February 1952

Radiography Applied to Grain and Seeds

Max Milner
Kansas State College

Milford R. Lee
Kansas State College

Robert Katz
University of Nebraska-Lincoln, rkatz2@unl.edu

Volume 6, Number 2

Radiography Applied to Grain and Seeds[a,b]

MAX MILNER, MILFORD R. LEE, AND ROBERT KATZ
Department of Milling Industry and Department of Physics, Kansas Agricultural Experiment Station, Manhattan, Kansas

(Manuscript received May 28, 1951)

A radiographic method for the detection of internal insect infestation in grain by means of low energy radiation from a cobalt-target beryllium-window X-ray tube is described. The utility of the technic for inspection of wheat, corn, rice, and beans is illustrated with cuts made from original radiographs.

The presence of insect fragments in flour and other granular foods has long been a major problem in industries which process grain or seeds. Such fragments occur because various insects deposit their eggs in or on the seed. The offspring may spend a portion of their life cycle within such materials and their detection or removal prior to processing of the grain or emergence as adult forms, until now has been virtually impossible.

The Food and Drug Administration has formulated and enforced rigorous standards to assure the freedom of such products from insect fragments. At one time it was believed that inadequate sanitation practices in the manufacturing plants of these industries were contributing factors to insect fragments and filth in the products. The recent report of the Food and Drug Administration *(4)* dealing with the relationship of the degree of internal infestation in wheat to fragments in the milled products of a number of commercial flour mills, indicates conclusively, however, that internal infestation in the grain received by the mill, rather than external filth is the major source of fragments in commercial granular cereal products. While the results of this survey of the Food and Drug Administration were generally anticipated, the fact remains that in the official grain standards of the United States under which all grains are bought and sold, no recognition exists of the extent to which internal infestation may influence processing quality of grain or the sanitary characteristics of the products. All suggestions that such standards should be modified in order to provide adequate discounts or penalties for infested grain have been met with the retort that until there is developed a method for detecting internal infestation, simple and rapid enough for use at any inspection point where grain is marketed, little can be done to segregate or discount internally infested commercial grain.

This problem has prompted studies now in progress at Kansas State College aimed at developing methods for the positive identification and quantitative determination of internal insect life and damage in commercial grain. The present report deals with an application of X-ray radiography, which appears to hold considerable promise for the inspection of many kinds of seeds. The utility of the method for wheat has been shown in previous reports *(1, 3)*.

PROCEDURE

Preliminary studies were carried out on infested grain selected by using a presumptive test for infestation *(2)* and utilizing a medical X-ray unit operated in conventional fashion. Poor results were obtained, confirming the experience of other workers in this field who had attempted radiography with this type of apparatus. However, when the technics of industrial radiography were applied, more positive results were obtained.

A cobalt-target Machlett X-ray diffraction tube equipped with a beryllium window was found to be a satisfactory source of low energy radiation. This tube was operated at currents ranging from 6 ma. at 12 kv. to 10 ma. at 30 kv., with various exposure times ranging from five seconds at the highest voltage to 3 minutes in the lower range of voltage. Eastman type A industrial X-ray film, which is of high contrast and fine grain, was found ideal. The manufacturer's recommendations for the processing of this film were observed. A major factor in obtaining clear radiographs showing good differentiation of insects within seeds is the presence of a minimum amount of absorbing material between the seeds and the film because the type of radiation used is so readily absorbed and scattered by even relatively permeable materials. In the present studies standard cardboard X-ray film holders were modified by cutting away a rectangular section of the cardboard face and replacing it with a sheet of thin photographic black paper to protect the film from light during manipulation and exposure of the film to X-ray. In some cases it was necessary to maintain the film holder in a vertitcal position, since the cobalt-target X-ray

[a] Contribution No. 198, Department of Milling Industry and Contribution No. 12, Department of Physics, Kansas State College, Manhattan, Kansas. This research was supported by a grant from The Millers' National Federation, Chicago, Illinois.

[b] Presented at the Eleventh Annual Meeting of the IFT, New York, N. Y., June 18, 1951.

diffraction tube was permanently mounted and the beam emerged horizontally. In such cases the samples to be examined were attached to the photographic black paper by means of rubber cement. Satisfactory radiographs have been obtained with cobalt, copper, and molybdenum targets when the excitation voltages were low enough and provided the tubes were equipped with a beryllium window to transmit soft X-rays. Tungsten targets also, doubtless, would be suitable. More complete details of the technic have been published *(1, 3)*.

Insects at various stages of growth were readily detected in the following materials: wheat infested with rice weevil, granary weevil, and Angoumois grain moth; corn containing rice weevil and Angoumois moth; rough rice and milled rice infested with rice weevil; cowpeas infested with common bean weevil and southern cowpea weevil; and pinto beans and kidney beans infested with common bean weevil.

RESULTS AND DISCUSSION

The photographs and radiographs of seed samples in Figures 1 to 4, although showing considerable loss of clarity in comparison to original prints due to reproduction, indicate the utility of the technic and are representative of numerous examinations which have been made. Studies are in progress to develop rapid sampling and inspection methods in order to render the technic suitable in commercial practice for the inspection and market grading of all major seed crops. It seems possible that the test will find a place beside the protein test for wheat as a test for quality auxiliary to the United States Grain Standards.

