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Colorimetric Determination of Grain Damage

Mofazzal H. Chowdhury
Iowa State University

Wesley F. Buchele
Iowa State University

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Abstract
Evaluation of mechanical damage has always been one of the most elusive problems associated with the harvesting, handling, and marketing of grains. A standard method to describe the quality of grain from the standpoint of physical or mechanical damage has not yet been developed. And without a standard measure, the equipment manufacturer cannot determine when he has developed an improved harvesting machine, the farmer cannot determine when he is harvesting a better quality of grain, and the grain industries cannot determine when they are processing a better quality of product. Hence, there has always been a need to develop a fast and efficient technique for the accurate determination of quality of grain. The desired technique has to be simple so that everyone can use it, and, on the other hand, it has to be a bulk method (for statistically sound results), by which each and every kernel would be equally checked for a consistent evaluation of qualitative, as well as quantitative, damage in the sample. And finally, the result should be presented on a continuous scale because mechanical damage occurs on a continuous scale from hairline cracks and tiny spots of pericarp missing to complete breakage and fines.

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Colorimetric Determination of Grain Damage

Mofazzal H. Chowdhury, Wesley F. Buchele
MEMBER
ASAE

EVALUATION of mechanical damage has always been one of the most elusive problems associated with the harvesting, handling, and marketing of grains. A standard method to describe the quality of grain from the standpoint of physical or mechanical damage has not yet been developed. And without a standard measure, the equipment manufacturer cannot determine when he has developed an improved harvesting machine, the farmer cannot determine when he is harvesting a better quality of grain, and the grain industries cannot determine when they are processing a better quality of product.

Hence, there has always been a need to develop a fast and efficient technique for the accurate determination of quality of grain. The desired technique has to be simple so that everyone can use it, and, on the other hand, it has to be a bulk method (for statistically sound results), by which each and every kernel would be equally checked for a consistent evaluation of qualitative, as well as quantitative, damage in the sample. And finally, the result should be presented on a continuous scale because mechanical damage occurs on a continuous scale from hairline cracks and tiny spots of pericarp missing to complete breakage and fines.

REVIEW OF LITERATURE

The USDA numerical grading system was established at a time when corn and other grains were shelled at low moisture with minimal damage. The adoption of combining corn at high moisture has introduced substantial levels of kernel damage. Combine-shelled corn contains a small portion of grain fines. The bulk of the kernels, however, are seriously damaged. But the present grading system does not account for all types of mechanical damage.

The visual inspection method has been widely used by research workers for accurate evaluation of mechanical damage. But this method is very time-consuming, and human fatigue influences the result (McKibben 1929, Morrison 1955, and Schmidt et al. 1968).

The other tests, such as the standard germination test, acid germination test (Arnold 1959), tetrazolium test (Moore 1961, 1967), and carbon dioxide production method (Steele 1967), give a pretty good indication of the mechanical damage, but all are time-consuming. Techniques such as the corn breakage tester (Kaminski 1968), electric color-sorting technique (Boyd et al. 1968), and infrared photographic technique (Chung and Park 1971a, 1971b), do not give a true and accurate picture of the damage level. Other experimental methods such as the water-absorption method (Chung and Park 1971a), light-absorption method (Wirtz 1971), and relaxation-time method (Mahmound 1972) are not sensitive enough to distinguish the damage level between samples.

Hence, not one of the techniques mentioned is fast and accurate enough to satisfy the present need.

PRINCIPLE OF OPERATION

Mechanically damaged grain would have a ruptured seed coat. The more severe the damage, the more the starchy area or inner portion of the grain would be exposed. In other words, the damage level is directly proportional to the total exposed area of the kernels in a sample. The exposed area of the ruptured seed coat can effectively be used as a criterion of damage to develop a technique for evaluation of grain damage.

The basic principle behind this technique is to use a dye or a chemical that will adhere only to the exposed area of the damaged grain and not to the seed coat. The next step is to use a solvent that will dissolve or bleach the dye sticking to the damaged part of the grains. Hence, by this technique, we can get back the dye that was adhering to the damaged part of the kernels. If the dye used follows the Lambert-Beer Law, then the amount of the dye present in the sample can be measured by using some colorimetric technique. This can be done by using either a simple colorimeter or an expensive spectrophotometer.

EXPERIMENTAL PROCEDURE

The objective of this study was to examine the effect of kernel damage on absorbency, while keeping all the parameters under control. The mechanical damage occurs on a continuous scale, but it is very difficult to obtain a desired damage level for experimental purposes from corn shelled by a combine. Hence, artificially damaged kernels were used for this experiment. The mechanical damage can occur on any part of the kernel; for example, the tip, seed coat, embryo, endosperm, horny endosperm, crown, or a combination of them. Artificially damaged corn kernels were prepared by cutting the kernel longitudinally so that all the parts of the seed mentioned are exposed to the dye. A single-edge razor blade was used for cutting the seeds.

