

MICROSCOPY AND COLOR PHOTOMICROGRAPHY IN THE STUDY OF FEEDSTUFF QUALITY

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During the past several years there has been a definite trend in the feed industry toward the use of microscopic examination in quality control of feedstuffs. A number of the State Feed Control laboratories have added microscopic examination to their usual chemical determinations of protein, fat, fiber, etc.; indeed at least one submits a color photomicrograph of the feed to the manufacturer to point out contaminants and low quality constituents. Further evidence for the interest in this field was the formation on March 15, 1953, of the Association of Feed Microscopists to formulate and standardize procedures and otherwise promote the work of feed control officials.

Probably the main feature of microscopic examination is that, whereas the conventional chemical methods of analysis only reveal the composition in a general way, i.e., protein, fat, fiber, ash, etc., the expert microscopist can identify the various constituents and tell whether they are desirable or undesirable.

In our laboratory attention has been directed toward quality improvement of feedstuffs of the animal and vegetable protein type. This company specializes in the production of protein-vitamin-mineral concentrates which, when fed along with grain and roughage, provide feeds that are as complete as the modern science of nutrition permits.

One of the best examples of the application of the microscope in this field is meat scrap, an important source of animal protein in many mixed feeds. This feedstuff is obtained either as a by-product in the packing industry or as one of the main products, along with the fat and hides, in the rendering industry. Meat scrap is usually purchased on the basis of protein content, which is determined by chemical analysis. However, the protein percentage is a measure of total protein only and leaves unanswered the important questions of digestibility and quality of protein.

The characteristics of good and poor quality meat scrap are easily distinguished under the microscope, as shown in the two upper photomicrographs in figure 1. The picture on the left shows a good quality product containing very little undesirable material. The rough-textured pieces (brown in color) are well-cooked meat; the white chunky ones are bone, which is not regarded as a contaminant because it furnishes calcium and phosphorus. The photo on the right shows a poor quality product containing hoof, hair, vegetable fiber, and overheated or scorched meat.

The effect of feeding these meat scraps is illustrated by samples A and B in figure 1, in which we see the feces from rats which have been fed each of these products. Sample

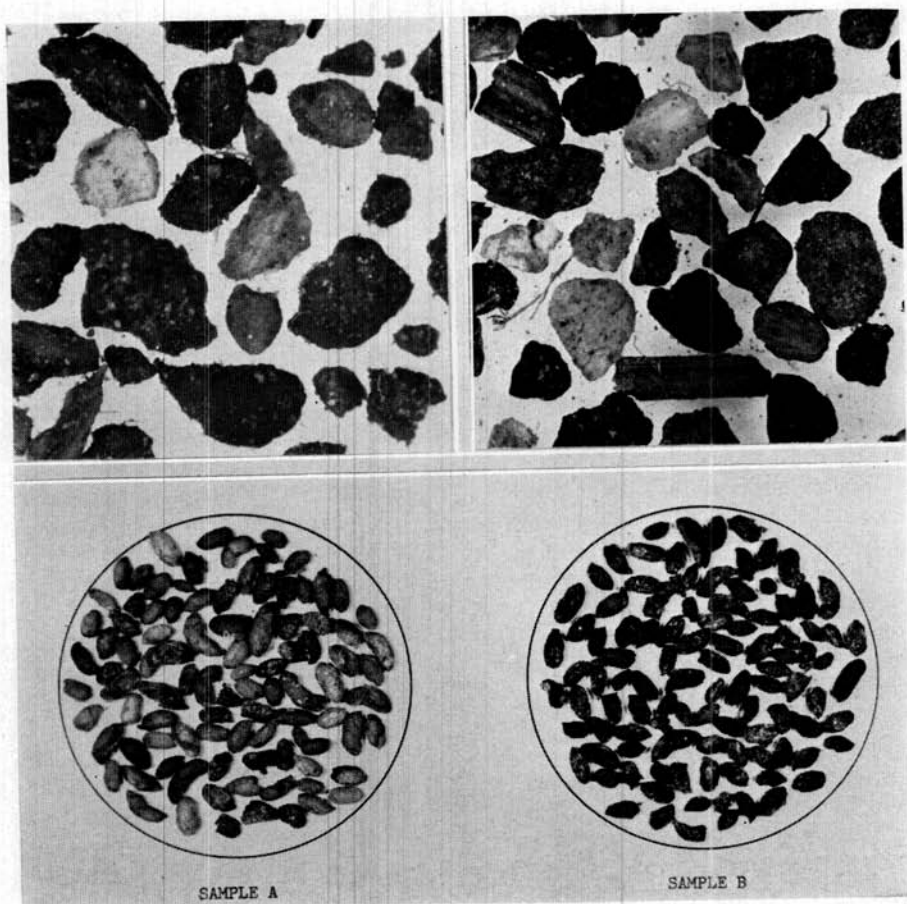


FIG 1.—Upper left: Good quality meat scrap consisting of well-cooked meat and bone. Upper right: Poor quality meat scrap with scorched pieces and vegetable fibre in addition to good meat and bone. Magnifications 7.5x. Lower photos ($\frac{1}{2}$ actual size): Comparison of feces from rats fed good quality meat scrap showing normal color (left), with feces from rats fed poor quality meat scrap showing black color from overheated meat (right).

