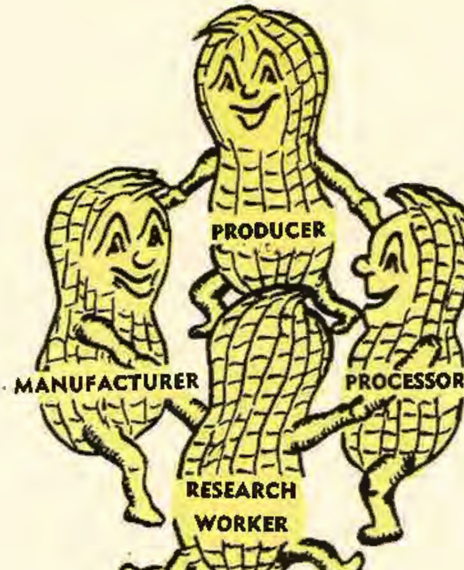
PROCEEDINGS

PEANUT RESEARCH CONFERENCE

Held In

Atlanta, Georgia
February 21-22
1957



Theme

"Quality Thru Cooperation"

PROCEEDINGS

PAPERS AND ADDRESSES

PEANUT RESEARCH CONFERENCE

Sponsored by

NATIONAL PEANUT COUNCIL

In cooperation with

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
FARM EQUIPMENT INSTITUTE
SOUTHERN FARM EQUIPMENT MANUFACTURERS
UNITED STATES DEPARTMENT OF AGRICULTURE
STATE AGRICULTURAL EXPERIMENT STATIONS

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Remarks from the Conference Chairman

R. C. CANBY, *Chairman National Peanut Council Research Committee*

Early in 1956 G. Wallace Giles, Head, Department of Agricultural Engineering of North Carolina State College, then chairman of the Sontheast Section of the American Society of Agricnltnral Engineers appointed to the Peanut Committee of said section the following men, Fred C. Kummer, Alabama; Wm. T. Mills, N. C.; James L. Sheppard, Georgia; Norman C. Teter, Virginia; and their chairman, John T. Phillips, Jr., of Georgia.

A series of meetings were held by this group during which it was proposed to bring together various phases of research in the agricnltural field relating to peanuts for a conference, the purpose of which wonld be to consider and study ways to improve quaility through research. Mr. Phillips, Jr., approached the National Peanut Council with the idea of sponsoring snch a program. Mr. Ben M. Birdsong, chairman of the board of the National Peanut Council, referred this request to the Council's Research Committee, chairman of which was Robert C. Cauby.

During the annual Convention of the Council at New Orleans in March 1956, Mr. Phillips discnssed the possibilities of a Research Conference with members of the Council's Research Committee. A Steering Committee was then appointed to work with Mr. Phillips. This Council Steering Committee, together with members of other agricultnral groups, met several times in various cities to formulate a program for a Research Conference to be held in Atlanta in February 1957. The basic idea of the Conference and its purpose was approved for sponsorship by members of the Board of Directors of the National Peanut Council in Washington on August 1, 1956. Cooperating in the Conference would be the American Society of Agricultural Engineers, Farm Equipment Institute, Southern Farm Eqnipment Manufacturers, U. S. Dept. of Agricnltnre, State Agricnltural Experiment Stations.

Plans went rapidly forward during the fall and winter so by January 1957 the program, the speakers and supporting committees were ready to function. Much praise is due Mr. John Phillips, Jr., for his splendid work.

On February 21, 1957 the Peanut Industry Research Conference opened at the Atlanta Biltmore Hotel. Over 160 registrants including Research workers, state and government representatives, manufacturers, equipment suppliers as well as educators and others related to the Peanut Industry, attended the two-day sessiou. The first day in two sessions was devoted to the presentation of papers on the need for improved quality in the peanut on three phases. Phase A—"Factors affecting qnality as influenced by breeding and pre-harvest conditions", presided over hy Mr. V. R. Boswell, Head, Div. of Vegetable Crops, USDA. Phase B—"Factors affecting quality as influenced by harvesting and curing", presided over by Mr. G. W. Giles, Head, Agricnltural Engineering Dept., N. C. State College, and phase C—"Factors affecting quality as influenced by sampling, grading, storing and shelling", presided over by Mr. E. J. Young, Exec-Vice President Stevens Indnstries. The purpose of the Confereuce was ably presented by Dr. Aaron M. Altschul, Head, Oil Seed Section, USDA, Southern Utilization Research Laboratory.

The keynote speaker who so capably outlined the need for "Quality as desired in the end-product" was Mr. Aaron S. Yohalem, vice president and assistant to the President of Best Foods, Inc., of New York.

The second day was devoted to work-shop sessions of each phase which filled the morning. Recommendations were developed by each of the three groups.

In the closing period following the luncheon these recommendations were presented by each phase chairman. Then the Resolutions Committee chairman, Mr. H. L. Wingate, read several resolutions which were duly proposed, voted upon and passed. One in particular, representing the studied consideration of the committee, significantly, may in the future lead to far-reaching advancements in the whole industry through research. It is entered below in its entirety—

> *BE IT RESOLVED*, by the Peanut Research Conference, held here in Atlanta February 21 and 22, 1957,
>
> 1. That a well qualified and experienced person be engaged to serve as the coordinator of all research and research information relating to peanuts and peanut products in all its phases, from the breeding of the peanut to its consumption;
>
> 2. That the Research Committee of the National Peanut Council and the Resolutions Committee of this Conference be requested to give the foregoing recommendation their earliest convenient attention and prepare plans and recommendations for its activation for consideration of the 17th Annual Convention of the National Peanut Council at the Fontainebleau Hotel, Miami Beach, April 28, 29 and 30."

In the fine spirit of cooperation that was so mnch in evidence throughout the Conference a most generous offer of $5,000 was made by the G. F. A. Peanut Association to make a search of all peanut research literature and to catalogue and publish this record. Such information is of immeasurable assistance to researchers.

It can be said without reservation that this Peanut Industry Research Conference was a most progressive step forward in the interest of improved quality. If we are to expand our markets it must come as the result of greater recognition of the importance that quality has in its relation to the bnying habits of our consumer friends. This responsibility must be shared by every grower, sheller and mannfacturer together with all others associated with onr Indnstry.

To attain the public acceptance that peanuts rightly should have, research carries the major share of the burden of raising quality and efficiency as well as lowering costs.

We must be persistent in this effort—month by month. Increased research activity, properly directed, will pay great rewards to every segment of the Peanut Industry.

Purpose of Conference

By A. M. ALTSCHUL

Southern Regional Research Laboratory, New Orleans, Louisiana

Before I discuss the "purpose" of this Conference, I should like to call your attention to the fact that a research conference on utilization of edible peanuts had been held at the Southern Utilization Research Branch in New Orleans on February 5 and 6, 1953. Copies of the proceedings are still available from that Laboratory to any who are interested. At that Conference talks were given on peanut research and on industrial problems relating to use of peanuts. Committees were appointed to review the status of research on peanuts in relation to the problems of the industry and to make recommendations; nine specific recommendations were adopted at that conference. Improvement in quality in the raw material was stressed repeatedly as the most important problem confronting the different segments of the industry. Other recommendations included need for research to develop methods of reducing the amounts of damaged and shrivelled peanuts and the variation in moisture content of the raw stock available to the industry. Moreover, it was suggested that research was needed to increase the use of peanuts as an oilseed and on the development of uses for peanut hulls.

This represents to our knowledge one of the first times that various segments of the peanut industry got together to try to take a look at the entire problem. It should be a source of encouragement to us meeting here at this Conference and should provide us with some momentum to go forward.

A conference of people is a many-sided thing. Many things are done as a group and equally important work is done individually. We cannot talk, therefore, of "purpose" in singular but of many "purposes' that might possibly be the objectives of this Conference. I should like to list five possible objectives and then discuss them individually. These would be the following:

(1) To become better acquainted,
(2) To exchange information,
(3) To broaden the outlook on peanut problems,
(4) To set the stage for an integrated approach to solving problems of the peanuts,
(5) To focus attention on needed research.

Objectives 1 and 2 would seem to be obvious and should, I suppose, be taken for granted. Yet even if that is all that is accomplished, it will be worthwhile because the act of just bringing research workers together and allowing them to become acquainted and to exchange information is one of the best ways for coordinating research, for inspiring people and for generating new ideas. I certainly would hope that at least these two objectives would be accomplished beyond a doubt.

We can, however, expect that perhaps other objectives could be attained or at least aspired to. The third objective which I listed is, to my way of thinking, the most important. Everyone tends to look at a certain problem from his own narrow viewpoint. There is nothing wrong with this approach; that is a natural phenomenon and one in which we are all guilty. But there comes a time when one has to broaden his outlook, to break away from the narrow lines of his individual interests and to try to see the entire picture.

And this is a painful procedure because it may turn out that what any one of us is doing is not as important as we think it is in terms of the entire picture. Yet everybody's work is important, especially if he keeps in view the entire picture and when he has in mind the broad objectives of the program. A conference is one of the best media for trying to broaden a person's viewpoint. I should think that everyone should try at this Conference to break away from the narrow lines of his own individual interests and try to think about the broad picture.

As a background for further statements, it might be worthwhile to mention a few facts about the peanut industry and the peanut. The peanut is the third largest oilseed produced in the world. Its production is about twelve million tons annually; it is exceeded in quantity of production only by cottonseed and soybeans. Production in the United States was 783,000 tons of farmers stock peanuts in 1956 or roughly about 6% of the world total. This was grown in the United States on 1.4 million acres and in 1955 was valued to the farmers at 189 million dollars.

While peanuts throughout the world are considered an oilseed, that is, a source of oil and meal, peanuts in the United States are produced primairly for human edible purposes; 77% of the shelled peanuts are consumed for that purpose in the United States, only 23% are crushed for oil and meal. Of the edible uses, peanut butter makes up by far the greatest use, constituting 53% of all edible peanuts, salted peanuts are next at 25%, peanut candy takes up 20% and other products account for the remaining 2% of the edible peanuts. Although peanuts in the United States are used mainly for human edible purposes, the per capita consumption of peanuts in the United States is rather low, about 4 lbs. per capita.

As an oilseed, peanuts in the United States served as a source of 70 million pounds of peanut oil in 1955 and about 53,000 tons of meal or cake. As a source of either oil or meal, peanuts hardly begin to compare in quantity with the production of oil and meal from soybeans and cottonseed.

It might be worthwhile to fix in our minds the composition of peanut kernels as is shown in Table I. It is clear from examination of these data that peanuts is a source of protein and oil; oil-free peanuts or peanut meal becomes an excellent source of protein; is indeed a protein concentrate. The oil in peanuts contains glycerides of oleic acid, linoleic acid, saturated acids and small quantities of other acids. The amount of linoleic acid in these peanuts varies, the range for runner peanuts is from 19.9 to 23.9% of the lipid fraction and in Spanish from 31.9 to 37.0% of the lipid fraction. Virginia peanuts are in between the two in range of concentration of linoleic acid. From the point of view of stability it is desirable to have less linoleic acid in a material, but in recent months there has been considerable interest in the role of linoleic acid in certain cardiac diseases. Although this picture is anything but clear, the outcome of these investigations on human health should be of interest to the peanut people who supply significant amounts of this acid in peanut butter, salted peanuts and confections. The protein in peanuts contains the essential amino acids needed for growth of humans and nonruminants but is somewhat limited in the supply of two of them, methionine and lysine.

As was pointed out previously peanuts are primarily an oilseed over most of the rest of the world. In certain areas of the world attempts are being made to use other peanut products such as peanut milk as a source of supplementary protein for the human dietary.

What might be the objective of research on peanuts? In its most general form this might be stated as, "to make the most out of peanuts." This is a

TABLE I. Composition of Peanut Kernels

Constituent	Range %	Average %
Moisture	3.9 - 13.2	5.0
Protein	21.0 - 36.4	28.5
Lipides	35.8 - 54.2	47.5
Crude Fiber	1.2 - 4.3	2.8
Nitrogen-Free Extract	6.0 - 24.9	13.3
Ash	1.8 - 3.1	2.9

general statement and can mean a lot or nothing. If we look into it further, it could mean that we mnst make for the most efficient production of peanuts; bnt at the same time we recognize that the greatest yield per acre and good resistance to disease are desirable only if at the same time we have a prodnct which has the widest possible use. We might say that to make the most out of peanuts wonld be to make the best qnality peannts; that is true only if the best quality peanuts are available at a price competitive with other materials. We might say that to make the most out of peannts means nniform quality and methods of measurement of qnality: that is good if the uniform quality is at a high enongh level to be nseful and competitive with other materials.

We might add that to make the most out of peanuts would be to find new uses and new forms for the peanuts. Utilizatian of peannts has been in the same sort of a groove for quite a long time and one might properly ask whether this is the pattern that shonld be frozen for all time. At our Laboratory, for example, we have de-oiled peanuts without crnshing them. We do not know whether this is a useful new product or not, bnt it is an approach to a new form of peanuts, peanuts with a lower caloric value.

In the United States peanuts are not considered an oilseed bnt in the rest of the world peanuts is one of the largest oilseeds, a source of oil and meal. If it were possible to achieve this status in this conntry for part of the crop by developing new varieties and by new means of harvesting, this wonld be a new approach to peanut utilization.

As pointed out earlier, there is considerable interest in the relationship of fat in the human diet and certain diseases. There is generally an increasing awareness of the need for more information on the composition of food and its relationship to health and well-heing. There are, no doubt, trace materials in all foodstnffs that might have an effect, good or bad. Only recently have techniques like chromatography been developed to the point that analyses for these trace nutrients become possible.

At our laboratory we have been isolating the bitter principles in peannt hearts. These are presumably related to the bitter materials found in improperly-cured peannts. Our objective is to obtain information about the materials that affect quality, to measnre them and finally to control the amount of these materials present through changes in processing and handling so that good-quality peanuts can be produced consistently and efficiently. The success that we have had so far in isolating bitter materials leads ns to feel optimistic about the success of this project. But the nnmber of hitherto unsuspected compounds that we have found emphasizes our colossal ignorance about trace materials and nutrients in peanuts.

I do not believe that I have exhausted all of the possible questions; I have raised just those that occur to me. Obviously if each group at this meeting confines its thoughts to its own narrow fields and prospectives, we will not even begin to cope with the really serious problems; therefore, I would urge that in the discussions we keep in mind some of the important questions and relate them to the kind of work that each of us is doing.

If we do succeed in broadening our attitude and our outlook on peanuts, then perhaps we can turn to objectives numbers 4 and 5 with some chance of success. The approach most likely to succeed in solving the difficult problems is an industry-wide and discipline-wide approach. The word industry-wide, of course, is obvious. Discipline-wide would mean that all the various disciplines, chemists, engineers, biologists, clinicians, etc., would work together to solve a particular problem. Certainly the problems of successful mechanical harvesting of peanuts, of developing quantitative measures of quality and of control of quality, of developing new uses for peanuts and peanut products, and for making the best nutritional use of peanuts require work of more than one group and one discipline.

Even talking about these problems will be helpful, but perhaps it may be the decision of this meeting to establish continuing committees on some of these problems to strive for a coordinated approach.

Having accomplished this attitude we can then focus attention on needed research. I do not propose to discuss this matter at this time because this is really what we are going to talk about at most of the sessions. Certainly our success in achieving the first four objectives will influence our efforts on the last one.

I might conclude by saying that there is need for more sophistication in thinking about, in work on, and in use of agricultural products. This is a general problem of agriculture; it applies equally as well to peanuts. We have to know more about the material that we are eating, about its composition and about the effect of the various things we do to it on composition. We have to have quantitative ways of measuring quality and we must know more about the nutritive effects of eating this material, beneficial and otherwise. We must apply to the study of peanuts the great advances in the physical, biological and engineering sciences so that this crop can be used to best advantage for our national health, for the farmers who grow it and for the economy in general.

QUALITY DESIRED IN THE END PRODUCT

By A. S. YOHALEM, *Vice President and Assistant to President, The Best Foods, Inc.*

I would like to preface my remarks with the observation that in my view a landmark in peanut agriculture has been reached today. Assembled here are all segments of the industry. You have come together with the common purpose of examining objectively every phase of the growing and utilization of peanuts, with the goal of increasing the consumption of peanuts in the United States.

It is a truism that an expanding market for peanuts is essential to the well-being of every phase of our industry. This much to be desired objective was not attained in the decade or more preceding the current marketing year. Except during the war years when demands were distorted, domestic per capita civilian use of peanuts, on a farmers stock basis, was 6 and 4 tenths pounds, as compared to 6 and 7 tenths pounds in the 1937-41 period. This failure of demand to increase not only on a per capita basis, but not even in line with population, took place in the face of notable product improvements, aggressive advertising and selling and, in most years, of surpluses diverted to crushing and exports.

A reversal of this pattern would redound to the benefit of the farmer, the sheller and the manufacturer. And such a reversal, according to my understanding, is the fundamental and underlying long-range purpose of this meeting.

In our modern world the man in the laboratory is the man of the hour, for scientific research, more than any one thing, has created our method of living in America. The men who pursue it are responsible for our prosperity and undoubtedly hold the key to our future. No one will deny that the transformations which have occurred during the last century have come from the inventive genius of men who worked in the laboratories of our universities, colleges, government and industry.

Many of these men were specialists and productive in their selective fields. The modern method of organizing a team of workers and pooling their accomplishments results in the coordination of their specialized works, which may then be put to practical application in creating a fundamental change and revolutionizing an industry. In this room we have a team of men whose endeavors, if pulled together, conld create the fundamental change we all seek for our industry. If successful, we would no longer be doing one small thongh very important research project here, another there, a third elsewhere—but each project would be a segment of an overall plan contribnted to and created by all members of the team. This meeting is the beginning of the organization of scientific information and its use and translation into new improvements—no, let us say new dscoveries, that will revolutionize our industry and succeed in reversing a pattern that has too long been left in a retrogressive state.

There has been much work done to date on many of the problems to be discussed here. Much of the work was born at the 1953 conference. But the time lag between discovery and application is often too long for the type of agricultural-industrial development we reqnire. We have here today the framework for the coordination and interchange of ideas among men in various branches of our agri-business and for their translation into practical developments. We must not fail to take advantage of this facility which is vitally important for our survival and growth. An industry that does not absorb new knowledge as rapidly as it can be reduced to practice is not fulfilling its responsibilities to itself and its customers and is doomed to defeat in the battle of the marketplace.

What is the end we seek? Not the growing of peannts as a thing of beauty, but rather the growing of peanuts as a wholesome, nutritious food, a daily constituent in the diet of the American family. In short, we seek the increased consumption of peanut products.

Recently I reviewed a national market research study of the peanut butter industry. According to this study, between 70% and 80% of the families in this country bought some peanut butter last year. This sounds fine, but despite this high percentage only about 30% of the families in our country can truly be called nsers of peanut butter, for the balance consumed either no peanut butter at all or less than three pounds per year. As a matter of fact, only 15% of the families in the United States use as much as one pound of peanut butter per month. When we realize that we are talking about a product that accounts for 50% of the peanut consumption in onr country, we can appreciate that if your work contributed to the increased usage of peanut butter alone to this level of one pound per month per family, we would multiply by up to six times the consumption of peanut butter and by perhaps as much as three times the total consumption of peanuts in the U. S. This is not a goal too far beyond our horizon.

There are many products that we can think of—shall I say competitive with peanut butter—which in the last decade not only kept pace with population increases but broadened their distribution far beyond this. My own company's experience in the margarine and mayonnaise fields offers two good examples—cheese and cheese spreads are others—jams and jellies—and so forth.

How can we increase the consumption of peanut products? There should be no mystery about this. If a food tastes good, looks good, smells good and is attractively packaged and displayed, it must sell—not on the level of peanuts today but on a greatly accelerated sales enrve.

When a person eats a peanut product, he either likes it or he doesn't. If he dislikes it, no attempt is made to analyze whether his dislike is caused by mold, dirt, decay, bitterness, freeze injury, or any other reason foreign to a good peanut. It is the effect on his taste, on the odor or appearance of the product that is important, and not that a peannt used therein went bad because an insect got to it, or because it became contaminated with foreign material. A bad peannt product means a lost customer, not just for one sale, but sometimes for a lifetime. To increase the consumption of peannt products we must, in one way or another, introduce them to new users. A bad first impression on a new user, resnlting from a bad peanut product, is more difficult to overcome than is a bad first impression in human or personal relations. From our long experience in marketing food products, we are impressed with the difficulty of regaining lost customers. If housewives break purchase habits for a food product, they and their families will develop new consumption patterns, and they may be difficult or impossible to reconvert.

There can be no compromise with the QUALITY DESIRED IN THE END PRODUCT.

Many years ago the doctrine of caveat emptor prevailed in business. Let the bnyer beware was the rule of the day. Times have changed. Industry, now more than ever, is keenly aware of its obligation to the consumer. It recognizes that the building of a franchise is dependent upon honesty and fair dealing in every respect. To give the highest qnality in any product is the guiding blueprint of all successfnl industries.

I have taken some time to develop my premise because I feel so strongly that it is fundamental. The object of research in our industry, simply stated, is this: increased sales through improved qnality.

Let us define as nearly as we can what we mean by improved qnality . . . and here permit me to digress. I am talking about all peanuts, whether they be Virginias, Spanish or Runners—or any new variety that can be developed. I do not believe that research in its broad concept shonld be restricted to the product of the geographical area in which the research is conducted, but rather should be conducted on peannts generally, so that all areas and all peanut producers can benefit. Insofar as industry is concerned, I am snre that with the improvement in the kinds and quality of peannts grown, there can be developed a great interchangeability—not at the cost of quality, but rather looking toward the npgrading of quality. I can recall when coconut oil was the predominant fat nsed in the manufactnre of margarine; when corn oil was the only winter oil nsed in mayonnaise or salad dressings. No other oil, it was thought, could be used with the same end results. Today, as you well know, coconut oil has been replaced in margarine by cottonseed and soybean oils—and these same oils can now be used as a winter oil in mayonnaise and salad dressings. Research developed this interchanegability. And research can also develop a better kind of peanut for utilization and interchangeability by end users.

