Nondestructive Quality Evaluation of Agricultural Products — Industrial Application

J.E. MARION,* J. L. AYRES, and BOB STEELE

Gold Kist Research Center
Lithonia, Georgia 30038

(Received for publication July 11, 1977)

ABSTRACT

Use of nondestructive quality evaluation techniques for agricultural products is steadily increasing. Reasons for increased application and refinements of techniques in processing of agricultural products are discussed, especially with regard to more automation and less labor in processing, increased processing rates, and demand for more quality and uniformity of product. Information is presented on a number of nondestructive techniques presently being used, and the need for additional development is covered. Special emphasis is given to the efficiency, practicality, and economic feasibility of various techniques. Agricultural products covered include peanuts, pecans, poultry, eggs, pork, and seeds. Nondestructive techniques discussed that are used for processing these commodities into uniform, high-quality products include visual examination, weighing, screening, gravity sorting, air classification, electronic sorting, and estimation of chemical composition. A more detailed discussion of electronic color sorting of peanuts, pecans and almonds is presented, particularly in relation to aflatoxin sampling and reduction, preparing for further processing, and evaluation of commercial sorters for speed and accuracy.

Humans have used their five senses to assess quality of food long before instruments or measuring devices were invented. Former Secretary of Agriculture Butz mentioned in a speech at the Institute of Food Technologists' meeting in June, 1976 that he could remember well the practice of sorting fruits and vegetables on the farm, and sorting out for immediate consumption those of poorer quality because the better quality products would store better for later consumption. A number of quality control techniques in use today are still based on sight, smell, taste, texture, and with apples, the crisp sound of the "bite".

The field of quality control has been recognized in the twentieth century, not as a science per se but as a profession in which one can practice after having been educated in one of many different scientific areas. Undoubtedly the recognized leader in the discipline of quality control is Dr. J. M. Juran. In a course taught by Dr. Juran, he lists one of the earliest recorded quality control practices as that of measuring dimensions of stone behind the stonemason in early Egyptian culture. The picture portraying this might bring on comments about some of our quality control practices, maybe some regulatory practices also. There is one man working and one man measuring. With increased automation in processing plants, line inspectors and quality control personnel may actually outnumber production workers on the line. After taking an associate through a poultry plant recently, he commented that automation has reduced all manpower requirements except U.S.D.A. inspectors, and company managers.

NONDESTRUCTIVE TECHNIQUES

Eggs

Only a few nondestructive quality techniques have been developed for eggs, but those used have been highly successful. The practice of candling eggs has been used for years to detect defects such as small cracks and checks, presence of blood and meat spots, stability of the yolk in the center of the egg, and in the case of hatching eggs, to eliminate infertiles. This method was first used with single-orifice candlers, but has been adapted for use with eggs in trays or on conveyors. Eggs are sized automatically by weight, and rough and thin shells are downgraded by candling or sight.

A nondestructive method of determining egg shell quality is by flotation in graded concentrations of salt water. However, this is not normally used in processing and is primarily a research tool.

In egg breaking plants, eggs are candled before breaking, and then are observed after breaking for blood and meat spots, smelted for off-odors or spoilage, and then measured for color. Visual comparison may be made with colored standards (15), chemical determination (2), or by instrumental methods (6, 7). An illustration of Hunter a and b values for eggs is shown by Philip et al. (11).

One of the greatest potentials for salvaging eggs for human foods would be a technique for detection of egg fertility during early incubation. Presently infertile eggs are discarded at 18 to 20 days of incubation when eggs
are transferred from incubators to hatches. At this time, the infertiles are processed with hatchery waste into a feed ingredient, or discarded to a land fill. We have heard that a technique is being studied for early fertility detection but were unable to find a lead on the method.

**Seeds**

Processing methods used for cleaning and purifying seeds are about as numerous as the varieties of seeds we handle in the diversified agri-business of southeastern U.S. In seed processing, quality control techniques and processing methods are frequently one and the same. Some of the methods most frequently used are screening for size, separation by density in air flows, separation by shape of seeds (round or flat in corn), color sorting for uniform size, and hand picking defects. The seed industry is unique in that blending of different quality lots can be done legally so long as the resultant blend meets State and Federal requirements for purity, germination, and levels of noxious seeds and inert material. Electronic color sorting is successfully used for a number of different seeds but particularly for peanuts seeds. In sorting peanuts for seeds, parameters are reversed so that light colored seeds (or those lacking skins) are discarded. Automation may bring problems to production workers since jobs are eliminated, but can result in considerable savings. At the Gold Kist Seed Research Farm, breeder and foundation peanut seeds are now being graded by a two-channel electronic sorter that previously required six workers hand picking from a moving belt.

Except for germination, the final assessment of seed quality is essentially nondestructive in that representative samples are subdivided as sound seeds and other material (inert, noxious, etc.). Germination potential of some seeds can now be determined with a degree of accuracy by tetrazolium staining technique, and by X-ray method. For a discussion of these methods [9] for a discussion of these methods.