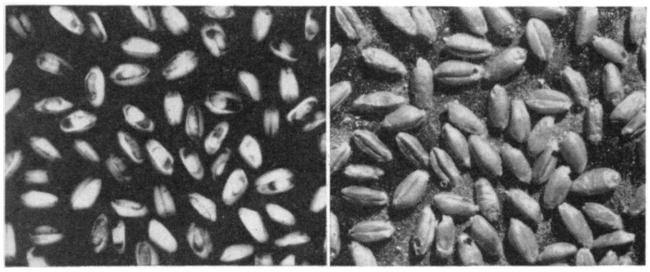

Figure 1. Left, radiograph of wheat containing rice weevil at various stages of development 22 days after infestation. Larvae, pupae, and adult stages are apparent. No emergence of insects had occurred at this stage. Right, ordinary photograph of the same sample of wheat shown, 40 days after exposure to rice weevil, when insect emergence was virtually complete. Note that no external indication of internal infestation appears until insect emerges.

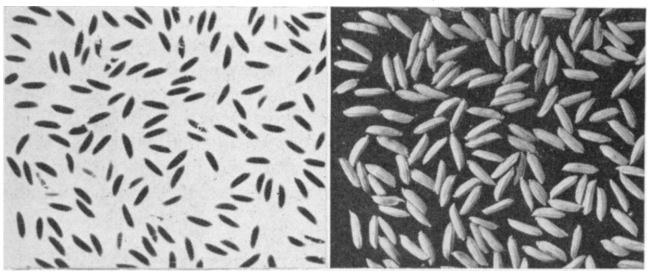

Figure 2. Left, radiograph of rough rice showing internal infestation by rice weevil, also cracked grains. Right, ordinary photograph of the same grain as in field on left. Internal infestation and cracked grains are invisible.

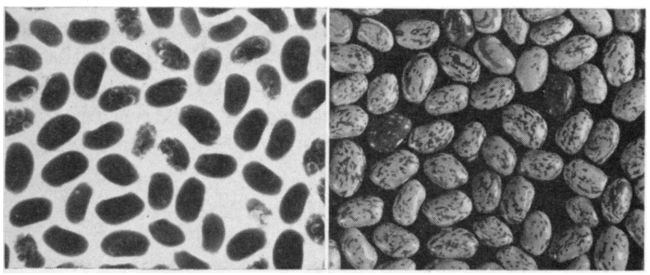

Figure 3. Left, radiograph of pinto beans infested with common bean weevil. Right, ordinary photograph of the same sample.

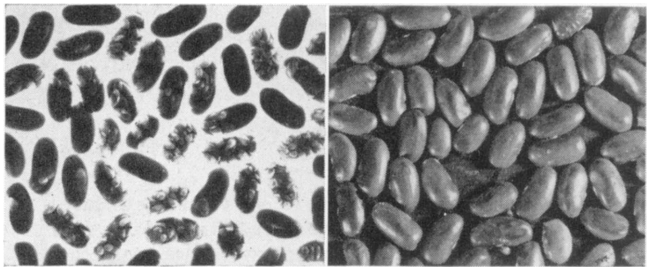

Figure 4. Left, radiograph of kidney beans infested with common bean weevil. Right, ordinary photograph of the same sample.

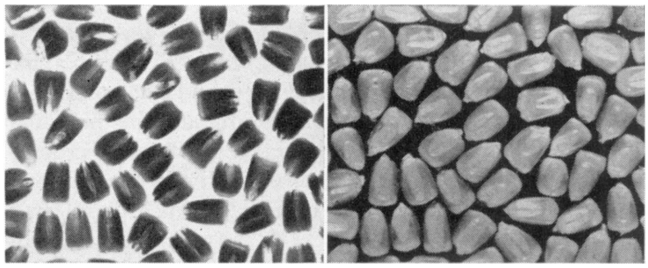

Figure 5. Left, radiograph of corn infested with Angoumois grain moth. Right, ordinary photograph of the same sample.

SUMMARY

For the detection of internal insect infestation in grain, low energy radiation from a cobalt-target beryllium-window X-ray tube was found ideal. The presence of a minimum amount of extraneous material between the seed specimen and film as well as the use of fine-grain industrial X-ray film facilitated the production of detailed radiographs showing clearly internal insect infestation at all stages of development, as well as the extent of internal loss of grain kernels due to insect feeding. The utility of the technic for inspection of wheat, corn, rice, and beans is illustrated with cuts made from original radiographs.

Acknowledgment

We wish to acknowledge the assistance of Mr. J. C. Frankenfeld, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in procuring for us various samples of internally infested seeds, and the kindness of the Picker X-Ray Corporation of New York, N. Y., in loaning us certain equipment used in these studies.

LITERATURE CITED

1. Katz, R., Lee, M. R., and Milner, M. X-ray inspection of wheat. *Non-destructive Testing,* Fall, 16, (1950).
2. Milner, M., Barney, D. L., and Shellenberger, J. A. Use of selective fluorescent stains to detect insect egg plugs on grain kernels. *Science,* 112, 791 (1950).
3. Milner, M., Lee, M. R., and Katz, R. Application of X-ray technique to the detection of internal insect infestation of grain. *J. Econ. Entomol.,* 43, 933 (1950).
4. Slocum, G. G. A progress report on the wheat and wheat flour investigational program of the Food and Drug Administration. Presented to the Association of Operative Millers Convention, Chicago, Ill., May 15, 1951.