In the course of my work, I come in contact with research and development workers in several fields. While I have no broad knowledge of the scientific fields concerned, I have been interested in a number of the fundamental principles concerned in research. To cite one or two, I might mention this matter of goals in research. I have already stated what I believe should be our goal, better and more general consumer acceptance through producing better quality peanuts. You will note, however, that I outlined no specific approach or even that there should be more than one approach (which I believe there should be). I have been impressed with the fact that tests and experiments are probings, probings of hypotheses and theories, of ideas. We routinely make tests and probings without being able to predict the results, just to acquire data. We realize two fnndamentals here: first, that research it built upon research, and second, that in the usual business sense there cannot be such a thing as "efficient" research. To put it another way, I know, very well, that you cannot predict today what you will discover tomorrow or next month. But you *must* start, and in *earnest,* to test and probe, constantly and incessantly.

Another example of fundamentals which this theme naturally leads into: ever hear of the word serendipidy? It's a rather seldom used word and not found in many dictionaries. It has reference to three princes of the mythical province of Serendip who had a goal to achieve and in the process came up with several happy new achievements they never even knew were in the books. Research is like that. While you may have a general goal, it is very characteristic of research that some entirely unlooked for results do come out of research explorations. Of course, in this connection a word of caution is necessary. I do not mean that research must not be directed. I most certainly do believe in its direction. In fact, good and clever direction are necessary to avoid wandering too far afield, a point we must not lose sight of.

Now to return to what we mean by improved quality—beginning at the lowest levels and moving upward, we mean the elimination of undesirables and the improvement of raw material qualities and processing steps. Undesirables, of course, are such items as rancid peanuts, worm cuts, frozen peanuts, mold, and so forth. By improvement of desirable raw material qualities, we mean any agronomical changes capable of producing a larger, better tasting and more easily processed peanut, improved holding or storage conditions, transportation and handling.

Such an understanding of our aims leads to a discussion of the areas of activity in which our goals may be achieved.

First, elimination of undesirables: Although this may be the least lofty part of any program, it is nevertheless the first in current importance. We have got to—simply got to have clean, sound, good-flavored raw material to start out with. We must have peanuts that are uniform as to size and maturity. There can be no discussion as to the acceptance of the degree of worm cuts, as to how much rancidity is passable, or how much decay or mold can be tolerated, or how much foreign material we can get away with, or how many frozen peanuts will make a bag unacceptable. These and other undesirables must be entirely eliminated.

This level of our program should call for the solution of these problems on a very positive basis. It was a sad day for our industry when dnring the meetings on the revision of standards for shelled peanuts, it was recognized that certain types of damage could not be readily detected. Methods should be developed for the rapid detection of such undesirable features as rancidity, bitterness, freeze injury and decay. Improved sorting machines should be developed. These tasks, it is recognized, call for top level research talent and experience. Hence, they call for a positive approach.

We deplore research to determine the effect of various kinds and amounts of damage upon the quality of peanuts or products produced from them. We know enough to realize that the rancid peanut in peanut butter does nothing good for the product. We are not interested in learning how much rancidity we can absorb, but rather in learning how to do away with rancidity altogether. There can be no question of tolerance with quality. Therefore, research directed to the recognition of and elimination of these undesirables is the first and major step in our program—and if we do nothing else at this meeting but discuss and set in motion research directed to this end, this meeting will have been a major success.

The next area of activity we must concern ourselves with involves problems so difficult and time consuming that it staggers the imagination and makes us wonder why we have not approached it sooner and more energetically. This is the area of agronomical research and raw materials handling, looking toward the improvement of desirable raw material qualities. In short, the period including the growth of the peanut plant, the harvesting of the peanut, and its shelling, storage and handling. Without this, the first area of activity mentioned will be immeasurably less valuable and important.

In mentioning this area of activity, I do not imply that we are introducing a new area for research. But heretofore this type of research has been conducted largely on a piecemeal basis. Various phases of a problem have been studied more or less independently. We can never expect to find answers in this way to the complex problems that exist today. The approach suggested here involves bringing together all related interests for the exchange, dissemination, publication and coordination of ideas and formulation of plans and projects.

This field of our work which encompasses cultural practices, including rotation, spacing, fertilization and seed treatment, as well as weed, insect and disease control cannot be over-stressed. Development of varieties that are resistant to damage is not beyond our vision. Research with special significance given to the effects of irrigation on flavor is of utmost importance. I need only to refer to the recent trip of the President throughout the southwest to bring home recognition of the fact that more and more of our lands devoted to the growing of peanuts will be subject to irrigation, with the resulting problems brought about by the growth of peanuts through this type of agriculture.

In the area of activity having to do with cultural practices we begin to see a cure for the evils of our industry, both from the agricultural as well as the economic standpoint. Carry this research successfully through to the harvesting and curing stages, and a good part of our problem will be solved. For example, artificial curing could result in a peanut of greater uniformity and eliminate some of the hazards of weather that we witnessed this year in the Virginia area. But much further work must be done before the peanut flavor apparently resulting from this type of curing is corrected. In the words of Dr. Altschul, when bitter material has been defined and methods for its assay developed, it will be possible to measure by chemical means the state of maturity and adequacy of curing.

Another part of this area of activity includes improving shelling and storing conditions. No one knows better than yon in this room how little fnndamental progress has been made in this phase of our industry. The improvement of these conditions wonld resnlt in the delivery of an end product to the consumer produced from a cleaner peanut, stored under proper conditions of hnmidity, temperature and air supply—and thns we will have a better tasting peannt product.

No one of us has ever seen a snccessfnl individual who did not have a forward looking attitude. The volume of peanut prodncts consumed in our country in relation to its population and income level is deplorable. Lack of growth in the consumption of these products must be attributed directly to the lack of spirit or will to go forward by all segments of onr industry. Not lip service, bnt the investment of time, energy, and even capital is required to make for a better tasting product.

I recognize that the topics I have discussed are not new to anyone in this room. One has but to look at the agenda of this meeting to appreciate this fact. Reports of the schools of agriculture of various state universities are replete with examples of the need for this type of research. The U. S. Department of Agricultnre recognizes it. The minutes of the meetings of associations of, or affiliated with, our industry are filled with instances of the needs of our industry.

The importance of this meeting, however, caunot be overstressed. We have here the opportunity to set in motion a unified, integrated program of research that will raise the standards of quality for peanuts, and this, in turn, will most assuredly result in far reaching expansion of our industry. The reward, in the form of growth of our iudustry, is well worth the very best efforts that every one of us can expend. In a material, direct manner not only the farmer but all segments of our industry will benefit. But to accomplish this end, we must set aside all selfish interests and join in this giganic task of research, with the over-all common goal of improving the peanut.

RELATION OF BREEDING AND VARIETIES TO QUALITY FOR SPECIFIC USES

By B. B. Higgins

Retired (former Botanist, Georgia Experiment Station)

At the time Linnaeus proposed the generic name *Arachis* (19) for the peanut, only cultivated forms were known, and the name *Arachis hypogaea* was proposed to include all cultivated forms known to him. Less than 40 years later Loureiro published his "Flora Cochiuchinensis" iu which he described (20) two new species: *A. asiatica*, based on a variety of the Valencia type, and *A. africana*, based on a prostrate type commonly grown in Africa.

Since that time most botanists working with peanuts have given some weight to this division of the species but noue have accepted Loureiro's species as such. Waldron (32) divided *A. hypogaea* L. into two sub-species, *procumbens* (runners) and *fastigiata* (buuch), aud suggested a different origin for each of the sub-species.

Chevalier (5), recognizing the fact that Waldron's sub-species *procumbens* included hoth runner and bunch vine types, discarded Waldron's subspecies but grouped cultivated forms of *A. hypogaea* L. into four groups designated as: var. *communis*, var. *stenocarpa*, var. *microcarpa*, and var. *robustior*. These groupings were based largely on shape and size of pods and seeds, and each variety included both bunch and runner vine types.

In 1951 Gregory et al. (14) suggested a classification of varieties based upon fnndamental botanical characters, with a key as follows:

"A. Lateral buds of the central axis all vegetative. First cataphyllar node of n + 1 order branches vegetative; second occasionally reproductive.
(a) n + 2 order branches occur as pairs of vegetative branches alternating with pairs of reproductive branches. .. *Virginia*

AA. Lateral buds of the central axis vegetative or reproductive. First and second cataphyllar nodes of n + 1 order branches reproductive.
(a) n + 2 order branches irregularly reproductive and vegetative. Pods two to three seeded. . . . . . . *Spanish*
(aa) n + 2 order branches all reproductive or sometimes mostly vegetative distal to the 6th to 8th node. n + 3 order brauches all reproductive. Pods 3-6 seeded. . . *Valencia*"

Anyone studying a large collection of Spanish and Valencia types will probably find difficulty in separating them along the lines indicated in the key; but the primary division, A. and AA., appear to be well defined.

In 1955 Bunting (2) published a report of his study and comparison of the botanical characteristics of more than 400 varieties assembled and grown at two locations in British East Africa. His conclusions were that the two primary divisions proposed by Gregory et al. were well founded. All late maturing varieties fell into their group A. (designated by Bunting as the "*alternate branching*" group,) while all Spanish and Valencia types fell in group AA. ("*sequential branching*" group of Bunting). He could find no basis on which the varieties of Spanish and Valencia types could be separated definitely.

Gregory et al. (14) noted several other characteristics associated with the two types of branching. These may be tabulated as follows:

Variable	Group A. (alternate branching)	Group AA. (sequential branching)
foliage color	dark glaucous green	paler green
leaflet size	small	larger
leaflet tip	pointed	more rounded
primary branches	longer than central stem	not longer
vegetative period	long	short
nut distribution	not basal	basal
seed dormancy	30 to 360 days	none
Cercospora leaf-spot	resistant	very susceptible

The last item does not seem to be a good differential characteristic. Apparently susceptibility to Cercospora leaf-spot is positively correlated with size and maturity of the nut crop. Varieties of both groups become very susceptible while maturing a heavy crop of nuts, and may be completely defoliated under favorable weather conditions. However, there are other differences that do appear to apply throughont the two groups: differences in texture, in ease of blanching, and in chemical composition of the seeds.

Since quality of peanuts for edible products is based largely on texture and flavor, the plant breeder conld go about his work with greater precision, if he knew the substance or combination of substances responsible for differences in textures and in flavor. Our peanut oil millers have long noted one difference which appears to be common to varieties of the two groups: that seeds of Spanish varieties are very tender and oil runs freely on grinding, while seeds of Virginias and runners have a more waxy consistency and oil does not run so freely. Formerly this was attributed to higher oil content in Spanish seeds; bnt chemists now know that, with fully matured seeds, the difference in oil content is too slight to acconnt for the texture difference.

From my own limited experience with crosses between units of the two groups, the hybrid progenies range in seed texture from very tender to waxy and to very hard, going in both directions beyond the parent types. If correct, this indicates that multiple genes are involved in determining texture. Are texture differences due to the presence or absence of pentosans or to the type of pentosans (16, 17, 22) present in seeds of the two groups? At present we do not know. We are here considering texture of normal stack-cured peanuts. Seeds of any type or variety may become very hard under certain nnfavorable curing conditions.

We now know some of the end products responsible for the characteristic flavor and aroma of roasted peanuts, but not what is lacking in seeds of varieties that fail to develop this characteristic flavor. Pickett and Holley (25) studied changes occurring in peanuts dnring the roasting process. They attributed development of brown color to the reaction of sugar (sucrose), and perhaps cellulose, with free amino groups of the proteins. Analysis of the gases given off during roasting showed carbon dioxide (about 98 per cent) with traces of ammonia, hydrogen sulphide, vanillin, and diacetyl. The carbon dioxide was released in the sugar-amino acid reaction. The sources of sulphnr, ammonia, vanillin, and diacetyl are not known. Comparison of varieties was not included in the stndy.

At this point it seems desirable to present a brief survey of published analytical work on the composition of peanuts, especially that indicating marked varietal differences. Until quite recently most chemists have giveu little consideration to varietal differences in planning and reporting their studies of peannt composition. Peanuts were just peannts and peanut oil was considered a constant entity nntil changed by development of some type of rancidity. Yet, differences in composition and in stability of the oil were among the first and most striking differences to be noted.

In 1921 Jamieson and Baughman (18) reported the fatty acid glycerides found in freshly expressed oil from a Spanish and from a Virginia strain. They found glycerides of oleic acid lower and linoleic higher in oil from Spanish than in oil from the Virginia. They also found glycerides of the saturated fatty acids higher in the Spanish oil than in that from the Virginia.

In 1941 Holley et al. (15) reported analyses of 24 hybrid selections, with Spanish and Southeastern Runner as checks. They found the proportions of oleic and linoleic glycerides in oil from Spanish and in that from Southeastern Runner similar to that reported by Jamieson and Banghman for Spanish and Virginia. In oils from the hybrid selections the percentages of these two fatty acids were quite variable.

Crawford and Hilditch (7), having noted the wide variations in composition of peanut oils as reported by previous workers, analyzed peannt oils from various countries and from three varieties grown nnder similar conditions in Africa. From the results they concluded that variations in the proportions of oleic and linoleic glycerides in the oils were due to varieties, climatic variations, and soil types. The importance of varieties was indicated by comparison of the glycerides of unsaturated acids in oils pressed from the three varieties: West African, with 60 per cent oleic and 20 per cent linoleic, against abont 40 per cent oleic and 35 per cent linoleic glycerides from both Natal Common and Valencia. They urged that, in producing peanuts for oil, the growers plant only varieties with low linoleic content, since linoleic glycerides oxidize most readily on contact with air.

Resnlts reported by Pickett and Holley (26) indicate that environmental factors nnder which peanuts are grown have no appreciable effect on iodine number or unsaturation of the oil. Genetic purity of the variety, maturity of the seeds, and method of sampling may be more important in obtainiug reproducible results.

The same authors (24) also reported results from more than 70 comparisons over a period of six years, showing that oxidative rancidity developed much more rapidly in oil in the seeds, either raw or roasted, and in the expressed oil of Spanish varieties than in those of Southeastern Runner or Virginia. Since publication of these results, the study has been extended (27) to include Tennessee Red and other available varieties of the sequential branching group. All behaved like Spanish in susceptibility to oxidative rancidity.

Chemists are not agreed as to the explanation for differences in susceptibility to oxidative rancidity. Some feel that differences in proportion of linoleic glycerides in the oil is sufficient explanation, while others feel that other factors may be involved. We know that peanuts contain numerous compounds that may act as antioxidants: tocopherol (10), lecethin (15), phytin (15), tannins (21, 29, 30, 31), squalene (11), free amino groups (25), and some ascorbic acid (6). Tocopherol, soluble in oil and always present in crude peanut oil, is one of the most powerful antioxidants found in vegetable oils; but little is known as to the amount and form of tocopherol found in the different varieties. Appareutly, both lecethin and phytin (15) occur in both groups of varieties, with only slight variations in amount. Ascorbic acid is found in only minute amounts in mature peanut seeds, but there are indications (12) that even small amounts may be very important in retarding autoxidation.

Recently Eheart and associates (9) reported significant differences between varieties and between types in coutent of some of the B group vitamins (thiamin, riboflavin, and niacin). While these vitamins affect the food value, we do not know their relation to other quality factors. There are indications that thiamin may play an important role in development of the characteristic flavor of roasted peanuts.

Apparently the tannoid pigments of peanuts also vary considerably among varieties, but too little is known to justify defiuite conclusions as to the nature of these differences or as to their effect on flavor or on the keeping quality of the seeds. Masquelier and associates (21, 30, 31) reported catechol tannin, phlobaphene, a flavonone, and leuco-anthocyanine isolated from testa of peanut seeds, but failed to report the variety studied. Stansbury et al. (29) studied the pigments isolated from testa of a Spanish variety and reported that the pigments differed considerably in chemical and physical properties from those of Masquelier et al. Daugouman et al. (8), in au effort to develop a staudard for the spectrophotometric determination for the preseuce of testa particles iu peanut products, studied absorption curves of extracts from seed coats of 11 varieties (uot named) and found that the extract from each variety had its own characteristic absorption curve. Pickett (23) reported that tannins coustituted about 7 per cent by weight of the testa from colored peauut seeds, and the extract had a bitter flavor. Extracts from the testa of a white-seeded variety were colorless, showed no tannin present, and had a bland flavor.

In 1931 "The Pearl", a white-seeded variety of the sequential branching group, was obtained from the Tom Huston Peanut Company. Officials of the company said they had tried to use it in their edible products but found it to have "an undesirable beany flavor, probably due to low oil and high starch content". Subsequent chemical analysis indicated oil and starch contents similar to those of Spanish varieties, and the off flavor or lack of flavor is still unexplained.

In an attempt to develop a variety with well flavored white seeds. The Pearl was crossed with a large number of varieties from both sequential and alternate branching groups, and numerous strains with white seed coats were selected from the hybrid progenies. A number of these proved to be fairly good yielders, but every one submitted for processing tests failed to develop desirable flavor on roasting.

Experience with a selection, with flesh colored seed coats, from one of these crosses, The Pearl X Virginia Runner, indicates that factors other than pigmentation may be involved in development of good peannt flavor. This selection, 11-9, gave high yields of medium large pods, seeds of very tender texture and high oil content; and it had become popular as an excellent peanut for boiling in the immature state. Submitted to Mr. Beattie (1) for quality evalnation by a taste panel, it was adjudged below standard for salted nnts and for butter.

The same indication is found in our experience with a selection from the hybrid progeny of a cross between Spanish 18-38 and Basse. In the second generation a profusely branched, erect bunch plant with pods and seeds similar to the Spanish type was selected. Continned selection through the eighth generation expanded the number of selections to nine. All nine strains gave unusually high yields of attractive pods and seeds. The seeds were very tender in textnre, blanched easily, and of high oil content. After extensive yield tests 207-3 was selected as best of the lot. Shelled seeds of this selection were submitted, for evaluation, to several manufacturers of peanut butter. Practically all judged the flavor too mild. Finally, Mr. Beattie's taste panel reached the same conclusion and the selection was not released.

Because of the high yielding ability of 207-3, it was used extensively as one parent in several hybrid lines developed by Dr. W. A. Carver of the Florida Experiment Station. From one of these hybrid lines he selected and released "Florispan Runner" (3). This proved to be the best yielding variety grown in the Southeastern Area, but recently it was excluded from marketing under the price support program. Shellers objected to its shelling qualities and processors objected to its lack of flavor.

The Basse variety came originally from the vicinity of Basse, Gambia, a British Protectorate in West Africa. We still have no evaluation of its edible qualities. Perhaps, under our conditions, breeders should obtain processing tests on all varieties that are to be used in a breeding program. Certainly shelling tests and processing tests should be run on all foreign introductions and on all hybrid selections before they are released to the growers.

Two other reports of unusual flavors in peanuts have come to my attention. Dr. Carver (4) has reported that from a cross of a Spanish strain with Rasteiro (a runner peanut of Brazil) a progeny was obtained which produced variegated seeds (red and white) with a very rich, sweet flavor like Brazil-nuts. This line was finally discarded because of low yield and susceptibility to concealed damage. I have also heard of a variety, grown in Peru, with a flavor very similar to pistachio nuts. Since both Brazil-nuts and pistachio uuts have a rather bland flavor, the peanuts compared with them probably lacked the characteristic peanut flavor, as does our 207-3.

Perhaps a careful analytical study of varieties that lack flavor, in comparison with standard varieties might briug to light the substances responsible for flavor aud develop chemical tests more sensitive than taste. Until that time, we shall have to rely upon trial and error methods and use taste panels to evaluate quality in peanuts and peanut products.

After comparison of taste panel evaluations over a period of three years, Beattie (1) reached the conclusion that an acceptable quality of peanut butter and of salted nuts could be produced from any commercial strain of Spanish, Virginia, or Southeastern Runner now grown in this country.

The greater snsceptibility to oxidative rancidity of oil in the seeds, both raw and roasted, and in the expressed oil from varieties of the sequential branchiug group (Spanish and Valencia types) deserves some consideration by processors. However, the work of Willich, Morris, and Freeman (33) indicates that this factor may not be too important in peanut butter. They reported that butter prepared from Spanish peanuts and stored in sealed jars at a temperature of 80°F. for two years had not developed rancidity detectable by taste.

In processing into butter, the seed coats and hearts are removed. Ease and completeness of seed coat removal is related to maturity and smoothness of the seeds and to freedom from pitting. Varieties of the alternate branching group generally show more or less deep pitting of the seed coats. The seeds are likely to be less uniform in maturity than in varieties of the sequential branching group. When specifications require absolute freedom from skin particles, Spanish appears to be the only available type with which this specification can be met. Other than this freedom from skin particles, the quality of peanut butter appears to depend more on method of processing than on variety.

The preference among peanut varieties for peanut candy appears to depend upon the type of candy. When the nuts are to be exposed to air, some consideration should be given to the greater susceptibility to development of oxidative rancidity in Spanish.

As roasted and salted nuts, my personal preference is Spanish type because of the tender, crunchy texture. No type or variety retains the original flavor or texture after long exposure to air after roasting.

For "hot roasted in the shell" peanuts, most baseball fans probably prefer Tennessee Red.

Discussion aud Summary

The classification of peanut varieties on the basis of defiuite botanical characters has focused the attention of chemist, peanut processor, and plant breeder on the characteristics of the two primary divisions, the alternate branching group and the sequential branching group. Beside the difference in seed dormancy, we now know that seeds from the two groups show other striking differences of interest to the processor of peanut products and to the plant breeder.

One of these that certainly deserves serious consideration is differences in chemical composition of the oils. Apparently the percentages of linoleic glycerides are consistently higher in oils from varieties of the sequential branching group than in oils from varieties of the alternate branching group; and associated with high linoleic content is greater susceptibility to oxidative rancidity. In spite of this lower stability of the oil, the high linoleic content may be desirable. Students of human physiology insist upon the necessity for linoleic glycerides in the diet. Some breeders of edible-oil seeds are now striving to increase the linoleic glycerides in the oil.