A shows feces from rats fed the good quality material, and sample B shows those from rats receiving the poor quality product containing overcooked meat and other indigestible ingredients which passed unchanged through the animal, imparting the dark color to the feces. Data from this test and others, when presented to the meat processors, have resulted

in the production of meat scraps of greatly improved nutritional value.

Another practical feature of microscopic inspection is its speed. Whereas a chemical analysis will take at least several hours, the evaluation of a sample under the microscope is usually completed in a few minutes. The foregoing discussion of possibilities of this type of quality

control is not meant to imply that the microscope acts as a substitute for chemical analysis; on the contrary, it acts as a supplement and in certain instances shows the necessity for some additional chemical analyses while indicating that others might not be needed.

Proper organization of the inspection program has contributed to its success. When the program was initiated, the variations and undesirable constituents of each raw material were studied to provide a basis for sample evaluation. A check list was then compiled for each feedstuff to insure against failure of the observer to cover all the necessary points. Meat scrap, for example, is evaluated for hair, fuzz, overheated material, vegetable fiber, glass, and hoof. Vegetable proteins are inspected for hull, foreign hull, fiber, and weed seeds. All data are entered on filing cards which cover the items observed microscopically and, in addition, physical properties such as color, odor, and fineness which come to the attention of the microscopist. A simple system for expressing roughly the quantity of each contaminant present is used in recording the data.

In our laboratory every incoming feedstuff is microscopically inspected immediately upon arrival; in fact, sampling of the cars takes place in the railroad yard so that the protein analysis and microscopic inspection are finished before the cars reach our factory. Protein content of the raw materials and any abnormalities revealed by the microscope are reported to the Purchasing Department daily.

Photomicrography, in both black-and-white and color, has become an

important tool in our quality control program. Photomicrographs of the various feedstuffs or fractions isolated from them have been very useful to our Purchasing Department when pointing out to a supplier the presence of undesirable constituents which are to be minimized or eliminated. These photographic records have resulted in greatly improved raw material quality in a number of instances.

The undesirable parts of the feedstuffs are separated chemically and then examined under the microscope. In our laboratory the crude fiber from most of the common vegetable proteins has been separated and photographed, giving a better understanding of the nature of this part of the feedstuff.

In addition to detecting impurities in the individual feedstuffs, the microscope can be used effectively in identifying and estimating the various constituents in feed mixtures. Because of the fundamental difference in structure between the various raw materials, each has its own distinctive properties which furnish clues to its identity. In the following discussion the more prominent characteristics of several feedstuffs are briefly described (see Fig. 2).

During the past decade soybean oil meal has become the most widely used vegetable protein. Hulls, weed seeds, and overheating or underheating are clearly visible through the microscope. In the photomicrographs the thin, curled, faintly pitted pieces are hulls. Weed seeds, a common contaminant in vegetable protein and grain by-products, sometimes occur in large numbers. These are easily detected microscopically and may be determined quantitatively by