The artificially damaged samples were prepared by adding the split kernels (according to the required percentage damage) with the sound hand-shelled kernels to make a 25-g sample. The samples were then completely soaked in 0.1 percent Fast Green FCF dye for 10 min. All the samples were then washed off under running water for 30 sec. By this operation, the extra dye on the surface

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The authors are: MOFAZZAL H. CHOWDHURY, Graduate Assistant, and WESLEY F. BUCHELE, Professor, Agricultural Engineering Dept., Iowa State University, Ames.

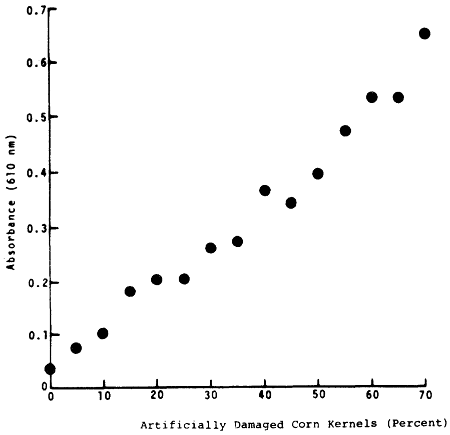

FIG. 1 The effect of artificially damaged corn samples on absorbency.

of the seed coat was washed off. The only places at which the dye was left were the tip and the exposed part of the kernel. The samples were then resoaked in 200 ml of 0.01N NaOH solution for an hour. All the samples were stirred for 1 min and allowed to settle for 15 min before the absorbency readings were taken.

In this experiment a Beckman DB-G grating spectrophotometer has been used to read the concentration of the dye in the NaOH solution. The cell thickness was 1 cm. The wave length 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. In pouring the sample solution in the cell, caution was taken so that the sides of the cell were clean and no bubbles were left inside. Fig. 1 shows the relation between absorbency and percentage of artificially damaged corn kernels.

COLORIMETRIC EVALUATION OF COMBINE-HARVESTED DAMAGED SAMPLES

The samples of corn used were harvested by combines. The varieties were unknown, and the moisture content was very low. These samples already were visually inspected for damage evaluation (Chowdhury and Buchele 1975). A 50-g corn sample was taken. The sample was soaked in 0.1 percent Fast Green FCF dye for 10 min and then washed off under running water for 30 sec. By this operation, the extra dye on the surface of the seed coat was washed off. The only places at which the dye was left were the tip and the exposed part of the kernel. The sample was then resoaked in 300 ml of 0.01N NaOH solution. The resoaking time was not controlled at that point. The sample was stirred for 1 min and was allowed to settle for 15 min before absorbency readings were taken. The Beckman DB-G grating spectrophotometer was used for this purpose.

Fig. 2 shows the relation between the absorbency reading and the total mechanically damaged corn kernels, which includes all damaged kernels by visual inspection. No statistical test was performed on the data, but there was a positive correlation between the total percentage damage and the absorbency. Fig. 3 shows the relation between absorbency and the damage index (Chowdhury and Buchele 1975). The damage index is a measure of both quantity (percentage) and quality (severity) of damaged kernels.

CONCLUSIONS

This technique may satisfy the present need for damage evaluation for the grain industries. The whole operation is rather simple and can be performed within a few minutes (by selecting the higher concentration of the dye and the right normality of the solvent). This technique can be used as a reasonably accurate method to describe the quality of grain from the standpoint of mechanical damage caused during harvesting, handling, and marketing of grains.

The concentration of the dye can be measured either by an inexpensive colorimeter or by an expensive spectrophotometer. A spectrophotometer can be converted into a damage meter just by changing the scale.

This technique may also be applied for fast and accurate evaluation of mechanical damage to other cereal grains.

The farmers, country elevator operators, grain dealers, seed producers, grain importers and exporters, workers in wet and dry milling industries, and food industries, harvesting equipment manufacturers and research and development workers in this field need a fast and accurate technique for evaluation of grain damage. It is believed that this technique might serve the purpose.

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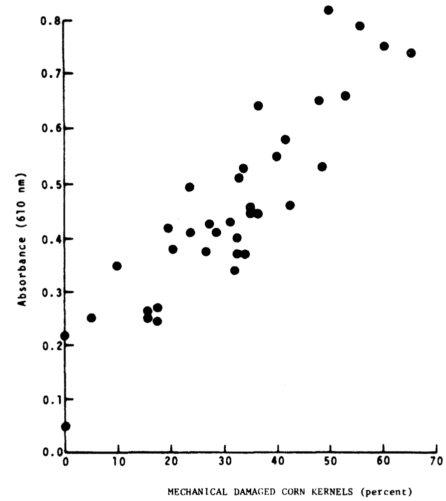

FIG. 2 The effect of total mechanically damaged corn kernels on absorbency.

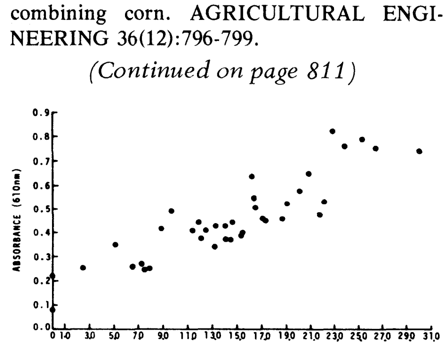

FIG. 3 The relation between absorbency and damage index.

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