While the percentages of oil and of protein vary somewhat among varieties within a group, both oil and protein are generally slightly higher in seeds of varieties of the sequential branching group than in those of the alternate branching group (9, 15, 28). The factors controlling deposition of oil and of protein in the seeds appear to be inherited independently of each other (15), which suggests to the plant breeder the possibility for radically changing the nutritive value of the peanut. This might or might not improve edible quality as this term is used in the trade.

The development of chemical tests to indicate presence or absence of substances responsible for texture differences and for development of the characteristic flavor on roasting would greatly simplify work of the peanut breeder.

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RELATION OF SOILS, FERTILIZERS AND SOIL AMENDMENTS TO QUALITY OF RAW PRODUCT FOR SPECIFIC USES

By P. H. Reid, *Research Assistant Professor of Soils, N. C. State College, Raleigh, N. C.*

Quality of peanuts as it relates to the end product for human consumption is an evasive character which is very difficult to measure. The measurement of quality, in this sense, is subject to the senses of taste and appearance, which, of course, vary tremendously among individuals. A product which appeals to the taste of one individual may be less tasteful to another. Therefore, for the purposes of this paper, quality is defined as those properties of peanuts which affect the taste, appearance or stability of the end product. It is realized that such factors as disease, discoloration, and insect damage to the nuts affect the use of raw peanuts for processing in that nuts so affected must be carefully hand picked before processing. These properties are therefore considered as factors which affect quality. The nutritional value of peanuts as influenced by oil, vitamin, and protein contents and by chemical composition are also properties which affect the quality of peanuts but a search of the literature failed to reveal any research on the effect of soils and fertilizers on these properties.

With the exception of the effects of certain trace elements, which will be discussed later, the available data indicate that soils, fertilizers and soil amendments do not markedly affect the quality of peanuts for specific uses except for the roasting trade. Shelling percentage, which is greatly affected by certain soil amendments is a very important property for roasting peanuts.

Nearly all work on the effect of preharvest cultural practices on the quality of peanuts is based on grade as determined by Federal-State Inspection Standards for this crop. This is not necessarily a measure of "quality" in the strictest sense. Quality as related to the end use of peanuts must satisfy the sight and taste of the consumer. Such factors as flavors, keeping qualities and stability of the product, thus become of prime importance as measures of "quality".

Because the grade of the peanuts determines the price which the farmer receives for his harvested product, this is the criterion commonly used to determine the response of peanuts to management practices. It is only when the practice has created some quality particularly objectionable to the manufacturer or consumer, such as off flavor, that particular attention has been paid to the factors of taste, appearance and keeping qualities of the final product.

Fortunately, for many purposes grade is a fair index of the quality of the final product. For nearly all manufacturing purposes it is desirable to have a product with a high percentage of sound mature kernels, a high percentage of "meat", very few unfilled cavities and no foreign matter. Although these properties are important to the manufacturing process, they have little effect on the quality of the final product except for the roasting trade.

The data which are available even on factors affecting the grade of peanuts are very limited. Much of the information on the quality of peanuts is based on observation rather than supported by quantitative data. Therefore, this discussion may only point out the great dearth of data and to postulate areas in which research is needed.

The greater part of the following discussion, therefore, is on factors which affect the grade of peanuts rather than quality in the stricter definition.

Soils

Many observations, but practically no quantitative measurements, of the effect of soil type on quality of peanuts have been made. The ideal peanut soil has been defined as a well-drained, friable, open textured sandy loam or fine sandy loam with sandy clay or sandy clay loam subsoil (Downing 1944), (York and Colwell, 1951). Peanuts produced on clay or clay loam soils, particularly the red soils of the Piedmont, as well as the soils containing much organic matter, frequently have high colored shells. It is very difficult to harvest the peanuts from such soils and large amounts of soil adhere to the pods. Although the discolored pods are objectionable to the roasters, and the foreign material creates problems in shelling peanuts from the heavy soil, there is no information to indicate that the shelled product is not of as high quality as that grown under more favorable conditions. The preference for the sandier soils appears to be more closely associated with the ease of harvesting and handling the peanuts, than with any effect on quality.

Reports have been made, particularly in some of the earlier literature, (Mainwaring 1926) of inadequate fruit on very fertile soil and of detrimental effects of manure and nitrogenous fertilizers on the fill of peanuts. However, Prevot (1953) has shown that this effect is largely due to an inadequate transport of the nitrogenous compounds to the developing fruit as a result of insufficient calcium.

The effect of soils on the grade of peanuts appears from all available literature to be indirect. Almost any soil which contains balanced quantities of the plant nutrients and an adequate but not excessive supply of water will produce high grade peanuts, although soils vary tremendously in the amounts of peanuts which they will produce and the ease with which the nuts can be harvested and processed. There is no doubt, however, that soils affect the grade of peanuts through the supply of mineral elements and water, the growth of soil borne organisms, both beneficial and harmful, and by harboring soil borne insects.

Of particular significance in this effect is the role of colloid type on the availability of calcium. Work by Mehlich and Colwell (1946) and Mehlich and Reed (1946) clearly showed that with soils containing the 1:1 and organic type colloids, the amount of calcium was the most important consideration, while in the 2:1 type colloids the percent calcium saturation was a better criterion. A larger total amount of calcium in the fruiting zone of the peanuts was required for adequate fill when the organic or 2:1 type colloids predominated over the 1:1 type colloids in the soil. Their studies revealed that a lower percentage of the calcium was available for the plants on the soils containing colloids than on the kaolinitic 1:1 type soils. When the 2:1 type colloid predominated the release of calcium appeared to be dependent upon the percent calcium saturation and only when the 2:1 minerals were 100 percent saturated was the fruit grade equal to that produced on the kaolinitic colloids.

Rate and Source of Calcium

Certain soil amendments have a very marked influence on the degree of fill of the nuts. Again, this is an effect on the grade of peanuts rather than an effect on quality as it is determined by consumer preference. Of the various mineral elements only two, calcium and potassium, have been extensively studied. The importance of calcium in the production of peanuts was recognized as early as 1895 when Handy (1895) wrote, "without lime there may be luxuriant vines bearing nothing bnt pops". Since that time numerous papers have been published on the subject. Pettit (1895) observed hairlike projections on the pegs of peannts and postnlated that nutrients might be absorbed through the fruiting organs. However, it remained for Burkhart and Collins (1941) to definitely prove that the pegs do indeed absorb nntrients and that a high calcium level in the immediate area in which the frnit were formed was essential.

Calcium must be present in the zone of fruit formation for the development of well filled pods. Brady *et.al* .(1948) found that calcinm was the only element which consistently increased frnit filling when applied in the fruiting zone and that potassium in the fruiting zone decreased fruit filling in the absence of calcium. Selected data from their experiments are in Table I.

Bledsoe *et.al.* (1949) showed that calcium is not translocated from the roots to the pegs, therefore, it is essential to supply the calcium in the fruiting zone.

TABLE I. Peanut fruit characteristics as affected by supplying various salt solutions to the frniting zone. (Brade et.al. 1948).

Treatment	Percent of Cavities Filled	Treatment	Percent of Cavities Filled
$CaSO_4$	87.8	K_2SO_4	33.1
$CaCl_2$	78.8	KCl	37.4
$MgSO_4$	51.4	$KH_2PO_4+CaSO_4$	15.7
$MgCl_2$	54.6	H_2O	23.9

It is very important to supply the calcium to the soil aronnd the developing frnit soon after the developing pegs penetrate the soil. Brady (1947) found that frnit development decreased rapidly if more than 14 days lapsed after the pegs penetrated the soil before calcium was applied, and that after 36 days calcinm was of no benefit.

Colwell and Brady (1945a) found that calcium increased the nnmber of pods and the average seed weight as well as the fill of fruit for the Virginia Bunch peanuts, but did not affect the Spanish peanuts. Colwell and Brady (1945b) found that even with calcium in the form of gypsum in the fruiting medium, from 30 to 60% of the ovarian cavities remained unfilled. Later work by Reid (1956) has shown that in the absence of calcium in the fruitiug zone that the pegs fail to develop into pods.

Studies of the rate and source of calcium bearing materials conducted by Batten and Hutcheson (1932), Beattie and Beattie (1935), Collins and Morris (1942), Batten (1943) and Reed aud Brady (1948) in the Virginia-Carolina Peannt Belt showed that almost without exception a response in yield and grade of peanuts was obtained when the soil calcium level was low.

Responses to lime and other calcium bearing materials in the Southeast Belt were reported by Davis (1951), hnt Harris *et.al.* (1946), Georgia workers (Anon. 1942) and Killinger *et.al.* (1947) did not obtain a response to calcinm with Spanish type peanuts. However, Rogers (1948) showed that the calcinm level of the soil need not be as high for the prodnction of Spanish peanuts as for the large seeded types grown in Virginia and North Carolina. He found that Spanish type peanuts ordinarily made adequate yields at much lower levels of exchangeable calcium than did the Virginia type peannts.

The diversity of response to calcitic materials between the Spanish and Virginia type peanuts was somewhat clarified by the results of Middleton *et.al.* (1945). Their data (Table 2) show clearly that the response as measured in percent of cavities filled was greatest for the large seeded Virginia bunch and became less as the size decreased to the small seeded white Spanish.

TABLE 2. Increase in percent of cavities filled dne to gypsnm applications. (Middleton, et.al., 1945)

Variety	Increase (%)
Virginia Bunch	35.5
N. C. Runner	24.8
Spanish 2B	19.0
White Spanish	4.6

In 1951, Bailey (1951) reported a very close correlation between the average size of seed of the varieties and the yield response to gypsum. Some of his data are shown in Table 3. In the absence of gypsum the Small Spanish produced yields which compared favorably with the large seeded types, but when gypsum was added, the large seeded type produced much more.

TABLE 3. Response of different varieties of peanuts to gypsnm in Crisp County in 1945. (Bailey, 1951)

Variety	Seed per ounce	Yield without gypsum	Increase from gypsum
Small Spanish	85-90	1334	101
N. C. Runner	60	1264	379
Va. Bunch	36	1475	620
Va. Bunch	30	1041	905

The data on the sources of calcium appear at first inspection to be somewhat conflicting. Although lime is recognized to exert many diverse effects upon soil properties, much emphasis has been placed upou the percent fill in evaluating various liming materials as sources of calcium. Numerous experiments have been conducted to compare liming materials for peanut production. Batteu (1942) found yields and grades of peanuts were comparable whether fertilized with 4000 pounds per acre of ground shell lime, 2000 lbs/a of burnt shell lime or 500 pounds of gypsum. Studies by Batten aud Hutcheson (1932) indicated that ground oyster shells and dolomitic lime were of equal value for peanuts.

Rogers (1948) in Alabama studied the effect of different liming materials upon the yield of Spanish and runner type peanuts grown in rotation with vetch. He found that calutic limestone, dolomitic limestone, oyster shell lime, paper mill waste, blast furnace slag and T.V.A. calcium silicate slag, all gave significant yield responses. Dolomitic lime appeared to be somewhat superior and calciuin silicate slag to be inferior to the other materials.

Colwell, *et.al.*, (1946) and Colwell and Brady (1945) found calcitic limestone to be superior to dolomitic limestone. Gypsum was better than limestone at one location, but inferior at another. Broadcast applications were better than over the row applications.

Reed and Brady (1948) found that under the conditions of their experiments broadcast applications of limestone increased the fill more than gypsum in the first year after application of limestone, but in the second year applications of gypsum were more beneficial. The data of Futrell (1952) as shown in Table 4, are characteristic of results obtained in source of calcium studies.

TABLE 4 Percent increase in peanut yields from calcium amendments (Futrell, 1952).

Amendment	Variety			
	Spanish	Carolina Runner	Va. Bunch	Va. Runner
lime	0.1	14.1	16.8	44.7
gypsum	8.3	20.4	58.3	67.8
gypsum and lime	−8.2	28.8	73.9	71.9

In this particular experiment the response to gypsum was much greater than the response to lime. The lime was applied in a row at the rate of 500 lbs/acre of dolomite. As has been shown in other tests, lime in the row is of less value than when applied over the row. These data also clearly demonstrate the effect of variety on the response to lime. The large seeded varieties respond much more than the small seeded varieties.

From the data just presented, it is obvious that the response which is obtained from various liming materials is dependent upon the soil conditions and the placement of the materials. In the various studies reported, applications of gypsum have proved to be superior to, equal to, or inferior to limestone depending on local conditions.

Effect of Potassium

Most workers are in agreement on the effect of potassium on the grade of peanuts. Brady *et.al.* (1948) found that applications of potassium to either the rooting or fruiting medium lowered the grade of the peanuts when the calcium level of the fruiting medium was low. Brady and Colwell (1945) observed that under certain conditions the application of potassium lowered the true shelling percentage and percentage of ovarian cavities filled. These observations are in agreement with those of Collins and Morris (1942), Colwell *et.al.* (1945), Middleton *et.al.* (1945), Rogers (1948), Reed and Brady (1948), and Harris.

Recent work by Balhuis and Stubs (1955) has shown that when potassium was applied to the fruiting zone, the calcium level must be increased greatly for comparable fruit fill. However, applicatious of potassium actually improved the quality of the fruit, when abundant calcium was supplied to the fruiting zone.

Trace Elements

Research on the effects of the minor elements on the grade of peanuts is largely in the preliminary stages. Harris (1952) found that copper applications to the soils of Florida reduced the number of shrivels. The copper applications also increased the number of nuts which were shed from the plant before harvest. This was probably due to an effect on the rate of "maturity".

Receutly Harris * has found that applications of boron improved the quality of the peanuts (see abstract at end of article).

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One factor which has been more or less ignored in peanut research is the effect of fertilizer elements upon the keeping qualities of the end products. It is well established that very small quantities of certain trace elements have a pronounced pro-oxidant effect when added to the product during processing. The most detrimental of these elements, according to Ziels and Schmidt (1945), appears to be lead, manganese, copper, cobalt, iron and chromium, listed in decreasing pro-oxidant effect. Two to five ppm of these materials, when added in processing procedures, reduce the induction period of organoleptic rancidity tremendously. Several of these elements, particularly manganese, copper and iron occur naturally in peanuts, and the effect of these naturally occurring metals on the keeping qualities of the final product has not been investigated. Dr. Avera * found in analyses of Spanish peanuts that copper varied from 0 to 23 ppm and that iron varied from 8 to 28 ppm. This is just one of the many fields of research which is relatively untouched at the present time.

Discnssion

The foregoing discussion, based on a thorough search of available literature, has clearly demonstrated the lack of data which is available on factors affecting the quality of peanuts. Nearly all research has been directed towards increasing the yield and grade of peannts. In general, there is a correlation between yield and grade although frequently peanuts will be of high grade when yields are poor. Because of the close correlation between grade and the prices received by the producers, very little attempt has been made to study quality as it affects the final consumer. In this case, quality is used to refer to characteristics which are desired by the final consumer. Several factors are probably responsible for this lack of attention.

1. The emphasis on the prodnction of maximum yields per acre has been accentuated by acreage controls to the extent that most soils and fertility work has been directed towards maximum yields from each acre of peanuts.

2. The lack of information on peanuts and the amount of apparently conflicting data have caused peanuts to gain the reputation of being totally unpredictable. Altogether too often the lack of agreement of experimental resnlts has been dismissed as being due to the unpredictability of the peanut crop. It is only in recent years that the research workers throughout the world have studied the crop objectively. As the canses for the apparent discrepancies in the early data become clarified, the fallacy that peanuts are unpredictable will disappear and research will progress much faster.

3. There has been a lack of liaison between the processors of peanuts and research personnel as to exactly what characteristics the processors require to manufacture a product which appeals to the consumer.

4. In general, the influence of soils, fertilizers and soil amendments on the quality of peanuts has not been of adequate economic importance to justify the time, labor and expense of the detailed analyses required for such measurements.

5. There has been insufficient promotion of peanuts as a staple food. Throughout much of the world peauuts are still considered as a novelty crop. When the potential uses of the crop are recognized, peanuts will gain the position they deserve in the agricultural program.

Fortunately, research on peanuts is increasing at a rapid rate and many of the problems which formerly were dismissed as being unsolvable because of the variance naturally encountered in peanut research are disappearing.

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However, it is quite obvious that there is a need to project our thinking beyond the mere effect of treatments on the quantity of nuts produced and consider quality of the final product as reflected in taste, appearance and keeping qualities.

SUMMARY

Search of the available literature on the effect of preharvest cultural practices on the quality of peanuts shows that investigations of this nature are very few, and that grade is the only measurement available on the quality of peanuts. Certain factors which are apparent are enumerated below:

1. Soils affect the grade of peanuts only through their effect in supplying plant nutrients and water to the plants or as they serve as environment for organisms, both beneficial and detrimental, or insect organisms.

2. Calcium applications improve the fill of peanuts when soil calcium is low. The response to calcium is directly correlated with the average seed size of the various varieties. The source of calcium which is most efficient depends upon the soil conditions and upon the method of application.

3. Potassium decreases the fill of peanuts in those cases in which calcium is limiting.

4. Copper has been shown to improve the quality of peanuts.

5. Boron applications in Florida have greatly reduced the incidence of internal damage.

6. Much research in the effects of treatment on quality needs to be done before a product can be manufactured which will have the very best properties possible from the raw material.

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ABSTRACT

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Peanuts grown on Blanton fine sand, under greenhouse conditions, yielded much higher with Boron applications than did the check plots. A large per cent of the nnts grown without Boron had a hollow heart, which ranged from slight off-color to badly rotten. Peanut plants grown without Boron exhibited slight visible deficiency symptoms but were somewhat larger than the plants which received Boron. A complete article will appear in a fall issue of *Soil Science*.

RELATION OF WEATHER, SOIL MOISTURE, AND IRRIGATION TO QUALITY OF RAW PRODUCT FOR SPECIFIC USES.

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This subject is conspicuously lacking in published research, thus most of this discussion is based on unpublished work on Spanish peanut varieties with mention of other known work. The trends so far indicate that supplemental water when properly applied will add to the general qnality of the raw prodnct. In fact, certain quality factors of the Spanish peanuts can be improved in the Southwest when the total rainfall from Jnne through September is less than 10 inches or when there is poor distribution of higher amounts.

To ascertain the relationship between peanuts grown at various soil moisture levels and their quality, it is necessary to measnre certain qnality factors. Some of the criteria often used for quality include percentage of sound mature kernels (SMK), shelling percent, percentage of small shriveled (SSK), loose skinned (LSK), damaged and immature kernels, foreign material, unfilled pods, size of seed as measured by slotted sieves and grams per 100 seeds, seedcoat color, damage, and the suitability of peanuts for specific food uses. Other quality factors more laborious to measnre inclnde thickness of skins and shells, shape of seed, chemical composition of seed and stability of the processed products. Evidence on a few of the above mentioned quality factors will be presented.

A preliminary study of the effect of irrigation ou peanut quality was initiated in Oklahoma after the extremely dry growing season in 1954. Samples of farmer stock peanuts were collected from eight growers with irrigated peannts and eight with non-irrigated peanuts (5). A comparison of means from the irrigated and non-irrigated samples showed the irrigated peanuts to contain 15.1 percent more sound mature kernels, 2.2

percent fewer small shriveled kernels, 13.0 percent less shells, and 18.1 percent more foreign material (Table 1).

A taste panel compared peanut butter[1] made from samples obtained from three irrigated and two non-irrigated fields (6) (Table 2). Seventy percent of the panel rated odor and 80 percent rated the taste of the irrigated samples superior to or eqnal to the standard brand, while approximately 60 percent rated the non-irrigated samples as snperior to or eqnal to the standard brand. After 30 days, a panel compared odor and flavor differences with a standard brand. Sixty-four percent of the panel rated the odor of the irrigated samples superior or equal to the standard, while only 33 percent gave the non-irrigated samples this rating. A greater percentage of the panel detected more off flavor in the non-irrigated than in the irrigated samples; however, the differences in flavor were small.

The peanut butter samples from the irrigated fields were more oily and less crumbly than those from the non-irrigated, bnt there was no appreciable difference in oil content (7).

Results were obtained in 1955 from the irrigated and non-irrigated variety tests near Lookeba, Oklahoma, where the irrigated test received five sprinkler irrigations for a total of 20 inches, in addition to 13.19 inches of rainfall from June through September. Under these more favorable conditions, the size of the peannts in the non-irrigated test were larger but less nniform than those of the irrigated test (Table 3). Deviations between the above tests were 1.3 to 4.6 percent fewer small shriveled kernels and 2.6 to 4.6 percent fewer pops per 100 grams in the irrigated test. The color of the kernels in the non-irrigated test was reddish while that of the irrgiated was flesh colored. The peanut bntter made from a composite sample of each of the irrigated and non-irrigated test did not differ in flavor and odor.

During the extremely hot and dry weather of the 1956 season, peannt samples from the two irrigated variety tests in Oklahoma produced mark-

TABLE 1. A comparison of means for various quality factors of Spanish peanut samples from irrigated and non-irrigated fields. Caddo County, Oklahoma, 1954.

Factor	Irrigated	Non-Irrigated
Sound Mature Kernels (%)	67.6	52.5
Small Shriveled Kernels (%)	4.9	7.1
Shelling (%)	72.6	59.6
Foreign Material (%)	4.9	13.0
Price per ton ($)	229.20	170.20
Oil Content (%)	47.3	47.0
Percent kernels held on slotted screens:		
20/64 inch	11.3	6.4
18/64 inch	24.7	14.2
16/64 inch	47.3	45.1
14/64 inch	16.7	34.3
Percent within 4/64 inch	72.0	79.4

[1] Peanut butter samples were prepared by personnel of the Vegetable Crops Section, Plant Industry Station, Beltsville, Maryland.