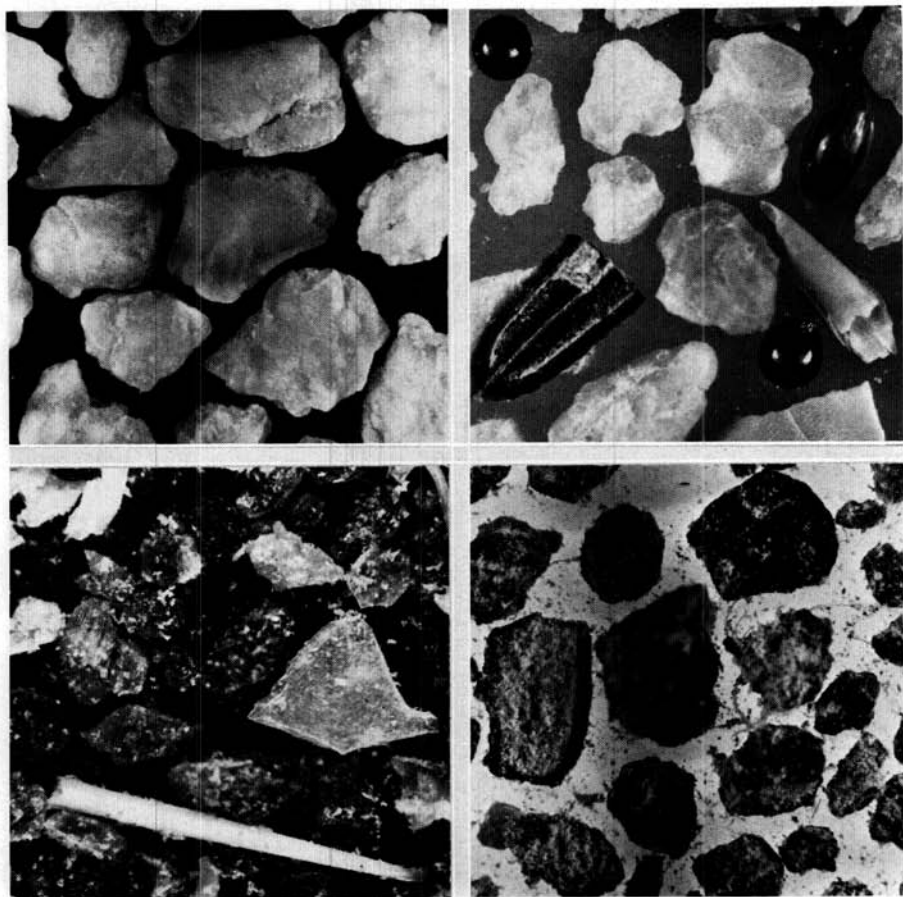


FIG. 2.—*Upper left*: Good quality soybean meal containing no foreign material. *Upper right*: Poor quality soybean meal with hull and weed seeds. *Lower left*: Fish meal, showing characteristic bone and scale. *Lower right*: Cottonseed meal with characteristic black rough-surfaced hull. Magnifications 7.5x.

counting the number of seeds in a weighed sample. Color of soybean oil meal ranges from lemon yellow when undercooked to dark brown when overheated. The two upper photos in figure 2 show the comparison between good quality soybean meal and poor quality meal containing excessive quantities of hull and weed seed.

By far the most important marine

source of animal protein is fish meal. In figure 2, lower left, the dark rough-textured pieces (brown in color) are the cooked flesh of the fish and appear similar to meat scrap, but the slender and sometimes pointed white bones and the flat transparent scales differentiate fish meal from other feedstuffs.

Another important vegetable protein, especially in the feeding of cat-

tle and sheep, is cottonseed meal, shown in figure 2, lower right. This product is predominantly yellow in color with rough-surfaced dark-brown hulls which furnish the chief means for its identification.

In general, most of the raw materials received are found to be free from serious contamination. This is especially true of vegetable proteins. It is recognized that products such as soybean oil meal and cottonseed meal normally contain some hull. However, this is not undesirable except insofar as it reduces the protein content and increases the percentage of crude fiber. As previously mentioned, certain samples of meat scrap have been found which contain considerable quantities of hoof, hair, vegetable fiber (from the stomach or intestinal tract), and scorched meat. Impurities such as hoof, hair, and scorched meat are undesirable because of their high percentage of indigestible protein. Microscopy detects these contaminants which are not differentiated from good quality protein by the chemical Kjeldahl method.

The photographic equipment used in this work is simple and may be on hand in many laboratories or purchased at a reasonable figure. We use a Zeiss low-power stereoscopic microscope equipped with objectives and eyepieces permitting from 4 to 32 diameters magnification. Photomicrographs are taken with a Speed Graphic Camera, which is rigidly supported above one eyepiece of the microscope and accurately aligned so that the plane of the camera film is perpendicular to the optical axis

of the microscope. Focusing is done on the camera ground glass. The sample is illuminated by two No. 1 Photoflood bulbs in metal reflectors placed at angles of approximately 45° above the stage and about 8 inches from the specimen. Cut film is used in black-and-white work, while Kodachrome roll film in a sliding back is used for color. Exposure must be determined by experiment. However, when once established it remains practically constant unless the lighting is radically changed.

As might be expected, color photography has been much more effective than black and white although it is somewhat limited from the standpoint of speed of processing and expense of making paper prints. In our laboratory it has been found quite feasible to project the photomicrographs as Kodachrome transparencies in a viewer or projector. The newer methods for paper prints in color which can be processed by the photographer might be practical in cases where much work of this type is involved.

The foregoing discussion has been presented to point out a few of the ways in which the microscope and camera are being used in product improvement. It is possible for the trained observer to learn much about a raw material in a minimum of time by microscopic inspection. Microscopic examination does not replace the time-honored feed analyses of protein, fat, fiber, ash, etc.; but used in combination with these, microscopy becomes a powerful tool in the quality control of commercial feed-stuffs.