**Pork**

The type of hog grown for pork products has changed very dramatically over the past 50 years. As vegetable oils replaced lard as shortening for cooking, lard-type hogs have been replaced with bacon-type. In adopting the new breeds, and in selecting for lean hogs, they were evaluated for production efficiency and carcass characteristics. Loin eye area and back-fat thickness were usual carcass measures. Unfortunately these were of little value in measuring genetic potential of breeding stock since animals must be slaughtered before these measures could be made. Later a back-fat probe method was developed that could be used with live animals. More recently ultrasonic techniques have been used with limited success to measure loin eye area and back fat thickness of live animals [12], thus allowing breeding of animals after these measurements were made. Most recently Domermuth et al. [4] used "Electronic Meat Measuring Equipment," based on the difference in electrical conductivity of fat and lean tissues, to predict ratios of these two tissues in live hogs. They found that this method, or 40K counts with liquid scintillation, correlated well with carcass protein and lean cuts.

In cured meat and in emulsion products, salt, moisture, fat and protein levels are determined by recognized A.O.A.C. methods. These tests help assure uniform quality, least cost products, and conformance to U.S.D.A. specifications. The Babcock (Paley) method of fat analysis and toluene distillation for moisture analysis have gained acceptance for quicker, in-plant use. More recently, X-ray (Anyl-Ray), specific gravity (Honeywell), and solvent extraction-dielectric (Steinlite) methods for fat analysis have continued to gain acceptance [see Kramlich et al. [9] for a discussion of these methods]. Of these methods, the X-ray and specific gravity methods are nondestructive in that samples are analyzed and returned to the processing line.

The greatest need in the pork industry is to supply uniform hog carcasses for processing at the plant, and then to measure rapidly and accurately the composition of different ingredients going into processed pork products. In-line analysis of emulsion product mix for fat and moisture would be of tremendous benefit to the pork industry.

**Poultry**

Quality control in poultry is different from many agricultural products because factors concerning production such as feed additives, antibiotics, etc., are under the control of FDA, the product during processing is controlled by USDA and is then again under FDA while in marketing channels if interstate shipment is made. Most in-plant tests such as weights, carcass fat level, carcass grades, skin color, etc. are nondestructive and are designed to segregate product into uniform groups. Sizing methods by weights are used routinely but some method of segregating product by body and parts conformation is needed to provide uniform lots of birds for specialized markets. Also machine measurement of skin pigment would be helpful in supplying market outlets for "pale" and "yellow" birds.

**Peanuts**

In the processing of peanuts, grading, screening, air separation, etc. have been used for years to separate stems, hulls, stones and trash from edible nuts. These methods have been refined and successfully combined with electronic sorting to remove undesirable peanuts and foreign materials to produce uniform lots of whole edible peanuts, splits, and peanuts with skins intact for seeds.

When it was definitely established that aflatoxin contamination was a problem in peanuts, a study was financed by the peanut industry and conducted by the A. D. Little organization which showed clearly that reject peanuts from the electronic sorter stream (off-color, dark, shrieved) were higher in aflatoxin than normal raw and roasted peanuts in the accept stream. With this finding, color sorting became doubly important as a
The efficiency of electronic color sorters versus hand picking has been studied by Dickens and Whitaker (3). Using aflatoxin-contaminated lots, they found that careful hand-picking for discoloration was far more selective for aflatoxin-contaminated kernels than was electronic color sorting.

Unpublished data from our organization (14) showed that three different commercial electric sorters varied greatly in their ability to separate foreign material and rejects from a uniform product stream. Machines were evaluated for four basic components: feed system, scanning system, control system, and reject system. Feed rates were studied, and a sustained sorting rate of 500 lb. per hour of peanut kernels is considered optimum for these sorters.

In removing splits from whole peanuts, the three machines tested varied greatly in sorting efficiency. On a scale of 0 to 25 (poor to best), the machines rated 0, 17, and 22. The two best machines had different operating characteristics that tended to equalize them as test parameters were changed (i.e., loss in value of accept with reject material, cost of sorting rejects, or in complete removal of rejects from accept product stream). One machine rated lowest in all sorting tests (splits and wholes, foreign material and rejects from edible peanuts, rejects from seed peanuts, etc.) while the other two were consistently superior in sorting ability.

A study was conducted by Shade et al. (13) in which aflatoxin was found in 14% of 74 samples of unsorted, in-shell almonds as received by processors in 1972. Aflatoxin levels were low (below 20 ppb in 90% of the contaminated samples). Commercial sorting procedures were effective in reducing the incidence of aflatoxin since none of the processed whole nut meats contained detectable aflatoxin levels.

In pecans, the potential for aflatoxin contamination has been demonstrated (5,10). To date, no extensive study has been published to indicate actual severity of the aflatoxin problem in pecans. However, methods for preventing and controlling mold growth and aflatoxin development are being studied, along with methods for economical sampling for aflatoxin analysis (1). If aflatoxin in pecans should prove to be a problem, studies should be instituted to improve color sorting of pecan halves and chopped pieces to reduce the problem.

REFERENCES