TABLE 2. Mean percentage of panel rating initial and exposed peanut butter samples from irrigated (I) and non-irrigated (NI) fields superior to, equal to or inferior to a standard braud, 1955.
Initial

Characteristic	Superior to: I	Superior to: NI	Equal to: I	Equal to: NI	Inferior to: I	Inferior to: NI
Initial						
Odor	37	20	33	40	30	40
Taste	23	5	20	15	57	80
Exposed 30 days						
Odor	24	5	40	28	46	67
Taste	28	25	52	37	20	38

TABLE 3. Summary of various quality factors obtained in irrigated and non-irrigated variety test near Lookeba, Oklahoma, 1956. [1]

Factor	Irrigated		Non-Irrigated	
	Large Spanish	Small Spanish	Large Spanish	Small Spanish
SSK (%)	2.4	6.0	1.1	1.4
No. pops per 100 gms.	2.8	1.3	5.4	5.9
Gms/100 seed	35.7	30.7	42.6	35.6
Yield (lbs peanuts/A.)	3696	3748	2286	2090
Percent held on slotted screens:				
21/64-inch	4.8	0.3	21.0	6.6
19/64-inch	29.1	6.4	47.4	29.8
17/64-inch	48.5	47.1	25.6	46.9
15/64-inch	17.3	46.2	6.0	16.5
Percent within:				
4/64-inch	77.6	93.3	73.0	76.7

[1] Total rainfall at Lookeba for June through September was 13.91 inches.

edly more sound mature kernels, fewer small shriveled kernels and contained less foreign materials than those in the non-irrigated tests (Table 4). There were no appreciable differences in the percentage of loose skinned and damaged kernels, grams per 100 seed and moisture content of the seed among the samples from the irrigated and non-irrigated tests.

Sparrow and Hammons (8) studied the response of a Southeastern runner and two Virginia Bunch strains of peanuts to irrigation at the Georgia Coastal Plain Experiment Station at Tifton, Georgia, in cooperation with the Soil & Water and Horticultural Crop Research Branches of the Agricultural Research Service. Results in 1956 showed the irrigated peanuts produced more sound mature kernels and fewer shells than non-irrigated peanuts. A Virginia Bunch strain in the irrigated test produced 15% more fancy pods and 16% more extra large than those in the non-irrigated test.

Bailey (1) described the following types of dronght damage occurring in Virginia Bunch peannts grown at Tifton, Georgia, under dry land conditions in 1956:

1. Whole pops.
2. Half pops.
3. Seed development arrested at various stages.
4. Discolored seed coats, including some with pale spots.
5. Damaged plnmules and epicotyls, which is directly associated with reduced germination and malformed seedlings.

TABLE 4. Summary of various quality factors obtained in irrigated and non-irrigated variety tests near Lookeba and Atwood, Oklahoma, 1956.[1]

Factor	Irrigated Large Spanish	Irrigated Small Spanish	Non-Irrigated Large Spanish	Non-Irrigated Small Spanish
Sound mature kernels (%)	68.5	72.1	44.0	44.8
Others (%)	4.5	5.8	16.8	22.3
Small shriveled kernels (%)	4.0	5.5	16.0	21.8
Loose skinned kernels (%)	0.0	0.2	0.0	0.1
Damaged kernels (%)	0.5	0.1	0.8	0.4
Foreign material (%)	2.5	2.8	11.8	8.5
Moisture (%)	5.5	5.8	4.8	4.8
Gms./100 seed (Atwood)	38.5	34.0	39.5	34.4
Percent held on slotted screens:				
21/64 inch	9.4	2.0	8.4	0.4
19/64 inch	42.4	22.2	23.4	10.2
17/64 inch	38.4	52.2	28.3	32.2
15/64 inch	11.5	23.6	40.0	57.2

[1] The total rainfall from June through September was 2.79 inches at Lookeba and 7.79 inches at Holdenville. The 12 year average for the same months was 11.98 inches at Lookeba and 15.69 inches at Holdenville.

A more critical irrigated study conducted in cooperation with Prof. James Garton, Department of Agricultural Engineering, indicates that the Spanish peanut can be grown under a wide range of soil moisture conditions with no detrimental effect on any factor except yield (2). Similar results and observations were also made hy other workers. Hughes reported that the relative yield difference between irrigated and non-irrigated peanuts in the West Cross Timbers of Texas during 1953 and 1954 were about the same, yielding 44 to 224 percent higher for the irrigated peanuts (3). Grade differences were small in 1953; however, under the more severe moisture stress in 1954 the irrigated peanuts graded from 67 to 73 while those of the dryland graded 48 to 52. Dr. Bailey has pointed out that the effect of prolonged shortage of soil moisture on the qnality of Spanish peanuts in Georgia is primarily one of yield without much effect on seed qnality. For the large-seeded varieties prolonged shortages of soil moisture can have a detrimental effect on both yield and seed quality (1).

The total amounts of water from all sources from planting to harvest in the irrigation study were 4.05, 9.17, 14.91, and 20.63 inches for the four treatments (Table 5). The lowest qnality as measured by the percentages of sound mature kernels, small shriveled kernels, foreign material, moisture content of seed, grams per 100 seed, value per ton, and the taste and flavor of the peanut butter, occurred on the plots receiving no supplemental water (2). The remaining water treatments had higher but similar amounts of sound mature kernels, similar valnes per ton, and similar increases in yield per inch of water. The three water treatments also contained lower bnt similar amounts of small shriveled kernels, shells, and foreign material.

A panel of twelve members compared various odor and flavor characteristics of peanut butter samples from each irrigation treatment with those of a standard brand (Table 6)[1]. The results showed that the odor and flavor of the peanut butter from the plots receiving no supplemental water were extremely lower than the standard and compared less favorably with

[1] Peanut butter samples were prepared by personnel of the Vegetable Crops Section, Plant Industry Station, Beltsville, Maryland.

TABLE 5. Summary of results obtained from Argentine peanuts grown at four moisture levels near Eakly, Oklahoma, 1956.

Factor	Irrigation Treatment [1] W_0	W_1	W_2	W_3
Amount Irrigation (ins.)	0.00	4.50	10.50	16.50
Total Water (ins.)	4.05	9.17	14.91	20.63
SMK (%)	51.00	65.00	63.00	63.00
Others (%) *	12.00	4.00	5.00	4.00
Shelling (%)	63.00	70.00	68.00	68.00
Foreign Material (%)	23.00	7.00	2.00	2.00
Gms./100 Seed	29.75	32.85	35.02	37.82
Yield increase (lbs./ins.)		106.80	91.20	99.30
Value per ton ($)	162.88	212.25	209.53	206.43
Value increase ($/ins.)		12.39	9.99	10.53
Percent held on slotted screen:				
21/64 inch	6.1	5.7	2.9	3.9
19/64 inch	26.3	24.8	34.5	36.1
17/64 inch	35.2	47.0	42.6	39.9
15/64 inch	32.6	22.5	19.9	20.1

[1] W_0—No supplemental water

W_1—Irrigated to maintain soil moisture above 5%

W_2—Irrigated to maintain soil moisture above 7%

W_3—Irrigated to maintain soil moisture above 11%

* Includes an average of less than ½% each of LSK and demaged kernels.

the irrigated plots. The peanut butter from the plots irrigated to maintain soil moisture above five percent was lower in quality than that of the other water treatments but preferred over the non-irrigated sample. The odor and flavor of peannt butter samples from plots irrigated to maintain soil moisture above 7 and 11 percent were similar to each other and to the standard brand. Smaller, less nniform kernels and pods and more reddish seedcoats were more evident in the two low-water treatments than in the high-water treatments.

There is some evidence to show that the Spanish and Valencia peannts require around 25 inches of moistnre during a growing season for optimum yield (9). It shonld be emphasized that moistnre stress is commonly caused by poor distribution of rainfall and irrigation during growing season and particularly during the flowering and frniting period.

Some peanut growers say that it is difficult to over-irrigate the Spanish peanut, but we visualize that excess water may have a detrimental effect

TABLE 6. Mean percentage of panel rating peanut butter samples, grown under varinns moisture levels, snperior to, equal to, or inferior to a standard brand (S), 1957.

Characteristics	W_0	W_1	W_2	W_3	S
			Superior to Standard		
Odor	9	22	45	50	64
Flavor	0	22	36	45	58
			Equal to Standard		
Odor	20	47	50	39	36
Flavor	5	33	50	44	25
			Inferior to Standard		
Odor	71	30	6	11	0
Flavor	95	44	14	11	16

on quality. For example, with irrigation the incidence of diseases and soil insects and harvest problems may increase causing more damaged kernels, hence lower seed quality. Krober and Collins (4) reported that weather damaged soybeans were more costly to refine and may produce an inedible grade of oil. The irrigated peanut may have thicker shells, thinner seedcoats, smaller kernels and in some cases, fewer sound mature kernels than non-irrigated peanuts with no prolonged soil moisture stress (8).

Evidence to date shows that many quality factors of peanuts can be improved by irrigating during prolonged soil moisture stresses and that inferior quality does not necessarily result when irrigation is practiced any given growing season.

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RELATION OF DISEASES AND DISEASE CONTROL PRACTICES TO QUALITY OF RAW PEANUTS FOR SPECIFIC USES

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Those of us who work ou diseases of peanuts have been primarly concerned with QUANTITY as expressed by yield. Published data on the relation of diseases of peanuts to QUALITY are meager; therefore some of my colleagues have made available their unpublished results. In this paper I shall present considerable data hithertofore unassembled showing that auy diseased condition of the growing peanut plant which adversely affects yield has a real potential for adversely affectiug quality also.

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Although there are many aspects of quality that market grades do not measure—flavor, texture, chemical composition and seed viability—market-grade components do reflect market quality of the raw product. Thus when we plant-disease men include quality in our investigations we usually do so by determining the market grade. The four most important components of grade are shelling percentage, pod and seed size, damage, and foreign material. We shall first take up shelling percentages, pod and seed sizes (and this includes maturity), then damage.

Size

One of the quality factors most sought after by end-use processors is complete and uniform maturity of seed. Unfortunately, one of the ways in which disease adversely affects quality is increasing the proportion of immature kernels. Disease brings this about by impairing vigor of the plant and thus arresting development of some seeds and also by damaging seed which otherwise would fall in the sound mature category. The full extent of the adverse effect of disease on seed size and seed development is not evident from market-grade determinations because many pods with imperfectly formed and immature seed are blown out in the picking operation. We do, however, have some data from observations on material which has gone through the picker.

Miller (4) included some quality data in his 1946 report on leafspot control. Table 1 is adapted from this report.

TABLE 1. Effect of leafspot control on yield and size of Adkins Runner peanuts *

Control program	Yield per acre	Pods in 1 pound	Extra-large kernels	Sound mature kernels
	pounds	number	percent	percent
A. Best control program **	2350	269	38	66.0
B. Check, no control	1900	283	35	60.5

* Adapted from Miller (4)
** These peanuts were dug 6 days after those of "B"

Note the larger pod size, the greater proportion of extra-large kernels and the higher content of sound mature kernels when leafspot was controlled than when there was no control.

Dr. W. E. Cooper of the North Carolina Experiment Station artificially reproduced leaf shed corresponding to three degrees of leafspot on Virginia Bunch peanuts by removing leaves by hand in mid-September from plants dug in early October. Some results of this experiment are given in Table 2.

In the fall of 1956 I made some observations on grade factors in connection with my work on stem rot of peanuts. I recognized two disease incidence classes in Virginia Bunch peanuts. These were: *low* (for plots in which 5% of the plants developed stem rot before harvest and yield was 4050 pounds per acre) and *high* (for plots in which 39% of the plants developed stem rot before harvest and yield was 2400 pounds per acre).

The effect of stem rot on kernel size of a Virginia Bunch variety is shown in Table 3.

TABLE 2. Yield and shelling percentages of Virginia Bunch peanuts with various simulated degrees of leafspot *

Simulated degree of leafspot	Leaves removed by hand	Pods on 8 plants	Dry weight of pods	Shelling percentage
	percent	number	grams	
Low	0	756	745	69
High	50	519	536	69
Very high	100	475	419	63

* Adapted from unpublished data of W. E. Cooper

TABLE 3. Size and maturity of kernels of Virginia Bunch 46-2 peanuts as related to incidence of stem rot in the plants

Disease incidence class	Extra large kernels	Sound mature kernels	
		Hand picked sample	Sample from picker
	percent	percent	percent
Low	53	71	71
High	42	63	66

The difference in extra-large kernels and in sound mature kernels were statistically significant.

Most of our soils are infested with nematodes many of which attack the roots and other underground parts of plants. J. M. Good, nematologist located in the Georgia peanut belt, stated (in correspondence) that "root knot nematodes reduce the size of peanuts". The data in Table 4 are further proof that nematodes influence size of pods and kernels of peanuts. (See figure 1).

Table 4. Yield and pod and kernel sizes of Jumbo Runner peanuts as related to sting nematode control in Virginia *

Year and plot description	Yield per acre	Fancy pods	Extra large kernels
	pounds	percent	percent
1953:			
Plots treated	2850	74	31.5
Check, no control	1880	54	21.6
1956, test 1:			
Plots treated	3300	71	33.0
Check, no control	3100	63	26.4
1956, test 2:			
Plots treated	3500	83	35.9
Check, no control	2900	63	23.9

* Unpublished data of L. I. Miller

Note the sharp increase in percentage of fancy pods and extra-large kernels associated with control of sting nematodes.

Figure 1. Size of pods of Jumbo Runner peanuts as related to sting nematode infestation. Note the numerous sting nematode punctures in the stunted pods of the upper row. Pods in both rows are from the same field and were harvested the same day. (Pods furnished by L. I. Miller).

Table 5 presents similar data from control studies on two root knot nematodes. Note that the data in Table 5 do not show as sharp differences as shown in Table 4 but they do snggest that the root knot nematodes have similar effects to sting nematodes on size of pods and kernels. In fact all the data presented so far indicate that either epidemics of the more serious diseases of peanuts or severe infestations of nematodes can bring about a reduction in size of pods and kernels and a reduction in the proportion of sound mature kernels.

TABLE 5. Yield and pod and kernel sizes of Jumbo Runner peanuts as related to sting nematode control in Virginia. *

1955, test 1:

Nematode, year, and plot description	Yield per acre	Fancy pods	Extra large kernels
	pounds	percent	percent
Northern root knot nematode			
1955:			
Plots treated	2300	59	18.0
Check, no control	1800	45	11.7
1956:			
Plots treated	3350	70	34.4
Check, no control	2950	63	31.2
Peanut root knot nematode			
1955:			
Plots treated	1500	62	15.0
Check, no control	1200	51	17.2
1956:			
Plots treated	3350	46	20.8
Check, no control	2950	32	16.0

* Unpublished data of L. I. Miller

Damage

At present only damage to kernels is considered when peanuts are graded. Since peanut fruits develop in a medium iuhabited by many living organisms some of the orgauisms invade some of the fruits and cause disfigurements, discolorations, and decays of pods and kernels. Thus most damage is of biological origin and results from what might properly be called diseased conditions. Damage is one of the peanut industry's most difficult problems and the extent of damage varies widely from year to year and from area to area.

Even though it does not at present enter the grading picture damage to shells is of considerable importance when peanuts are to be retailed in the shell. There are pod stainings of undetermined cause, which do not seem to be associated with seed deterioration. Root knot nematodes sometimes disfigure pods to a considerable extent. Sting nematodes produce many minute punctures on pods. Soil-inhabiting molds can, and frequently do. become established in these nematode punctures and other wounds and cause pod rot. I suspect that much pod rot develops without initial wounding, but this has not been definitely established. If we open the rotted pods that come through the picker we almost always find damaged kernels. This added to the damage which is not evident as pod rot makes for varying amounts of decayed and partially decayed kernels in the shelled product. These are unsightly, have an undesirable flavor and are unfit for human consumption.

Frequently in farmers' stock peanuts there are seeds with faded or unsightly seed coats. We know that some of these faded seed coats result from pods staying in moist soil for a time after the seed matured, but we suspect that some of them are the result of diseased conditions. For market purposes defects such as faded or unsightly seedcoats are classified as "minor damage". The appearance of such seed is definitely impaired, but their flavor and other quality aspects have not been investigated. It is the opinion of marketing specialists of long experience that where seed coat discolorations of this sort are not associated with mold development little or no flavor deterioration will be involved, but if molds are present the flavor of the seed might be impaired. It is possible for fragments of mold hyphae to be associated with any peanut kernel and escape detection even when the kernel is examined for concealed damage. We would expect such fungus fragments to have some effect upon flavor. Published information on this is sorely lacking.

Since most damage results from a diseased condition I make the prediction that a disease occurring in the soil can result in damage to pods and seeds and control of such a disease should be accompanied by a reduction in amount of damage in the end product. I shall first show data from experiments in which the results have borne out this prediction. I assume that these are not unusnal results.

TABLE 6. Damage in Virginia Bunch 46-2 peanuts as related to incidence of stem rot in the plants.

Disease incidence class	Pods rotted	Pods badly discolored	Pods bright	Damaged kernels
	percent	percent	percent	percent
Low	1.0	13	86	0.4
High	2.2	18	80	2.1

In this case there was 5 times as much damage in high-disease plots as in low-disease plots, and there were more than twice as many rotted pods in the high-disease plots as in the low-disease plots.

Table 7 gives data showing differences in damage in favor of plots treated for nematode control.

TABLE 7. Damage in Jumbo Runner peanuts as related to nematode control in Virginia. *

Year and plot description	Northern root knot nematode	Sting nematode
	percent	percent
1953:		
Treated plots		4.6
Check, no control	. .	15.2
Ratio (treated/check)		1 : 3
1955:		
Treated plots	0.9	1.0
Check, no control	1.6	2.3
Ratio (treated/check)	1 : 2	1 : 2
1956:		
Treated plots	0.2	.
Check, no control	1.1	
Ratio (treated/check)	1 : 2	.

* Unpublished data of L. I. Miller

The differences in percentages of damage were not significant in the other 6 plots in this test. This does not necessarily mean that the other 6 attempts at disease control had no effect on damage. It is more likely to mean that the data were taken in a way that masked the full effect of the nematodes on pod and seed quality. Many of the rotted pods which are harvested are blown out during the picking operation and data on damage are usually taken after curing and picking. This completely ignores many of the rotted pods which remain attached to the dug plant and all of the rotted and otherwise damaged pods that remain in the soil when the crop is dug. In the latter connection in 1956 I scratched pods out of the soil after peanuts were dug and obtained the results given in Table 8.

TABLE 8. Quality of pods left in soil and of kernels from apparently sound pods of Virginia Bunch 46-2 peanut left in soil at digging.

Disease incidence class	Decayed pods left in soil	Apparently sound pods left in soil	Kernels from apparently sound pods: Bright, plump		Damaged but usable		Not usable	
	lbs./acre	lbs./acre	lbs./acre	percent	lbs./acre	percent	lbs./acre	percent
Low	74	164	24	21	75	65	16	14
High	735	475	52	15	232	68	59	17

Obviously there was associated with stem rot a considerable amount of pod rot not detectable in the end product. The large numbers of apparently sound nuts left in the soil at digging always attracts the attention of passersby and at least one machine has been developed for salvaging them. Nevertheless they still are of active interest primarily to children, growers, and plant pathologists. Growers regard these pods as lost yield and plant pathologists feel that eventually effective disease control will drastically reduce this loss. We understand why at present shellers consider these to be substandard pods when we consider the condition of kernels in apparently sound pods scratched out of the soil after the crop was dug. The rotted pods obviously are of no value.

Another factor to be considered is the variation in effectiveness of disease control measures. The tables used so far compared results from a single measure with those from a check. Table 9 includes results of several different control measures but since it is not the purpose of this discussion to recommend specific control measures the measures are listed in Table 9 by number only.

TABLE 9. Stem rot incidence, yield, and damage as related to various control measures.

Variety and control measure	Plants obviously having stem rot	Yield per acre	Damaged kernels
	percent	pounds	percent
VIRGINIA BUNCH 46-2			
1	5	4150	1.3
2	20	3250	0.8
3	10	3700	2.2
Check	39	2300	2.7
SPANISH			
4	7	2250	1.2
5	8	2000	1.8
6	18	1400	1.6
7	18	1500	0.4
Check	28	1250	1.5

It is obvious that all measures resulted in some control of stem rot. Note that control measures 1 and 4, which gave the greatest increase in yield and the greatest decrease in percent of infected plants, did not result in the least damage. We have long recognized that the degree of disease control varies from year to year, from area to area, and from field to field in the same area. It is not surprising, therefore, to find a similar variation in the effect of disease-control practices on damage.

Sometimes a fair proportion of damaged pods remains attached to plants when they are stacked, and, as indicated, many of these are blown out in the picking operation. On the other hand, we sometimes find that peanuts appearing to be almost free of pod damage will have considerable damage in the end product. This damage we might call "post-digging" damage and it would be of interest to know when the infection for such damage occurs. In the case of concealed damage (2, 6) and blue damage (3, 5) the findings indicate that the causal infection occurs before digging but the diseases continue to develop on through curing. Thus these damages are connecting links between my topic and Mr. Teter's discussion of curing scheduled for this afternoon. I shall attempt to set the stage for Mr. Teter, but I shall leave for him the more important topic of the relation between curing procedures and these damages.

As the name indicates concealed damage is an internal breakdown of peanut seeds for which there is no external evidence. It has been reported from French West Africa (1) as well as from this country. It is caused by mold fungi. These molds normally live on bits of plant debris in the soil, but occasionally they invade developing pods. Frequently some of them become established between the cotyledons of halves of the kernel and produce rancidity and internal decay (6). Obviously this causes some concern among end users since there is always the possibility that enough concealed damage will escape detection to taint an end product.

