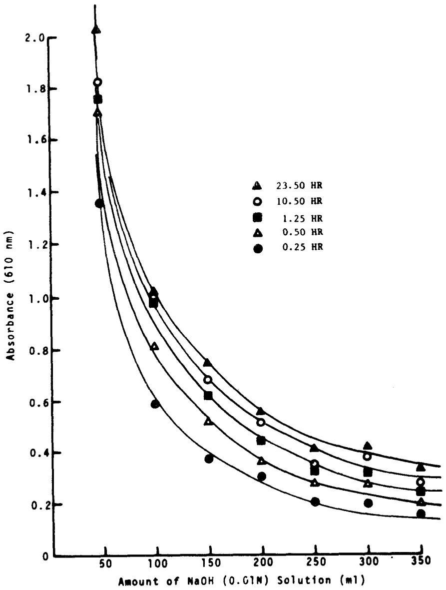

FIG. 6 The effect of the amount of the bleaching solution (NaOH, 0.01 N) on absorbency.

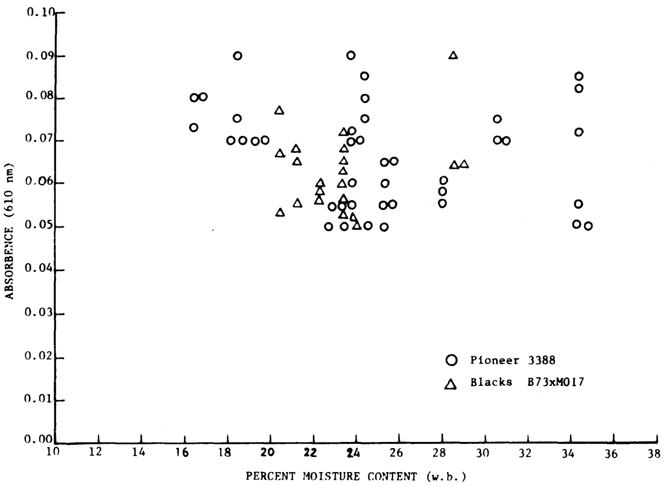

FIG. 7 The relation between kernel moisture content (wet basis) and absorbence for two varieties of corn.

During each replication, 10-g of split kernels were taken from the field harvested samples stored in the freezer. The 10-g samples were then soaked completely in 0.1 percent Fast Green FCF dye for 30 sec and the dye was rinsed off under running water for another 30 sec. After the dye was washed off the seed coat, the sample was resoaked in 200 ml of 0.01N NaOH solution and was stirred for 1 min for recovering the dye from the seeds. The sample was allowed to settle for 30 min before the absorbency reading was taken with a Beckman DB-G grating spectrophotometer.

The relation between kernel moisture content (wet basis) and absorbence (610 nm) for the two varieties of corn is shown in Fig. 7. No statistical analysis has been performed, but visual inspection indicates hardly any relation between kernel moisture content and absorbence for both the varieties. In other words, absorbence seems independent of kernel moisture content and corn varieties.

CONCLUSION

More samples need to be analyzed for absorbency tests with different varieties of corn at different moisture contents. A statistical analysis needs to be performed to show the effect of varieties and kernel moisture content on absorbence. If, as it seems from visual inspection, the absorbency reading is independent of corn varieties and kernel moisture content, then colorimetric evaluation of grain damage will be a simple and rapid method for evaluation of grain damage.

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