Blue damage resnlts from what chemists call an "indicator reaction". Acids secreted by fungi react with the normal peannt seedcoat pigments and turn them dark blue-black. Usually some of the blue-black color diffuses into the meat of the kernels. Although the result is an unsightly kernel preliminary tests (3) indicated that taste is not affected. Blue damage is a disorder of Spanish peanuts primarily and most of it is caused by *Sclerotium rolfsii,* the same fungus which causes the very common and very important stem rot of peanuts. This means that many peanut fields are badly infested with a fungns capable of cansing blne damage and many peanut plants are overgrown with this fungus when the plants are dug. This fungus can become associated with the porous peannt shell in the soil or in the stack, windrow, or cnring bin and can become sufficiently active thereafter to cause blue damage. If we conld reduce the amount of stem rot fungus infestation in peanut soils to any considerable degree, we might largely eliminate blue damage as a cnring problem.

Conclusion

To conclude, even though we feel that we have made a fair start on determining the relation of diseases and disease control practices to qnality of peanuts we recognize that much still remains to be done. Those of ns who do research on peannt diseases now have an obligation to design and carry out our experiments so as to obtain more nearly complete data on quality in addition to the data presently obtained.

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The following persons have contributed unpublished data from their researches:

Cooper, William E. Assistant Professor, N. C. Agric. Expt. Station. Research studies on: the etiology, epiphytology, and control (including varietal resistance, cultural and chemical control measures) of peanut seedling diseases, peanut leafspot diseases, nematode induced diseases of peanuts and Southern Stem Rot.

Garren, Kenneth H. Plant Pathologist, Horticultural Crops Research Branch, U. S. Department of Agriculture and Tidewater Research Station of Virginia Experiment Station. Research on diseases of peanuts with emphasis on control of (Southern) Stem Rot caused by *Sclerotium tolfsii.*

Miller, Lawrence I. Plant Pathologist, Tidewater Research Station of Virginia Experiment Station. Research stndies on: nematode, fungus, bacterial, and virns diseases of the peanut.

The following persons not previously listed are authors of cited publications, and some have made additional contributions to this talk:

Bouriquet, G. Director, Laboratory for Services to Colonial Agricultnre, Paris, France.

Futural, J. Gordon. Agricultural Engineer, Georgia Experiment Station. Peannt harvesting and cnring.

Higgins, B. B. Botanist Emeritns and Vice Director Emeritus, Georgia Experiment Station. Peanut breeding, peanut diseases.

Jaubert, P. Phytopathologist and Agronomist, Experiment Station, Bambey, Senegal, French West Africa.

Norton, Don C. Asst. Professor, Plant Pathology, Texas A & M College. Formerly did research on storage diseases of peanuts, blue damage.

Wilson, Coyt T. Associate Director, Alabama Experiment Station. Peanut diseases and harvesting and curing of peanuts.

The following persons have contributed to the preparation of this talk in a form other than unpublished data:

Boyle, Lytton W. Associate Plant Pathologist, Georgia Experiment Station. Research on cultural practices with respect to peanut yields and control of (Southern) Stem Rot and root rot.

Carver, W. A. Agronomist, Florida Experiment Station. Peanut breeding for (1) superior market varieties having seed qualities of Spanish peanuts; (2) superior varieties for livestock feed and with good qualities for hogging-off. Method: Hybridizing varieties and extracted lines, and pedigreed selection for seed quality.

Good, J. M. Nematologist, Horticnltural Crops Research Branch, U. S. Department of Agriculture and Georgia Coastal Plain Experiment Station. Research on: (1) Relationship of meadow nematodes to peanuts, including pathology, effects soil management practices on populations, and influence of meadow nematodes on yield and quality of peanuts. (2) Methods of soil fumigation for meadow nematode control. (3) Snrvey of occurrence and distribution of meadow, root-knot, and other plant parasitic nematodes on peanuts.

RELATION OF INSECTS AND INSECTICIDES TO QUALITY OF RAW PRODUCT FOR SPECIFIC USES

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Some of the insect pests of peannts have been known as snch in the United States since the tnrn of the century. Certain others have been recognized only recently. A review of the more important species and their habits will aid in nnderstanding the ways in which their activities and the insecticides used in their control may affect the quality of peannts.

The Nature of Insect Damage

One of the earliest (18) and best known of the peanut insects is the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber. The rootworm is an insect of the soil, hatching from eggs deposited beneath the plants by the spotted cucumber beetle. Although the beetle itself does some damage through feeding on the foliage, it is seldom sufficiently abundant to warrant concern. The rootworms, on the other hand, are quite destructive, tunneling into developing pods, pegs which have penetrated the ground, or the roots wheu the plants are young. It is the tunneling into the pods that may affect the quality of the peanuts. In many cases the damaged nuts are left in the ground or blown out of the picker, but others, destined for market, contain poorly developed or damaged kernels.

Several species of wireworms (10, 11) including the tobacco wireworm, *Conoderus vespertinus* (F.) and the corn wireworm, *Melanotus communis* (Gyll.) may affect peanuts in a similar mauner as is also true of larvae of the elongate flea beetle, *Systena elongata* (F.) (23, 32) and the banded cucumber beetle, *Diabrotica balteata* Lec. (3).

Generally speaking, damage by rootworms, wireworms and flea beetle larvae occurs in heavier soils, poorly drained fields, or during moderately wet summers. However in light, well drained soils or during dry summers the lesser cornstalk borer *Elasmopalpus lignosellus* (Zell.) may have an appreciable effect on both yield and quality of peanuts (24). The borer hatches from eggs deposited on the lower portions of the plant by a moth. It may bore into the stem of the plant but its most important effect on peanuts is the result of its damage to the pods which it reaches by crawling down the gynophore or peg into the soil. Nuts damaged by this insect will have damaged and sometimes discolored kernels and usually contain webbing and frass, for as it moves, this insect spins silken threads in which its excrement becomes entangled.

Various kinds of grubworms (10, 11, 25) and cutworms (10, 11) also feed on developing pods. In most cases damaged nuts do not reach the market for these insects destroy a large portion of the pod attacked. If marketed, the pod will have a rather large hole or holes and kernels will be missing, loose, broken or possibly discolored. Some "honeycombing" of the outside of the pod caused by grub feeding may restrict the use of such nuts.

The effects of insects feeding on the above-ground portions of the plant are much more difficult to determine.

The tobacco thrips, *Frankliniella fusca* (Hinds) has been recognized as a peanut pest for a long time (33). Although its most obvious damage results in stunting and malformation of plants early in the season, feeding often continues to sap plant vigor well into the summer. This may result in smaller, more poorly filled peanuts.

Damage by the potato leafhopper (26) *Empoasca fabae* (Harris) is brought about through sucking plant juices. Leaves become yellow and the leaf-tips may turn brown. Loss of sap to the leafhoppers, and interference with the vital functioning of the leaves decrease the plant's ability to set and develop fruit. Smaller kernels might be expected, but no data is available which demonstrates this.

The corn earworm, *Heliothis zea* (Boddie) feeds on the terminal leaves for a short time after hatching and then turns its attention to the tips of the pegs (14). Though this type of damage has a pronounced effect on yield, no evidence of effects on quality has been reported.

Two species of bugs, the southern green stinkbug, *Nezara viridula* (L.) and *Pangaeus bilineatus* (Say) have been recorded as attacking peanut pods in the stacks (1). Kernels that were spotted and of poor quality were believed to be the result of attacks by these bugs.

Other insects commonly attacking peanuts, but of which the effect on quality is unknown are the grape Colaspis, *Colaspis flavida* (Say), (10) the red-necked peanut worm, *Stegasta bosqueella* (Chamb.), the southern army-worm, *Prodenia eridania* (Cram.), the green cloverworm, *Plathypena scabra* (F.), the velvetbean caterpillar, *Anticarsia gemmatilis* Hbn., the fall armyworm, *Laphygma frugiperda* (S. & A.), and the white-fringed beetles, *Graphognathus* spp. (4).

Insects may continue to have an influence on quality after the peanuts have left the field. In storage the most important insect pest is considered to be the Indian meal moth, *Plodia interpunctella* (Hbn.) (29).

Damage by larvae of this insect is similar in nature to that caused by the lesser cornstalk borer in the field. Kernels show tunneling and webbing and frass are found in association with this injury. Other moth larvae which may cause the same sort of damage are those of the Angoumois grain moth, *Sitotroga cerealella* (Oliv.) and species of *Ephestia*.

Several kinds of beetles are also involved in affecting the quality of stored peanuts. These include the red flour beetle, *Tribolium castaneum* (Hbst.), the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) which has been reported as the most abundant insect associated with shelled peanuts (5), the confused flour beetle, *Tribolium confusum* Duv., the flat grain beetle, *Laemophloeus pusillus* (Schonh.), the foreign grain beetle, *Ahasverus advena* (Waltl.), and a corn sap beetle, *Carpophilus dimidiatus* (F.) (2). The general effect of feeding by these insects is the presence of minute tunnels in the kernels and of mealy or powdery debris in the pods and kernels. The cadelle, *Tenebriodes mauritanicus* (L.) is a larger insect which would be unlikely to cause the minute tunnels just mentioned.

Effects of Insects on Quality

The apparent influence of the insect factor on shelling-out percentages is not great and appears to be associated with insect populations rather than with particular control measures. In North Carolina (11) bunch peanuts from plots in which soil insects were controlled shelled out 2.3% higher than those from untreated plots, less than 1% higher when thrips were controlled (13) than when they were not controlled and 1.6% higher when soil insects, thrips and leafhoppers were controlled (15) than when no insect control measures were used. Runner peanuts from plots in Virginia in which rootworms were controlled did not shell out any better than peanuts from untreated plots (9).

Though kernel size, sometimes associated with the maturity of nuts at harvest time is believed to be beneficially influenced by insect control, the data (9) available do not show this to be the case.

The influence of the control of soil insects, particularly the southern corn rootworm on general kernel condition is illustrated by some data from Virginia (8). In a maturity study in which four insecticides were used effectively against the rootworm the percentage of the kernels that were healthy and from sound whole pods was consistently higher in treated than in untreated plots. In peanuts dug on September 30th there were from 29.5 to 33.1% more sound kernels, on October 7 from 19.0 to 22.8% more sound kernels and on October 17 from 11.9 to 24.4% more sound kernels. Generally speaking, then, one of the principal effects of insects on the quality of the raw product is on the percentage of sound mature kernels.

Another important effect is the very obvious one of direct cause of damaged kernels. In five untreated plots in Virginia (27) an average of 86% of the pods were injured aud 78% penetrated by rootworms. The percentage of damaged keruels would be expected to be lower but appreciable, nevertheless.

It has been estimated that farmers in one county made an aggregate net profit of $40,000 on increased quality alone as the result of insect control. Treated peanuts on the heavier soils were worth 2 to 3 ceuts a pound more, those on the lighter soils, ½ to 1 cent a pound more than similarly grown untreated peanuts (16). A possible increase in value of as much as 3 cents a pound is also reported by others (28).

The Effects of Insecticides on Quality

The use of insecticides, while often enhancing the quality of peanuts through the control of insects may also have a detrimental effect on peanut quality. The possibilities of imparting a flavor which may make the peanuts unacceptable or unpalatable and of leaving harmful or illegal chemical residues have made necessary the careful selection of the insecticides that may be nsed and the manner in which they may be applied.

The use of DDT at rates of application used on foliage has not been associated with unpleasant flavors (32). There has been no evidence presented of the presence of harmfnl residues on treated peannts.

Benzene hexachloride or BHC which was a promising material for use against rootworms and thrips was suspected in 1947 and 1948 of imparting an off-flavor to peanut butter and candies. Roasted, unroasted, roasted and salted peanuts, and peanut butter made from nuts in plots treated with the equivalent of 1 pound of gamma BHC per acre were scored low in taste tests for both absence of off-flavor and general acceptability (20, 27, 32). Off-flavors were detected in peanut butter even when lindane (pnrified gamma BHC) was applied at ¾ pound per acre. As a result, BHC was not subsequently recommended for use on peanuts.

This insecticide was also commonly used on cotton and the question arose concerning the effects of residues remaining in the soil on peanuts grown on the same land at a later date.

When samples of peanuts from fields in the four principal cotton-producing areas of the country where peanuts followed cotton treated with BHC were processed into peanut butter and subjected to taste tests, the results were inconclusive (30). Subsequent palatability tests with other samples (30, 31) indicated that residues from the application of 3.8 ponnds of gamma BHC per acre to cotton could impart a detectable off-flavor to peanut butter made from peanuts grown in the same field the following year.

In other work (22), flavor tests indicated that as little as 1.5 pounds of gamma BHC per acre applied to cotton or 0.5 pound applied the year before (7) might produce a detectable, though not significant flavor in peanut butter from a subseqnent peanut crop.

Benzene hexachloride residues on shelled peanuts have been found to exceed 7 ppm (27) following the application of practical amounts to the soil.

Taste tests revealed that oil-cooked peanuts from plots treated with chlordane spray at the rate of 2 pounds per acre had a significant off-flavor (32). Otherwise products from such plots have been rated down (6, 7, 21, 32) but not significantly.

The use of toxaphene on peanuts at rates up to 120 pounds per acre generally has not resulted in siguificant off-flavor (6, 17, 20, 21). In a few instances peanut butter has been said to have some chalkiness or medicinal flavor attributed to this compound.

Aldrin applied to the soil or to the foliage of peanuts has generally not resulted in off-flavor in the crop produced (17, 20, 21, 32) when used at rates up to 4 pounds per acre. Peanut butter representing plots treated with aldrin in fertilizer was rated low in quality in one test (21) and there was some indication of aldrin's presence in peanut oil in another (20).

Iu only one case (32) has there been evidence of off-flavor in oil-cooked peanuts from soil treated with heptachlor mixed with fertilizer. Otherwise heptachlor at rates up to 4 pounds per acre has not been found to adversely affect peanut flavor (17, 21).

Dieldrin applied to the soil or to peanut foliage has not produced detectable off-flavor in peanut products (17, 20, 21, 32). As with toxaphene, in a few cases some chalkiness was noted in peanut butter samples taken in soil treated with dieldrin. Owing in part to dieldrin's appareut persistence in soil clinging to hulls and in the hulls themselves, the use of this material in the soil at rates between 1.3 and 1.5 pounds per acre may leave residues on peanut kernels exceeding the legal tolerance of 0.1 ppm (12).

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FACTORS AFFECTING QUALITY AS INFLUENCED BY HARVESTING

By H. F. MILLER, JR., *Agricultural Engineer, Head, Farm Machinery Section, Agricultural Engineering Research Branch, Agricultural Research Service, USDA, Beltsville, Md.*

The following questions were asked of personnel in several states who are familiar with peanut production and particularly peanut harvesting machinery and methods.

1. What is the peanut harvesting situation in your state at the present time regarding the number of combines in use?
2. What are the real problems preventing faster acceptance of combine harvesting?
3. What are the factors affecting quality as influenced by harvesting as you see them for (1) Stack and picker harvesting and (2) combine harvesting?

Replies to questions 1 and 2 from each state were as follows:

Texas: J. W. Sorenson, Jr. and B. C. Langley. The commercial peanut crop in Texas consists entirely of the Spanish variety. Two rows are dug using either 10" cultivator sweeps or two long-bladed half-sweeps bolted to tractor cultivator frames. In preparation for combining, four to six rows are windrowed together with a side delivery rake or shaker-windrower which may also be pulled behind the tractor when the crop is dug. Drying in the windrow covers a period of 3 to 10 days, but peanuts may be picked after a shorter drying period if the crop is artificially dried after picking. From 10 to 20 acres may be combined in one day depending on vine growth and moisture of the vines. Damp vines slow down the picking rate and forward speed of the combine.

It is estimated that 95 percent of the peanuts in Texas are harvested with a combine indicating that this method has been well accepted.

Oklahoma: J. G. Porterfield. The peanut harvesting situation in Oklahoma is similar to that described in Texas with the exception that approximately 80 percent of the peanuts are combine harvested.

Alabama: C. M. Stokes. Peanut combines have started to come into general use in Alabama. Last year's sale of combines exceeded any previous year. Approximately 100 peanut combines were used in Alabama in 1956.

Weather conditions and peanut buyer discrimination plus undesirable result obtained by some farmers with experimental combines after World War II had detrimental effects on the acceptance of the present day combine. Other related problems include the failure to get the farmers to use the proper procedure in preparing the peanuts for the use of peanut combines and proper education of the farmers for the production of peanuts for combining.

Poor results were obtained from our early work with peanut combines. People were adversely influenced by these early results but the new combines now have eliminated many of the problems.

Georgia: J. L. Shepherd. Both Spanish and runner varieties are in production in Georgia. Two-row diggers are common in the area and these are followed by shaker-windrowers which precede combining. The side delivery rake has proved less desirable than special type shakers.

It is estimated that 50-60 percent of the 1956 peanut acreage was combined from the windrow. There are approximately 1,000 combines in use.

Florida: J. M. Myers. Approximately 40% of crop is combined.

North Carolina. W. T. Mills. Bunch varieties predominate. Digging is accomplished with 2-row diggers and shaking is accomplished with shaker-windrowers.

Movement to combine harvesting is in its early stage. In 1954 there was only one combine used, 3 were in use in 1955, and only 10 to 15 were in nse in 1956. Based on early predictions combining is expected to more than double or triple in use in 1957.

It is felt that several problems need to be solved before windrow harvesting will be accepted by the majority of North Carolina farmers, namely:

(a) Initial high cost of combine and windrow-shaker.

(b) Lack of a satisfactory windrower to accomplish a desired windrow that will prevent peanuts from touching the ground or exposure to direct sunlight. We are not certain how practicable it is to obtain the ideal windrow.

(c) Lack of proper education to familiarize the farmer with the saviugs he cau accomplish by using this method.

(d) The existence of certain dangers in using the windrow method of harvesting.

Virginia: G. B. Duke. Production in Virginia is of the bunch and runner varieties. Harvesting consists of digging with a one- or two-row digger, hand shaking and stacking on poles and picking with a stationery picker.

No record is available of any combine having been sold in Virginia prior to January 1, 1957. Three farmers with drying facilities have indicated that they will use peanut combines next season. Recommendations are now being made for combine harvesting provided drying facilities are available.

Based on experimental methods of windrow harvesting, it is recommended that the peanuts be first dug with a digger-shaker-windrower unit that exposes some of the peanuts to the sunlight. They should be reshaken again reasonably soon after digging, 24 to 48 hours, and left in the windrow at least 4 to 8 days before combining. Shaker-windrowers are preferred over the side delivery rake. Artificial curing and drying after combining is currently considered a necessity for Virginia conditions. Moistures after 6 days in the windrow range from 20 to 30 percent.

Problems preventing faster acceptance of combining are:

(a) Lack of available information relating to methods of digging, windrowing, combining, curing, and drying.

(b) Hand labor has been adequate for past harvesting operations but farmers are beginning to report scarcity of labor.

(c) Many farmers have small acreage allotments.

(d) Peanut combines need further development.

(e) Drying facilities are not available and have not been provided.

(f) Initial large investment for combines, shakers, handling equipment, and drying facility.

Factors Affecting Quality as Influenced by Harvesting

In answer to question No. 3 relative to factors affecting quality as influenced by harvesting most all states listed the same factors. The two most important factors recognized are weather and machine damage.

Weather. During the peanut harvesting season weather is an uncontrollable factor that may influence the trend toward obtaining either good or bad quality peanuts. Wet weather may delay digging, picking from stack poles, or combining from the windrow. Under high moisture conditions delayed picking or combining may result in mold growth, discoloration and even rotting of some of the peanuts. On the other hand, fair weather if not extremely hot at harvest time aids in the curing, drying, picking and combining operations.

Certain quality factors are associated with equipment used for digging, windrowing, picking or combining. Some of these factors are of little consequence but are listed for consideration since they may become of major importance under poor management.

Digging and windrowing. Peanuts may be damaged during digging by cutting or crushing if the digger blades are operated too shallow. Tractor wheels may crush or damage the pods in the soil. Tractor and equipment wheels may damage pods which are run over in the mechanical shaking and windrowing operation. While peanuts are in the windrow waiting to be stacked or combined, other potential sources of damage are birds and rodents. Peanuts stacked and exposed for long periods, 4 to 6 weeks, or more, are likewise exposed to all of the above mentioned deteriorating elements. Other factors are correct timing of digging with maturity, and failure to produce a light fluffy uniform and dirt-free windrow.

Picking with stationary pickers or with pick-up combines. The major factors affecting quality from the standpoint of picking or combining are the type of picker used and the adjustments of the picking, separating, and cleaning units. Improper adjustments of these mechanisms may resnlt in failnre to accomplish separation of the peanuts from the vines, soil, trash, pops, gravel and other foreign material. Fnrthermore, improper adjustments may result in an excessive number of loose shelled kernels and damaged hulls which lowers the quality under present grading standards and increases possibility of insect damage during storage.

Other closely related factors that have effects on quality dnring picking or combining are:

(1) Overloading the picker mechanism by excess feeding or speed of the combine.

(2) Undne delays in picking windrowed peannts causing overexposure to rain (wet peannts) or sunshine (overdried nuts below 8 or 9 percent).

(3) Damage caused by conveying and handling equipment on the pickers and combines.

(4) Possible damage to the radicle of the embryo when nsed for seed.

State reports generally indicate that better qnality peanuts are obtained from the windrow method of harvesting than from the stack pole method of harvesting. Comparisons made at the Stephenville, Texas, Station show that the combine does an excellent job of picking and also obtains high commercial grades. Several Georgia buyers and processors last year preferred windrowed peanuts over stack pole peannts and stated that the former method gave better quality and fewer damaged and rotten kernels. North Carolina has not fonnd any indication of increased internal damage due to harvesting at a high moistnre content from the windrow as compared to harvesting from the stack pole.

Unpublished information from North Carolina indicates that kernels with broken seed coats inside the hulls may be an important qnality factor as influenced by different types of picking principles. At the present time very little attention is given to mechanical damage when peanuts are graded with the exception of loose shelled kernels. This information indicates that work needs to be done toward elimination of some of the rough treatment given to peannts by present day peanut pickers.

Other unpublished material, also from North Carolina, reports work on a combine that digs, picks and cleans peanuts in one operation through the field. Developments are advanced to the point where fine adjustments are being made to the cleaning and elevating system. The picking principle is different from that of the carding or cylinder type pickers. The tops of the peanut vines do not come in contact with the picking mechanism and therefore, emerge from the rear of the combine in excellent condition. The main mechanical problems at the present time are limited capacity and trashy samples.

Unpublished data from Virginia and U.S.D.A. indicate that mechanical damage to seed peanuts may show up during germination in the form of curled hypocotyls or no primary roots. This type of damage is being further investigated.

In Virginia, experimental data indicate that combined peanuts, if properly cured under favorable conditions, have quality equally as good and in some instances better than stack pole peanuts. Table 1 compares combine and picking efficiencies of four machines operated in Virginia in 1956.

Results of data in the table indicate that the percent of sound mature kernels, loose shelled kernels and foreign matrial are approximately the same from both stackpole and comhine methods. The recorded data are from a stationary picker and from two combines having separate types of picking principles.

TABLE 1. Results of Recent Peanut Picker and Combine Tests, Holland, Va. 1956

	Moisture	SMK*	LSK**	Foreign Material	Loss. SMK
Combine (Experimental Commercial Model Carding Type)					
1. From windrow	34%	77.5%	3.0 %	4.0%	3.5%
2. From stackpole	8%	71.0%	7.2 %	3.5%	5.0%
Combine (Commercial Cylinder Type)					
1. From windrow	34%	77.5%	6.36%	5.5%	5.7%
2. From stackpole					
Combine (Commercial Carding Type)					
1. From windrow					
2. From stackpole	8%	72.0%	3.2 %	1.2%	5.8%
Stationary Picker	8%	73.0%	1.66%	1.5%	5.9%

* SMK—Sound mature kernels.
** LSK—Loose shelled kernels.

Most important problems and direction future research should take:

A. Relative to digging:
   1. Determination of the most desirable type windrow for a given area.
   2. Determination of the type of shaker-windrower equipment needed and best adapted to produce the desired windrow.

B. Relative to combining:
   1. Determination of the biological damage (particularly concealed damage), percent loss, shelling damage, and foreign material obtained from different principles for each element of the combine when operating under various variables such as picking speeds, moisture conditions, different types and sizes of windrows and varieties.
   2. Further exploratiou of the possibility of once-over harvesting direct from the ground and determination and machine requirements for this method of harvesting.
   3. Development in cooperation with other subject matter groups, both in research and in the industry, standards of quality measurements to be used in the future for evaluating peanut harvesting research.

Nature of Research on Peanuts Including Publications

Texas:

Langley, B. C. and Sorenson, J. W.—Respectively, Superintendent, West Cross Timbers Experiment Station, Stephenville, Texas, and Professor, Department of Agricultural Engineering, Texas Agricultural Experiment Station, College Station, Texas.

Conducts research studies on mechanical harvesting and drying of the threshed nuts.

Publications:

"A Handbook of Peanut Growing in the Southwest", combined publication listed as Bulletin 727, Texas Agricultural Experiment Station, and Bulletin B-361, Oklahoma Agricultural Experiment Station, 1950.

"Harvesting and Drying Peanuts in Texas", Progress Report 1124. Texas Agricultural Experiment Station, March, 1948.

"Mechanization of Peanut Production in Texas", by J. W. Sorenson, Jr. Agricultural Engineering Vol. 33, No. 9, September 1952.

"Labor Savings Related to Mechanization of Peanut Production in the West Cross Timbers Area, 1950", by M. N. Williamson, A. C. Magee and Ralph Rogers. Progress Report 1410, Texas Agricultural Experiment Station, October 1951.

Alabama:

Stokes, C. M.—Associate Agricultural Engineer, Department of Agricultural Engineering, Alabama Polytechnic Institute, Auburn, Alabama.

Publications:

"Mechanization of Peanut Harvesting in Alabama", by C. M. Stokes and I. F. Reed. Agricultural Engineering Vol. 4, April 1950.

"Factors Affecting Germination of Runner Peanuts", by J. H. Blackstone, H. S. Ward, J. L. Butt, I. F. Reed, and W. F. McCreery. Alabama Experiment Station Bulletin 289, 1954.

"Developments in Peanut Harvesting Equipment", by I. F. Reed and O. A. Brown. Agricultural Engineering Vol. 25, No. 4, pp. 125-126, 128, April 1944.

Georgia:

Shepherd, James L.—Head, Agricultural Engineering Department, Georgia Coastal Plain Experiment Station, Tifton, Georgia.

Conducts research studies on peanut mechanization, including land preparation, planting, cultivation, and harvesting. Involves development of methods, facilities and techniques in all phases which are complementary to mechanized harvesting of highest feasible quality and quantity of peanuts.

Publications:
G.C.P.E.S. Annual Report, 1949-1950, Bulletin No. 49.

"Peanut Mechanization", by J. L. Shepherd. Mimeograph Leaflet, 1955.

"The Georgia-USDA Peanut Harvester", by Charles E. Rice and James H. Ford. Agricultural Engineering Vol. 35, No. 3, pp. 168-170, March 1954.

North Carolina:

William T. Mills—Research Instructor, N. C. Agricultural Experiment Station, Department of Agricultural Engineering, N. C. State College, Raleigh, North Carolina.

Conducts research stndies on planter damage and spacing at varions speeds, windrowing and windrow harvesting, once-over harvesting with combine using new picking principle, and comparing harvesting methods.

Publications:

North Carolina Peanut Production Guide (Revision 1956), Progress Report on Peanut Harvesting, Circnlar No. 10, Angust 1955.

"Mechanization of Peannt Harvesting and Artificial Drying of Peanuts and Peannt Hay", by N. C. Teter and G. W. Giles. Progress Report, Angust 1949.

Virginia:

Duke, George B.—Agricultural Engineer, Farm Machinery Section, AERB, ARS, USDA, Tidewater Research Station, Holland, Virginia.

Conducts research stndies on field operating equipment requirements for the production and harvesting of the Virginia type peannt with reference to: application of nematocides, application of herbicides, planting, cultivating, digging, and harvesting peanuts planted in close rows, seedbed preparation, planting, and cnltivation to control stem rot in peanuts, and digging, windrowing, and combining of peannts from the windrow.

Other References

"Peanut Harvesting and Drying Research", Virginia Agricultural Experiment Station Bulletin No. 439, June 1950.

"Mechanical Drying and Harvesting of Peannts", by J. M. Myers and Frazier Rogers, University of Florida Bulletin 507, November 1952.

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PHYSICAL AND PATHOLOGICAL FACTORS AFFECTING QUALITY OF PEANUTS AS INFLUENCED BY CURING

NORMAN C. TETER, *Agricultural Engineer, Agricultural Engineering Research Branch, Agricultural Research Service, U. S. Department of Agriculture*

Qnality is defined as the combination of attributes which determine the uuit value of peannts for use as a food, an oil, or a seed. Some of the specific attributes considered in the use as a food are: flavor, biological or mechanical damage, shelling characteristics, chemical constituents, rancidity (fat acidity, peroxide valne, iodine number), ease of blanching, size, color, and texture. The valne for oil has been jndged on fat content, and oil characteristics such as refractive iudex, viscosity, specific gravity, and light transmission (17). Farmers who plant the seed are interested in germination, vigor of seedling, and genetic characteristics. The problem that now exists is whether these attributes are the proper ones, which are the most important, and how they can be quantitatively given a measure of their proper importance. This is a difficult problem and very probably one which will never be fully solved, but withont the solution, "quality" remains an ambiguous term with different meanings to different people.

Curing is a process of physiological change from the freshly dug state to a condition suitable for storage or shipment. The peanut reaches maturity when, although vitally attached to a living parent plant, it reaches an approximate maximum size and ceases to increase in dry matter content. Theoretically, we should dig the peanut at that time, but practically it is impossible to dig all of the peanuts at maturity. Even though a peanut is mature, it is not necessarily ripe. Ripening is a physiological change of non-growing peanuts and requires the presence of water. The peanut is considered ripe when it exhibits sound physical structure and acceptable flavor even though it may still contain too much water for safe storage.

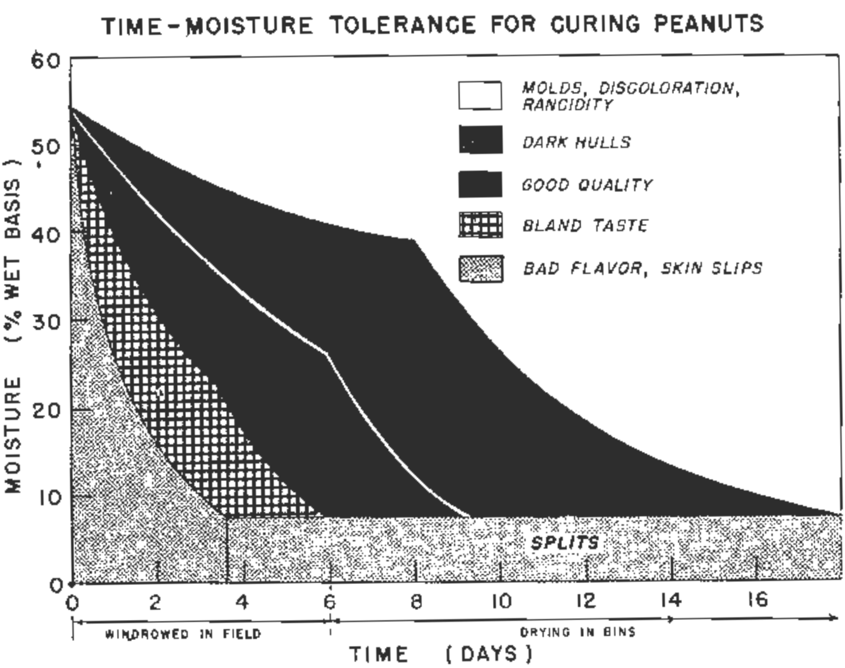
Several branches of scientific discipline in state and governmental research agencies are now working on quality problems inherent to peanut curing. At the Alabama Agricultural Experiment Station Drs. H. S. Ward, Jr., a physiologist, U. L. Diener, microbiologist, and E. T. Browne, Jr., a histologist, are working on curing with particular emphasis on how curing affects the subsequent behavior of peanuts in storage. They are also working on relationship of curing to flavor and chemical properties. F. A. Kummer, J. L. Butt, C. M. Stokes, and I. F. Reed formerly did considerable work on the engineering aspects of peanut drying and shelling, but do not presently have an active project. The Georgia Experiment Station has an active project on the chemical changes occurring in peanut curing which will be reported by Mr. K. T. Holley. James L. Shepherd at Tifton, Georgia is working on methods of eliminating loss in quality during the peanut cure and developing efficient and economical curing methods for the farm. At the North Carolina Experiment Station, James W. Dickens is investigating the effects of various curing techniques on flavor and conducting basic engineering investigations while R. O. Simmons is working on chemical analyses of peanuts cured by different methods. At the Texas Station, J. W. Sorenson and B. C. Langley have made considerable studies of the storage and drying of peanuts and Dr. Don Norton is making pathological studies of the curing process. In the U. S. Department of Agriculture, Dr. J. W. Diekert and Miss Nelle B. Morris are working at the Southern Regional Laboratory on the isolation and characterization of the bitter principle from peanut products. Drs. Boswell, Bailey, and K. H. Garren of the Horticultural Crops Research Branch, ARS, study shelling damage, and biological damage as affected by curing; Drs. Eben and Vivian Toole are actively engaged in germination and viability studies. Dr. Reynolds of the Human Nutrition Research Branch, ARS, does some work on taste testing of peanuts cured by different methods. In the Agricultural Engineering Research Branch, ARS, N. C. Teter and R. L. Givens work on effect of curing environment on quality, and the application of improved curing practices on the farm. There are no doubt others engaged in this field, but failure to mention them is through ignorance and not intent.

In the conventional method of peanut curing, the vines of the freshly dug peanuts are allowed to wilt, and then they are placed about poles set up in the field. By this method, the peanuts are allowed to ripen in a semi-weather-protected stack, and dry slowly. Under favorable weather conditions this method produces good quality peanuts.

The more recent method of allowing the peanuts to ripen in the windrow and then drying them in bulk bins has created some problems in management of the best quality of cure. This innovation in harvesting accented problems pertaining to the cure because during the ripening period the peanuts are not as well protected from the weather and during the drying, they are subject to artificial conditions.

The best quality peanut results from carefully avoiding the failure to ripen and the failure to take steps to prevent damage from occurring after the peanuts are ripe. The first slide roughly illustrates for Virginia the general conditions for good quality as based on a time-moisture relationship. Notice that in moving from the radical treatment of the left side to the conservative right side the flavor characteristics make progressive changes through (1) unpleasant "off-flavor", (2) bland lack of flavor, (3) normal flavor, (4) nutty flavor which is slightly sharp and preferred by many consumers, and (5) rancid off-flavors. The tolerance on the left between damage and acceptability is much lower than the tolerance on the right. In peanut curing it is better to err on the conservative side in relation to rapidity of drying and temperatures, than to err on the radical side. In other words, ripen fully in the windrow and dry slowly. Do not dry below 8% moisture or damage in shelling will be increased.

Peanuts may ripen in the soil. When they cease taking in food they begin to ripen. When vines have shed leaves and cease to synthesize food, peanuts may begin ripening in the soil, and in some such instances may be dried quite rapidly right after digging without impairing quality. Unrelated experiments in 1949, 1951, 1953, and 1956 confirmed this observation. The same principle applies when the vines are removed mechanically with mowing machines prior to harvest. Mature peanuts should exhibit shorter



time for ripening requirements than immature. Therefore, in this slide it is difficult to say that start of ripening is at time of digging; the ordinate may be moved to the left by special field conditions or to the right by virtue of less moisture in the peanut.

Weather plays a dominant role in the curing process, aud man's action is not always able to produce the optimum quality. In the Southwest and sometimes in the Southeast, hot, dry conditions at digging time will arrest ripening. Under these conditions shading by the foliage in the windrow or removal from the field early to protect from the sun may aid in obtaining better quality. Conceivably the practice of clipping vines before harvest may enhance ripening in the soil. Prolonged periods of wet weather which prevent harvest allow pegs to decay causing the peanut to shed from the vine and hulls become discolored if they are in the windrow. Prolonged exposure to moist conditions in the stack pole produces concealed damage in runners making stack pole curing an objectionable curing method.

The Virginia area with comparatively cool, humid harvest conditions has more favorable curing weather than other areas. However, curing proceeds more slowly and requires, on the average, a six-day aging in the field windrow to produce a product with quality as high as that procured from the stack pole. When removed from the windrow and bulked in a bin, the drying must be fast enough to prevent excessive molding, but the temperature of drying air cannot be raised over 95°F. on Virginia type peanuts having relatively high moisture without haviug some effect on shelling damage. Drying before the peanuts ripen gives poor quality. When growing peanuts are freshly dug and dried before ripening they exhibit poor physical structure aud flavor. Brittleness and hardness of the seed result in splitting and skin slippage when they are shelled. The abnormal flavor of these peanuts defies an accurate word description, but is unpleasant to most consumers. Temperature plays au important role in causing "off-quality" products. Many enzymes are inactivated at temperatures ranging around 115°F. High temperature on the peanut will act to give bad flavor and physical texture as surely as drying before ripening. Temperatures above 100°F. are considered high temperatures for peanut curing.

Conditions in the field windrow may produce peanut temperatures exceeding 105°F. and in part of the production area at certain times will dry peanuts before they are ripe. Peanuts react the same to nature's high temperature and fast drying as they do to artificial conditions. Bailey, Pickett and Futral (1) point out that adverse flavor wrought by drying too rapidly at high temperatures is irreversible. Furthermore, the same general reactions occur in Spanish, runner, and Virginia types of peanuts. (1) (2) (3) (13) (15).

Germination of seed is not adversely affected by rapid drying as much as other physical properties. If mechanical damage has not occurred, a rapidly dried peanut germinates as well, if not better, than slowly dried peanuts. Blackstone, Ward, Butt, Reed, McCreary (4) say that conditions which give maximum protection from adverse weather result in the best germination of Dixie runners. They recommend that drying facilities be available as insurance against unfavorable weather.

Not as well recognized because we blame the weather is the poor quality result of drying too slowly. When ripening is complete the peanuts should be held in the perfectly ripened condition at their point of optimum quality. But peanuts are often left lying on a stack pole or possibly in a drying bin in a warm moist environment. Molds grow rapidly in this favorable environment and rancidity may develop either from molds or from chemical oxidation. On the stack pole, the peanuts are isolated one from the other and some air movement occurs so mold growth does not proceed as rapidly as it does in insufficiently aerated bins where peanuts are intimately bulked.

Heavy mold growth may develop on the hulls of peanuts without readily apparent damage on the kernel. Pathologists (8) have identified the molds associated with discolored shells and damaged kernels as *Aspergillus*, *Penicillum*, *Rhizopus*, *Diplodia*, *Alternaria*, and *Botrytis*, all of which may exist in the field or in bins under conditions favorable for mold and unfavorable for peanuts. Please refer any questions concerning molds to Dr. Garren as these comments are based on pathological work.

Although conclusive data are not available, it appears that fungus growth causes peanuts to lose more dry matter than comparable peanuts free of mold and even though damage to kernels is not apparent, kernels from peanuts with molded hulls will not store as well as clean peanuts.

Garren, Higgins, Futral (7) and Norton (12) report that although blue damage of Spanish peanuts may also be associated with runners and Virginia types, Spanish are much more susceptible. The damage has been shown to result from oxalic acid and to a lesser degree from Kojic acid. Oxalic acid is produced by *Sclerotium rolfsii* and *Aspergillus niger*, while Kojic is produced from *Aspergillus flavus*. If humid weather with damp soil prevails over a few days in the Texas region, blue damage may appear on windrowed Spanish. In Georgia, the blue damage was associated with damp plants stacked in the field and under shelter but did not appear on peanuts with good aeration and more rapid drying. The conclusion is that stacked peanuts placed on the pole while green and held under warm humid conditions are particularly susceptible to injury by *Sclerotium rolfsii*.

Concealed damage, a quality-reducing factor associated with curing, is most prevalent in runner peanuts. Garren, Higgins (6) and Wilson (16) have illustrated that common micro-flora of peanuts (*Sclerotium bataticola*, *Diplodia* sp., *Fusarium* spp., *Rhizopus* sp., *Aspergillus* spp., etc., *Diplodia theobromae* was the most prevalent species) are associated with concealed damage. Living mycelia or spores of these fungi were present inside the shell and probably between the cotyledons at harvest time. Rapid drying as obtained through windrowing, greatly reduces concealed damage. Moistures of 25% (16) are optimum for damage. Heiberg and Ramsey (9) found that at the terminal market in Chicago, *Diplodia natalensis*, *Penicillum*, spp., *Rhizopus*, spp., and *Aspergillus*, spp. accounted for over two-thirds of the damage of runner peanuts. Concealed or visible damage from curing of the Virginia type of peanut has not been a serious problem in most seasons. In 1956, when rainfall at harvest time produced extremely wet conditions, the peanut damage rarely exceeded 6%. However, the hulls on many peanuts were badly discolored. Hull discoloration is undesirable in Virginia types as it ruins Jumbo and Fancy sizes for hand pick sale.

In judging the quality of peanuts obtained by different curing methods, the commercial grade has little significance. Statisticians (5) (10) (11) (14) have made progress in planning and interpreting organaleptic tests which at present play an important role in quality. Shelling damage by methods similar to those developed by J. H. Beattie and applied by Boswell, Bailey and Welch, all of the Horticultural Crops Research Branch, ARS, are considered of primary concern. In our work we consider fat acidity the next most important attribute, but other chemical tests may be more appropriate. Germination and vigor of seedling as determined by

Drs. Eben and Vivian Toole of the Horticultural Crops Research Branch, ARS, is considered. Brightness of hull has been noted but did not enter into the formulation (15) for determining qnality of peanuts. No accurate evaluation of molds or mold concentrations have been made in bin drying studies of peanuts.

At the Tidewater Research Station in Holland, Virginia, a windrowing time of six days after digging is recommended. Air flow of 10 to 15 cfm/ft^3 of peannts and a temperature rise of 15°F. is recommended to dry these windrow ripened peanuts. Virginia type peanuts weigh on the average 13.6 ponnds per cubic foot when settled in a bin and containing 8% moisture.

Field trials are being made annually to check the laboratory findings and to test the practicability of application. The resnlts of field trials on drying after being cured in the windrow are gratifying and it appears that this method is superior to stack poling as a procedure for harvesting peanuts.

Some of the more recent findings of Dickens at North Carolina State are: Maturity is defined by the interior color of the hnll. Peannts with dark or splotched interior are considered mature. If a batch has "off-flavor" because of failnre to cure, the immature portion will taste worse than the mature. The "off-flavors" are produced by time-temperature-moistnre relationships, but drying rate alone does not account for "off-flavors".

An oxygen atmosphere for curing gave better flavored prodncts than nitrogen or carbon dioxide atmospheres.

Rapid drying does not affect the final weight of peanuts as compared to the final weight of those dried in natnral air.

"Off-flavor" and "off-odor" are associated. Volatile extractions from "off-flavored" peannts are being condensed in evacuated tubes cooled with a dry ice-acetone mixture.

The hearts had no detectable influence on 'off-flavor" prodnced by high temperature drying. No difference in "off-flavor" could be detected between the radical end and the other end of peanuts dried at 130°F. when the ends were separated before curing.

Mr. Holley, chemist at Experiment, Georgia, will give some of their findings on some physical and chemical aspects of curing so these remarks from Georgia are confined to engineering studies.

Fntral at Experiment, Georgia, recommends that for green Spanish peanuts the temperature should be maintained below 110°F., that drying time be at least 60 to 72 honrs and that peanuts should not be bulked over 4 feet deep for drying.

Shepherd at Tifton, Georgia, conducted basic studies to determine tolerance of peanut quality to artificial curing as compared to the common field stack. He found the slowest feasible cnring rate the best. Consistent drying air temperature exceeding 100°F. may adversely affect flavor. For assurance of avoiding damage to peanuts by too rapid drying, moisture removal should not exceed ½ of 1% per hour. An air velocity of 50 to 100 feet per minute at 100°F. is considered safe. For velocities of air above 100 feet per minute, the temperature should not exceed 95°F.

Damage in shelling appears to be associated with the lowest moisture content to which peanuts were dried at any time. No peanuts should be dried below 7% moisture and an average moisture coutent of farmers' stock should not be lower than 8½%.

In discussing problems of the future he makes this statement, "The major problem currently in evidence appears to be the lack of sufficient incentive for grower and buying agent to acknowledge and observe common treatment specifications for best quality preservation in curing peanuts. It is the opinion that the latest grading methods do not provide adequate delineation of quality characteristics to warrant closely discriminating peanut curing specifications. Of fundamental importance to all concerned is the establishment of firm peanut quality standards, and appropriate and fully reliable grading methods. This should provide the incentive for optimum treatment of peanuts in curing."

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PHYSICAL AND CHEMICAL STUDIES OF PEANUT QUALITY AS INFLUENCED BY CURING

T. A. PICKETT, *Chemist, Georgia Experiment Station*

(Paper presented by Mr. K. T. Holley, Chemist, Georgia Experiment Station, due to illness of Mr. Pickett)

When the principal constituents were determined throughout the development of peanut seed a typical S-shaped growth curve was obtained (1). The flat portion of the curve, at about 70 days after flowering, represents maturity as far as major constituents are concerned. By this standard maturity may be anywhere over about a 14 day period. Beyond this the nuts are classed as overmature, while the preceding segmeut of the curve represents the immature stage. These three stages, although not sharply defiued, are more or less represented in practically every harvest of this crop because of the indeterminate fruiting habit of this plant.

The immature nuts are characterized by a high water content, by more inorganic phosphorus, by an oil more prone to oxidative rancidity development, and by a protein differeut in character from that in mature nuts. At this stage they do not respond to various curing treatments as do mature uuts, and they are often the cause of inferior quality.

The mature nuts contain less water, more organic phosphorus, a protein different iu solubility characteristics, and have the properties of a living organism approaching the resting stage.

Overmatures are characterized largely by browning of both the testa and the inside surface of the shell. Objective methods are needed for characterizing this stage.

If a mature peanut is dried from 40 to 7 percent moisture that means a loss of one third its weight and a volume shrinkage of the same magnitude. It is reasonable to assume that along with this change there is a parallel decrease in respiration rate. On this basis it was postulated that the shrinkage in volume and the lowered respiration rate must be brought about rather slowly in order to avoid a disruption of the normal metabolic sequence and an unsatisfactory end product—in other words, that there is a minimum time requirement for these changes.

On the contrary when mature, shelled nuts were dried at room temperature under vacuum with a good drying agent to a low moisture level a satisfactory product was obtained in 16 hours. This has not happened in every trial but it has been done and for that reason the time factor in peanut curing does not appear to be so significant. It should be remembered however, that these experimental results were obtained under laboratory conditions and they do not suggest any departure from the recommended slow curing for practical purposes.

For an additional complication—a natural sequence of enzyme action in the curing process has been postulated which also requires a minimum time for development of a desirable flavor and aroma in peanuts. The above mentioned relatively short period vacuum drying appeared to disprove that theory also. But then freshly harvested nuts were freeze-dried at abont −80°F. whereby all enzyme action shonld have been negligible during the drying process. So far the product from this treatment has never had any flavor; all these nuts have been very bland. From this then, it is still possible that enzymes do play a significant role in flavor development in peanuts during the curing process.

When freshly harvested peanuts are dried at various temperature levels nndesirable flavors are especially evident after the 120°F. treatment. This is in the critical temperature range for living processes and as might be expected germination is adversely affected by such treatment. Often nuts so dried have an odor of putrefaction and it seems that this borderline temperature is the least satisfactory of all levels tried in cnring as far as flavor and aroma are concerned.

In this connection the protein splitting enzyme in peanuts, known as protease, seems to be more active at 120°F. than at lower temperatnres. Yet a definite relationship between this enzyme and the disagreeable odors and flavors in peanuts dried at 120°F., which bear some resemblance to that from putrefied protein, has not been established.

When drying is carried out at temperatures above 120°F., unpleasant flavors and odors are not encountered so often but skin slippage and splitting are much more common. Regardless of these serious defects in nuts cured at high temperatures, in repeated observations it has been found that the oils from nuts cured at or above 140°F. have better keeping qualities than those air dried or dried at slightly above room temperature.

The freqnent appearance of peanuts on the market which show some evidence of high temperatnre drying has created a demand for a method capable of differentiating nuts according to the temperature at which they were dried.

Recently, a rather simple method based on specific volume measurements has shown promise for this purpose. The displacement of about a pound or more of shelled nuts is measured in a suitable gradnate by filling the voids with measured volumes of 20-30 mesh sand.

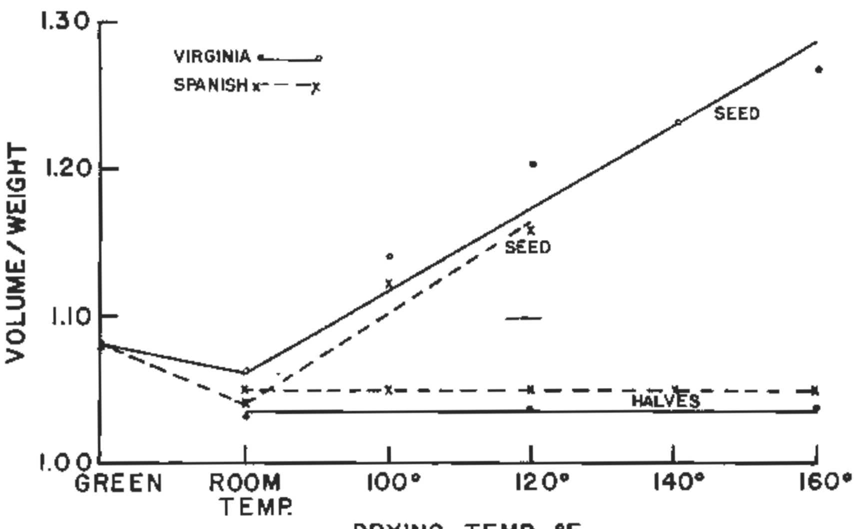

Fig. 1. The effect of drying temperature on the apparent specific volume of peanuts.

This curve shows that increasing the drying temperature increases the apparent volume/weight or the specific volnme of whole shelled nuts. In contrast, when the nuts are split into halves there is no appreciable change in the apparent volume. This means that rapid drying enlarges the cavity between the cotyledons and as higher and higher temperatures are applied more distortion and splitting occur. When split the halves of rapidly dried nnts show the deep indentation of the cotyledon interface which is associated with this cavity enlargement.

Results of drying freshly dug nuts at 140°F. for varying periods followed by room temperature storage until the moisture level of cured nuts is attained, are presented in Table 1.

TABLE 1. Effect of Drying at 140°F. Followed by Room Temperature Storage on Volume/Weight of Virginia Seed.

Prior Drying Period at 140°F.	Volume/Weight and Moisture Content After Subsequent Room Temperature Storage									
Hours	0		24		120		192		264	
	Volume/Wt.	H_2O %	Volume/Wt.	H_2O %	Volume/Wt.	H_2O %	Volume/Wt.	H_2O %	Volume/Wt.	H_2O %
0	1.07	36			1.04	7			1.06	5
1	1.03	27	1.07	20	1.11	7			1.13	5
6	1.15	8	1.20	7	1.19	4			1.19	4
20	1.23	3	1.26	3			1.22	4		

It may be seen that one hour at 140°F., while the nuts had a high water content accounted for much of the change in apparent volume due to elevated temperatures. Grauted that 140°F. is a high temperature yet, Bailey, Pickett and Futral, (2) reported that peanut seed tissue in the shell, in direct sunlight attained a temperature of 131°F. Thus these results suggest that a relatively short exposure to such temperatures could lead to distortion and splitting.

This brief review of some peanut curing studies should, if nothing more, emphasize the great complexity of the curing cycle in relation to product quality. This, in turn, points up the need for a great deal of work to be done before the peanut quality problem can be solved.

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"COMMENTS ON ANALYTICAL ASPECTS OF SAMPLING, GRADING, AND QUALITY PICKING PEANUTS"

By J. J. MODER, JR., *Professor, Industrial Engineering, Georgia Institute of Technology*

1. Introduction

I would like to review this afternoon the published work carried out jointly by the Georgia Tech Engineering Experiment Station and the Georgia Experiment Station on the sampling and grading of farmers' stock peanuts; i.e. the statistical studies leading up to the Bainbridge test which will be described in detail by Mr. Tom Elliott. I will also briefly describe the studies on quality picking, most of which have been recently carried out in the Georgia Tech School of Industrial Engineering and have not as yet been published.

2. Statistical Nomenclature

2.1 **Definition of accuracy, bias, and precision.** To begin the discussion of the statistical aspects of sampling and grading farmers' stock peanuts, it is appropriate to define such terms as accuracy, bias and precision. I would like to do this by analogy with a target and shot impact points. The diagram on the left of Figure 1 is an example of a weapons system which is neither accurate nor precise. The system is not accurate because the shots on the average do not fall on the target center; we say this system is biased. The system is not precise because of the relatively large dispersion in the shot pattern. Now the diagram on the right is an example of a weapons system which is both accurate and precise; the usual goal in weapons systems as well as sampling and grading systems.

The present status of sampling and grading farmers' stock peanuts can be appropriately described by the diagram on the left. First, sample grades are not centered on the target, in this case the true value of the load of peanuts in question. This inaccuracy of the grades is primarly due

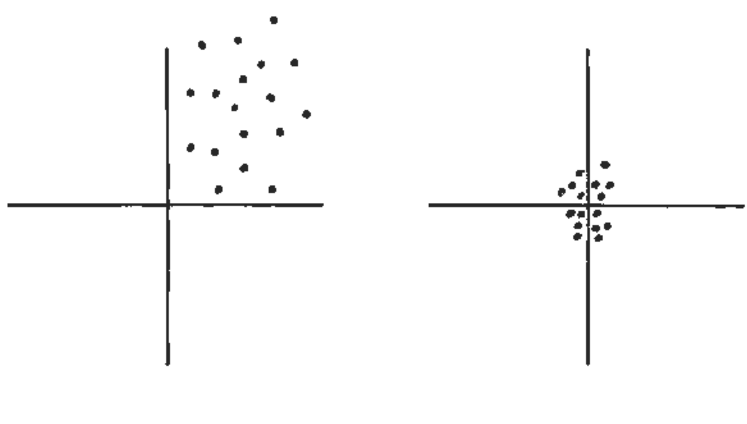

FIGURE 1. Diagram Explaining Accuracy, Bias, and Precision.

to the bias in the sample. This bias may be in favor of the buyer or seller depending on the amounts and types of foreign material in the load, the methods nsed in loading the truck, the amount of agitation which the load receives in reaching the market, and a number of other minor causes. Second, there is considerable dispersion in regrades of the same load of peanuts. This is primarily due to the small size of the sample graded. These factors have separate causes and effects and each will be discussed separately.

3. Details of Biased Sample

3.1 First, the grades of farmers' stock peanuts are biased becanse the sample is obtained in a manner which is not representative of the entire load of peanuts. This bias is due to the nature of the sampling tnbe and the manner in which the material enters the sampling-tnbe openings. This tnbe, which has a pointed tip, will not sample material at the bottom of the truck for a distance of at least three inches. Furthermore, farmers' stock peannts, especially those with a high foreign-material content, are not free flowing, and as a result, the material which enters the sampling tube is not representative of the cross section sampled. Actually, the heavy, free-flowing material such as small rocks, dirt, and dense peanuts enter the sampling tnbe in greater percentages than are present in the load of peannts, while light materials such as large sticks and hay fall into the sampling tube in lesser percentages than are present in the load of peanuts. The results of these facts are that the sample selected for grading represents he peanut load in a biased manner and actnally does not represent the material near the bottom of the truck at all.

We see no satisfactory solution to this problem short of unloading the truck of peannts to be sampled and automatically withdrawing a representative sample of the entire load. This appears to be a rather formidable task; however, our studies have indicated that this can be accomplished rapidly and at a reasonable cost by the use of a 40° hoist dump pit type nnloader. Before pursuing this recommendation further it may be well to take a broader look at this problem of marketing farmers' stock peanuts. Here we see a growing need for cleaning all peanuts before purchasing and warehonsing. Some of the advantages of this proposal are:

(1) More accurate and precise pricing of peanuts; this shonld help to improve buyer-seller relations and enable the buyer to guarantee outgrades.

(2) Reduction of peanut damage and dirty-faced split peanuts in subsequent storage and handling operations.

(3) More rapid subsequent shelling with fewer splits. Foreign material is one of the more important causes of splitting peanuts during the shelling operation.

(4) Reduction during the shelling operation in the storage volume required per ton of farmers' stock peanuts.

(5) Improved honse cleaning in storage and shelling plant. This is a factor which is certainly destined to take on added importance in the future.

If we consider automatic sampling and cleaning as a joint marketing problem, we find that both can be accomplished at the cost of cleaning alone. Thus we have a proposal of much broader scope and basis for support.

A cooperative project, the Bainbridge test, was established to study this proposal and will be described by our next speaker.

4. Details of Lack of Precision in Grading

4.1 **Introduction.** Now let us turn our attention to the effects of poor precision or reproducibility io the sampliog and grading of farmers' stock peanuts. It should be emphasized that this factor behaves independently of the bias in the sample.

4.2 **Explanation of how poor precision manifests itself.** The effects of poor precision can best be explained by Figure 2 which shows the variation in the value of Spanish peanuts in dollars per ton which cau be expected in repeated grades of a single load of peanuts whose true value, except for bias, is $200 per ton.

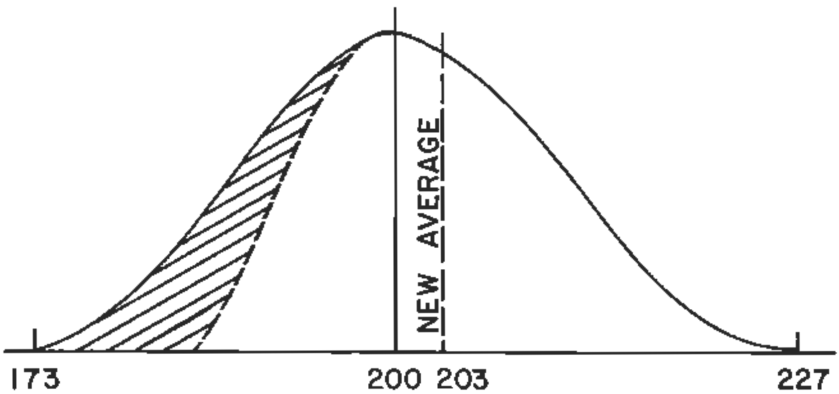

FIGURE 2. Variation in the Value of Spanish Peanuts in Dollars per Ton for the Present Grading System. Effects of Regrades Shown by Shaded Area.

This figure brings out two important points. First, the magnitude of the variation makes it clear why the small peanut producer must be on guard against an unfavorable grade because he markets too few loads to allow for the chance variation to "average out." A second more subtle point illustrated in Figure 2 is the effect of the producer's knowledge and the buyer's ignorance of the true value of the load of peanuts being graded. If a producer by chance gets a grade on the low side, below $200, he very likely will request a regrade or may choose to market his peanuts elsewhere. The producer's actions in this case are certainly justified since he is seeking a fair price for his product. Now the chances are that the regrade will result in a higher dollar value than the first, and as a result, peanut loads will not be sold at the very low grade values. This phenomenon has been verified by analyzing the results of a random sample of 200 regrades of Runner peanuts made during the 1951 buying season. The second grades averaged $6.43 higher than the first. Since a similar phenomena of requesting regrades does not usually take place if the first grade is on the high value side, above $200, the net result is to increase the average price paid for the peanuts above their true value as shown in Figure 2 by the skewed distribution.

4.3 **Experimental Investigation of Precision Problem.** This problem of lack of precision was studied in detail by a balanced factorial experiment in which four loads of Spanish peanuts were each sampled three times; these samples in turn being quartered down to permit eight inspectors to grade each of the twelve samples. An analysis was then made on each grade factor.

4.31 **Foreign Material.** The foreign material data indicated that there was no significant differences among the inspectors but there were significant differences among the foreign material content of the three samples taken from each truck, and further, these differences increased as the foreign material content of the load of peanuts increased; a fact which is not too surprising since foreign material is not randomly distribnted throughout the load of peanuts. These results brought out quite clearly the advantages of cleaning farmers' stock peanuts prior to sampling and grading to reduce this variatiou from sample to sample. Additional tests indicated that further improvements in the grading precision could be made by iucreasing the size of the sample graded.

4.32 **Other Factors.** Of the other three grade factors, variation in moisture was found to be negligible as long as the instruments were properly calibrated. The remaining two factors, SMK and damage are strongly dependent on each other so that a discussion of the damage content data will suffice.

An analysis of this set of data revealed no systematic differences among the inspectors; a result which indicates that these inspectors were well trained iu the technique of scoring damaged kernels. Further, there were no significant differences among the three bucket samples taken from each truck. This is to be expected since damaged kernels are usually distributed at random throughout the load of peanuts. Thus, the variation in repeated damage analyses is attributed entirely to the chance variation in the damage content of the four-ounce sample analyzed plus the relatively small chance variation in scoring damage. Since chance is the only significant factor affecting the variability, only one thing can be done to decrease it—that is, increase the size of the sample used for analysis. In general, if the sample size is quadrupled, the variability will be halved so a one pound sample would cut the variability of the present four ounce sample in half. It should be pointed out that the extent to which variability can be reduced in this manner is limited. For example, if we went to extremes and graded a ten pound sample, the chance variation present in the four ounce sample would be virtually eliminated from the grade; however, now even small previously undetected variations in inspector judgment on scoring damage may be revealed and thus limit the final precision attainable. Fortnnately, this fine degree of precision is unnecessary.

To carry out this recommendation will require mechanization of the grading operation; however, there are no immediate hopes of complete mechanization from both a cost and technological standpoint. Fnll automation is usually too expensive for seasonal type equipment; further, we know of no means to automatically score damage according to the present grading criteria. For these reasons, some hand operations mnst be retained and thus the size of the sample graded must strike a happy medium between two opposing forces, one requiring a large sample to reduce the variability and the other requiring a small sample to make it feasible to handle from a time and cost standpoint. We have made some recommendations on sample size which vary from one to four pounds depending on the size and damage content of the load of peanuts. However, we feel that more work should be done before these recommendations are finalized.

5. Summary on Sampling and Grading

In summary then, on this subject of sampling and grading farmers' stock peanuts, we rocommend first that all peanuts be cleaned and automatically sampled, and second, that the size of the sample graded be increased. The effects of these recommendations as revealed by the Bainbridge tests will be presented by our next two speakers.

6. Quality Picking Shelled Peanuts

We have made a rather extensive study of the quality picking of shelled peanuts because of its economic importance in the processing of farmers' stock peanuts. At present, it amounts to almost half of the total shelling plant labor costs and one-fifth of the total costs.

The methods of quality picking in use today are either by hand or by means of electric eye tubes. Each of these methods have important applications in the peanut indnstry and both will be discussed briefly.

6.1 **Electric-Eye Picking.** The usual basis of operation of electric eye picking machines is the amount of light reflected from the surface of the peanut kernel being inspected. The wave length of the light used is adjusted to maximize the differences in reflectivity of souud kernels and damaged kernels or bits of foreign material.

Since the electric-eye machine looks at each kernel individually, the input capacity, unlike handpicking, is independent of the percent damage present in the feed peanuts. For this reason the electric-eye provides greater savings over handpicking operations on high damage content peanuts. It is possible to exploit this characteristic by concentrating the damaged kernels by precision sizing, the concentration taking place in the smaller size kernels. A detailed economic analysis of electric-eye picking has been made, based on this concentration principle. The results indicate that all but the very small peanut sheller can profitably employ these machines.

6.2 **Hand Picking Methods.** Even though the trend is to the use of electric-eye picking machines, several applications of handpicking still remain. For example, the small seasonal operator, or after the electric-eye machines to give added assurance of the removal of objectionable materials. For these reasons, we have conducted a number of controlled laboratory studies designed to determine the optimum methods of haud quality picking. I would merely like to summarize the results of these studies.

First, in contrast to onr earlier beliefs, we found no significant differences in the picking rate between the picking positions at the side and end of the belt.

Second, we found that by discarding the damaged kernels one at a time, the picking rate could be increased from five to eight percent over the conventional method of palming the keruels.

Third, the picking rate is a maximum for belt speeds in the range of 45 to 50 feet per minute. This result is relatively independent of the flow rate which should be controlled by proper adjustment of the density of peanuts on the picking belt. Since high densities reduce the picking rate, the recommendation is to set the belt speed at 45 to 50 feet per minute and keep the density of peanuts on the picking belt as low as possible as determined by the plant capacity requirements. We also found that the percentage of good peanuts in the pickouts was a minimum at belt speeds at about 30 to 35 feet per minute, in the case of peanuts, however, this is not of economic importance and the belt speed should be adjusted to maximize the picking rate. This would not necessarily be true for more expensive commodities such as pecans.

Since these recommendations are based primarily on laboratory studies, plant investigations are now in order to verify these results which we feel can possibly result in overall improvements of 10 percent or more in the picking rate.

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RESULTS OF THE BAINBRIDGE TESTS ON CLEANING, SAMPLING AND GRADING FARMERS' STOCK PEANUTS

By T. A. ELLIOTT, *Research Engineer, Engineering Experiment Station, Georgia Institute of Technology*

Introduction

The task of analyzing the sampling, grading and cleaning of a large volume of peanuts is a complex one. The Bainbridge, Georgia project which was devised to do this is a good example. Prior analysis and tests had indicated that more accurate results could be obtained by using a larger sample. In addition to a larger sample it was felt that a better method of obtaining the sample was necessary. The Bainbridge project was designed to compare the conventional sampling methods and analysis of a small sample with automatic sampling and analysis of a larger size sample. When the complete project was evolved we had the following groups participating:

The Agricultural Experiment Station at Griffin
Engineering Experiment Station at Georgia Tech
The GFA Peanut Association
The Commodity Credit Corporation
The Federal State Inspection Service
The Georgia Peanut Company.

Phase 1 of the project consisted of the design and fabrication of the cleaning and sampling facility and the design and fabrication of the mechanical components used to grade larger samples.

Phase 2 of the project consisted of receiving the peanuts, processing them through the sampling and cleaning plant and placing them in the proper bins in the warehouse. The following spring the peanuts were moved out of the warehouse, reprocessed through the sampling devices and carried to a shelling plant.

The third phase of the project consisted of a tabulation and analysis of the data collected and the reduction of this data to tables where it could be readily compared. Let us briefly review phases 1 and 2.

The cleaning facility consisted of a conventional pit and hoist where an incoming load would be dumped, from there is was elevated and at the top of the elevator an automatic sample was drawn. The peanuts then passed over a heavy rock and sand screen, and next over an air blast cleaner and slot screen which removed sticks, hay and pops from the load. After this a conventional type of stoner removed the rocks and dropped the peanuts into an elevator pit. At the top of this elevator a second automatic sample was drawn. Three holding bins were provided so that a load could be retained until an analysis determined in which bin in the warehouse it was to reside.

The semi-automatic grading equipment included a foreign material screen which removed sand, rocks, and hay from the sample; a sheller (which shelled the peanuts catching the shells and screened the shelled goods over the proper size of screen); and a splitter which split the peanuts so that they could be inspected for hidden damage. It might be mentioned that this equipment, which was all developed for this project, worked well and gave us good results throughout the project.

When a load arrived at the buying point it was weighed, sampled and graded in the conventional manner and a record made of the weight and grade. If the peanuts were unmerchantable on account of moisture being over 9 per cent the load was not included in the test. If unmerchantable because of high foreign matter the load was precleaned and resampled and graded for loan purposes. The original grade was used for test purposes because it was made as the peanuts arrived from the farm. This was done in order to compare original grades with the grades of identical loads after cleaning. If a load was merchantable and the producer decided to sell, it was accepted for the test and unloaded at the cleaning plant. The conventional trier sample was the sample first taken, and is referred to as Sample 1. When the peanuts were elevated in the plant before being cleaned, an automatic sample referred to as Sample 2 was taken. This sample was approximately ten pounds in weight but was reduced to two pounds for grading. After this, the peanuts were passed through the cleauer and elevated and were sampled by the second automatic sampling device. This sample, referred to as Sample 3, was graded ou the same equipment used for Sample 2. The peanuts were collected and held in holding bins nntil the grade on Sample 3 was determined, at which time they were deposited on a special truck. The loads were re-weighed, sampled by the conventional trier method, giving Sample 4, and stored in designated bins according to damage content as determined by Sample 3. The peanuts remained in storage until June the following year when they were removed from storage for shelling. The peanuts were moved by bins to the cleaning plant and elevated for auother automatic sample referred to as Sample 5. From here the peanuts were deposited in a semi-trailer truck. When the truck was one-half loaded it was sampled by the trier method and when full, sampled again; the two samples were then mixed together and used for grading. The data on this sample were recorded as Sample 6. The loads of peanuts were then carried to the Moultrie shelling plant of the Georgia Peanut Company and shelled there by bin lots. Output and grade records on each bin were kept separately. The shelled peanuts were bagged in burlap and graded as prescribed by the conventional methods for shelled peanuts. This sample was called Sample 7. To summarize briefly I will repeat the samples.

Sample 1, trier sample, unclean, 4 ozs.
Sample 2, automatic sample, unclean peanuts, 2 lbs.
Sample 3, automatic sample, cleaned peanuts, 2 lbs.
Sample 4, trier sample, cleaned peanuts, 4 ozs.
Sample 5, automatic sample after storing cleaned peanuts, 2 lbs.
Sample 6, trier sample after storing, two 4-oz. samples.
Sample 7, conventional sample of shelled peanuts.

Details of record keeping were worked out in advance to insure the ideutity of the load until it was comingled with the other loads to the same bin. Thus the variability both within and among loads according to the different methods of sampling and grading could be analyzed and summaries of results by bius and by sampling the grading methods could be prepared. Necessary weight reductiou for the samples withdrawn were made as the data was aualyzed in order to maintain material balauces. All loads were adjusted to a 7 per cent moisture level.

The analysis of the data collected can best be presented in two sections, the first being a condensation of the data iu tabular form showing absolute quantities of the entire lot of test peanuts. The second comparison will deal with the accuracy and precision in trier samples versus automatic samples.

The first results are shown on foreign material.

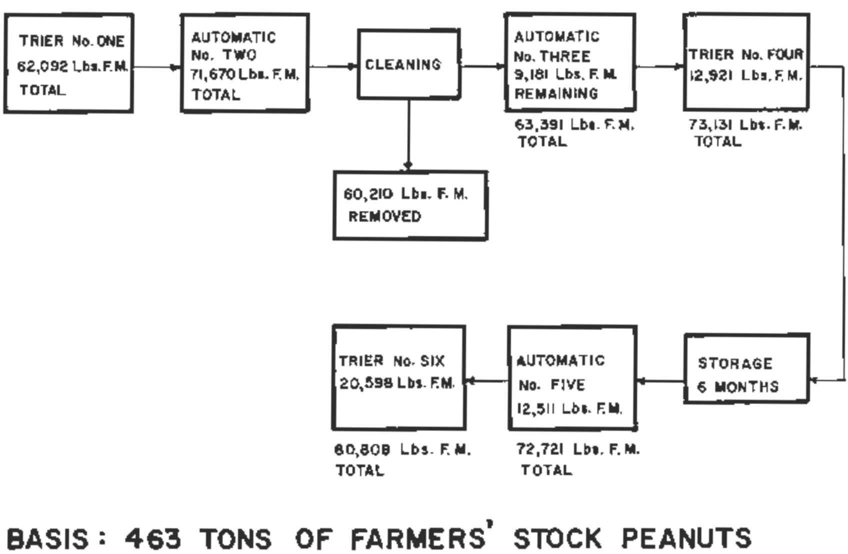

FIGURE 1. Results of Foreign Material Determinations, Gross Weight Basis.

We see here in Figure 1 the foreign material determinations. First sample, trier number 1, indicated 62,000 pounds of foreign material. The second sample, automatic number 2, indicated 71,000 pounds of foreign material. In the cleaning process actually 60,210 pounds of foreign material were removed. Automatic sample number 3 showed 9,000 pounds of foreign material remaining indicating a total foreign material of 69,000 pounds. Trier number 4 showed 12,921 pounds of foreign material giving a total of 73,000 pounds. After six months' storage automatic's number 5 showed a total of 12,000 pounds of foreign material making a total of 72,000 pounds in the load. Number 6 sample after storage showed 20,598 pounds of foreign material indicating a total of 80,800 pounds of foreign material in the load. The question now is which of these samples is correct. In examining the trier sample we will see that they indicate from 62,000 to 80,000 pounds. The automatic samples show a range of 69,000 to 72,000.

Without comparing each grade factor, let us examine the calculated value per ton according to grades on samples 1 through 6. This is shown in Table 3.

TABLE 3. Calculated value per ton according to grades obtained on samples one through six.

Sample	Value per ton		
	Spanish	Runner	Average
	(dollars)	(dollars)	(dollars)
One	239.41	205.16	212.70
Two	231.70	205.22	210.96
Three	233.56	203.84	210.32
Four	234.07	205.20	211.50
Five	232.24	203.32	209.54
Six	237.50	197.02	205.79

Sample 1, average dollars per ton showed a value of $212.70; Sample 2, a value of $210.96; Sample 3, $210.32; Sample 4, $211.50; Sample 5, $209.54; Sample 6, $205.79. This table indicates that if the peanuts had been stored on the basis of grade obtained from the trier Sample 1 and been delivered out by the warehouseman on trier Sample 6 there would have been a shrinkage of $6.91. If an automatic Sample 2 had been used to determine the value into storage, automatic Sample 5 to determine the value out of storage the difference would have been $1.42 per ton or a total shrinkage of 0.67 per cent. If automatic Sample 3 of cleaned peanuts had been used to determine value of peanuts in storage and automatic Sample 5 had been nsed to determine the value out the difference would only have been $.78 per ton or a total shrinkage of 0.37 per cent. Likewise the difference for comparable trier Samples 4 and 6 is $5.71 per ton. Trier 4 is 2000 pounds heavier than trier 1 because of mixing of peanuts and shaking loose of some dirt. Trier 6 is 18,800 pounds heavier than trier 1 because of additional mixing but primarily due to clay and dirt released from the peanuts during storage which gets into the trier in far greater per cent than is actually present in the load. If this were carried out in this instance to cover the whole 470 tons of test peanuts, the shrinkage of dollar value by trier Sample 1 and 6 wonld have been $5,725 or 5.75 per cent. If automatic Samples 2 in and 5 out had been used the difference would have been $1,336 or 1.37 per cent.

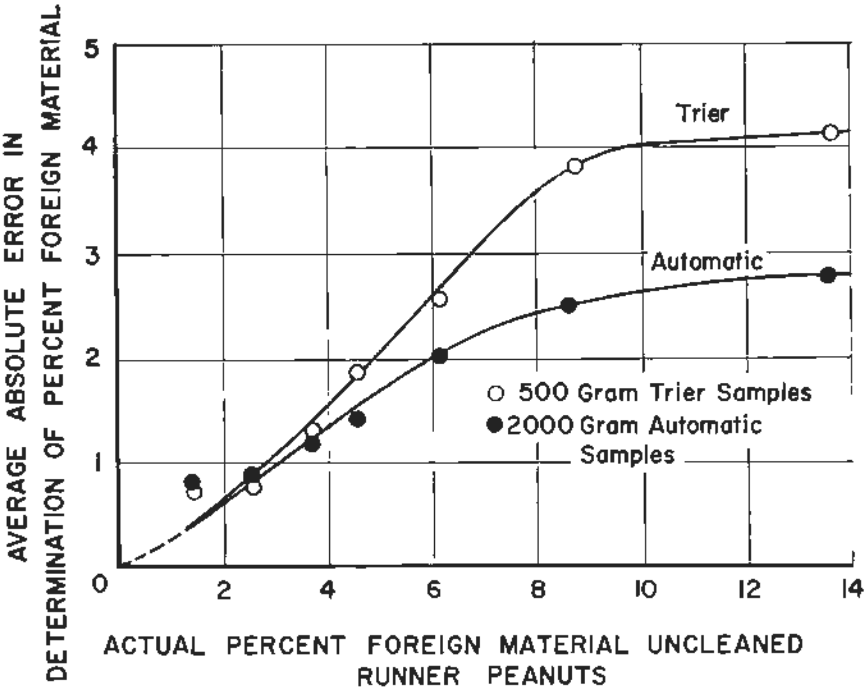

FIGURE 5. Average Absolute Error in Determination of Percent Foreign Material Vs. Actual Percent Foreign Material (Basis Sample No. 3) for Uncleaned Runner Peanuts

Now if you will recall Dr. Moder's illustration in the preceding talk it is apparent that the automatic sample and larger sample is more precise than that of the conventional trier and large sample. These figures present a strong argument for larger automatic samples.

The analysis of precision of the two methods of sampling and grading can best be demonstrated by looking at some further slides.

Figure 5 shows the average absolute error determination percent of foreign material versus actual per cent foreign material, basis Sample Number 3, for unclean runner peanuts. By absolute average of errors we mean that these are the difference between various samples with no regard to sign whether it was above or below what it should have been. In other words this gives you the complete amount of error inherent in that type of sampling and grading. On this curve which shows horizontally plotted the foreign material in unclean runner peanuts versus the vertical curve with the average absolute error in determining the per cent of foreign material. You can see that as the amount of foreign material increases the amount of error in both systems increases. The trier method shows greater absolute error than that of the large automatic sample. The next figure shows the average absolute difference in per cent total damage farmers' stock basis between Sample 1 and 4 trier and 2 and 3 for Spanish pea-

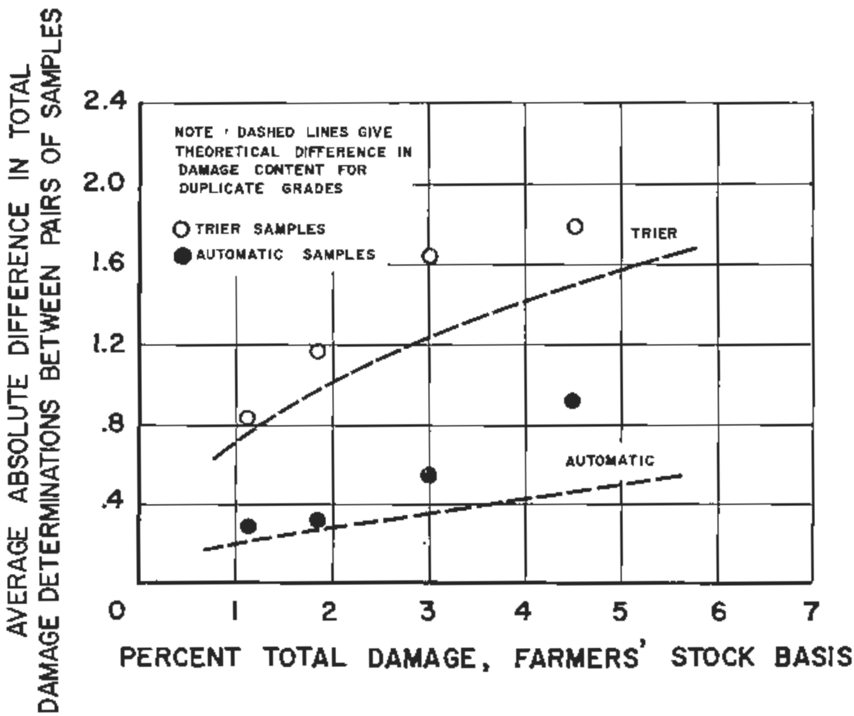

FIGURE 11. Average Absolute Difference in Percent Total Damage, Farmers' Stock Basis, Between the 100 Gram Trier Samples ONE and FOUR and the 1000 Gram Automatic Samples THREE and TWO—Spanish Type Peanuts.

nuts. In this case no curves have been fitted to the data, the dotted lines are theoretical curves on which these points should lie. In both cases it is apparent that the points did not lie closely on the line. However, here again we see in each case that the trier samples show considerably more difference than do the automatic.

The next slide shows the average absolute difference in price determinations in dollars per ton in farmers' stock peanuts comparing trier Samples 1 and 4, automatic Samples 3 and 2 for Spanish type peanuts. This plot shows the average absolute error in price determinations for autnmatics to lie in almost a straight line regardless of the average value of the incoming peanuts. The trier samples show a curved line which decreases as the value per ton increases. This is due to the fact that high value-peanuts have little or no damage which makes for good precision. This illustrates most clearly the precision of the automatic method. Here we see practically a straight line regardless of the grade factors which lessen the value of peanuts whereas on the trier samples no such precision is shown.

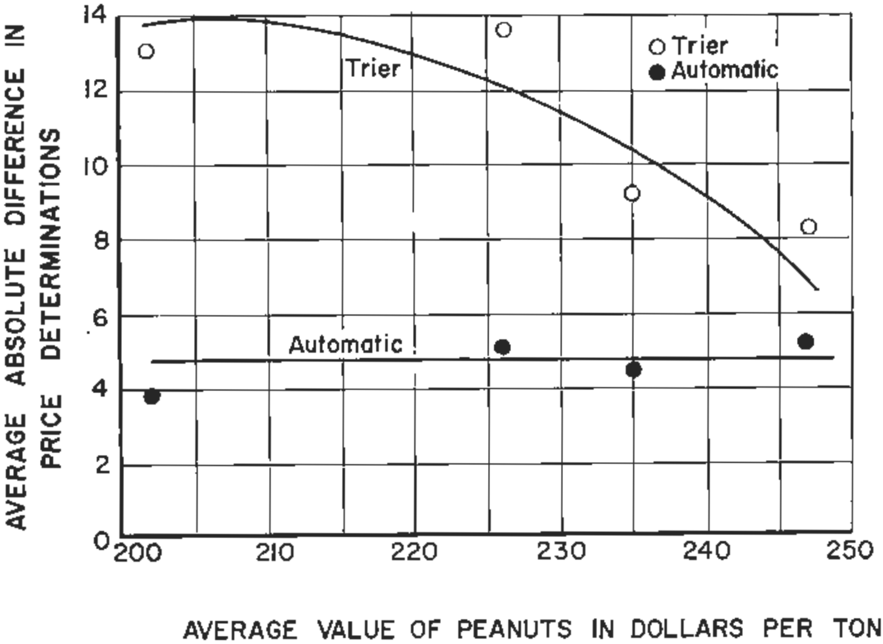

FIGURE 12. Average Absolute Difference in Price Determinations, in Dollars Per Ton of Farmers' Stock Peanuts, Between Trier Samples ONE and FOUR and Automatic Samples THREE and TWO—Spanish Type Peanuts

In conclusion let us see where this leads us. This conference is for the purpose of presenting factors which affect the quality of peanuts. I certainly agree with the previous speakers that there are many factors which go into determining the quality of a peanut. Precise and accurate grading and sampling are the yardstick by which these various qualities are measured. Our endeavors have all been directed towards means of fairly and equitably determining this quality when the peanuts are brought to market. We are of the firm conclusion that precise and accurate methods can be developed and installed at receiving points to insure good sound marketing of farmers' stock peanuts.

IMPLICATIONS OF RESULTS OF RESEARCH IN CLEANING, GRADING, AND SAMPLING FARMERS' STOCK PEANUTS, PROBLEMS IN APPLICATION, AND NEED FOR ADDITIONAL RESEARCH

By N. M. PENNY, *Economist, Georgia Experiment Station, Experiment, Georgia*

Mr. Chairman: Since this is a belt-wide review of peannt research, information was requested from Florida, Alabama, South Carolina, North Carolina, Virginia, Oklahoma, and Texas concerning any work that has been completed, is underway, or is planned related to quality of peanuts as influenced by sampling, grading, storing, and shelling. In most cases, the reply was negative. Texas reported two projects underway: (1) "Methods, practices, and costs of handling that affect market quality of peannts." (2) "Marketing significance of changes in farmers' stock peannts in storage."

Oklahoma is initiating a project in the field of agricultural policy and resource allocation related specifically to peanut production and marketing. Alabama, Georgia, and Virginia reported cooperative work on peanut storage with the USDA.

It boils down to the conclusion that there has not been any comprehensive research on sampling, grading, and shelling relative to effects on quality except that just discussed by Mr. Elliott and Dr. Moder.

From 1947 to 1950 we had active projects on the economics of marketing farmers' stock peanuts. Beginning in 1950 the Georgia Experiment Station and Georgia Tech initiated a more comprehensive project on peanut marketing which embraced the economic and industrial engineering phases of problems in marketing peanuts. Mr. Elliott and Dr. Moder have just reported to you certain phases of that comprehensive program.

We believe that in this particular field of peanut research the problems are economic, technological, and iustitutional in character and that elements of each are involved in most of the problems. For example, the question of grading large automatic samples taken from cleaned or uncleaned peanuts presents an economic problem by adding additional costs to processing; it presents the technological problem of perfecting a satisfactory sample sheller; and there are the problems of its being adopted by the Federal-State Inspection Service, the revisions of grades, price schedules, and related details, all of which are institutional problems. Therefore, it is clear that the final solution of the technological or economic problem and its application to the job of marketing the crop hinges upon institutional situations. Likewise, problems the government and industry may have in adopting results of research related to specific economic and technological problems hinges upon still other unsolved economic or technological problems.

Moreover, there is a sort of chain reaction in research. Solution of one problem creates the need for solution of related problems in order to make the solution of the first applicable from a practical standpoint. In other words, the more problems we solve the more new problems we open up and bring to the forefront.

The research viewpoint in agricultural experiment stations has changed considerably in recent years. Originally, the work done was almost entirely from the farmer point-of-view. However, mechanization, specialization, and commercialization in agriculture have helped create the point-of-view that farmers have an indirect interest in commodities until they are consumed. To a large extent, what happens to peanuts after they leave the farm determines whether farms may produce less peanuts, more peanuts, or remain about where they are. It conditions the extent to which the peanut industry is a growth industry, a stagnantly stable industry, or a declining industry. The peanut industry has not developed to its fullest potential, i.e., under certain conditions it could be a growth industry.

It appears to me that one of the reasons for the reluctance to adopt innovations, such as new equipment and new developments in peanut shelling, storing, and processing, is the fact that processors buy peanuts according to a fixed price schedule but sell the peanuts in a free market. I think this situation causes the probable profit margin on processing to be so low that plant owners and buyers do not wish to risk capital in new ventures such as the purchase of cleaning and automatic sampling equipment.

Other practical difficulties in developing more efficient equipment and machines for marketing and processing peanuts are as follows:

(1) The peanut processing industries are too small to provide themselves with research departments that would have much chance of important accomplishments.

(2) The costs of research and development in the technological field are relatively large.

(3) The market for such equipment is rather limited and therefore the equipment manufacturing concerns have little incentive for developing new equipment unless such equipment would be adaptable to processing commodities other than peanuts. There is the possibility that the peanut industry could pool resources and perhaps work with the State and Federal research agencies.

(4) The uncertainties from year to year of what the peanut program will be create reluctance on the part of business men to plan expensive developments in plants, equipment, and in short, investment in the future of the industry.

We have tried to consider them in the course of our work from a practical standpoint and have published a report in mimeographed form (Mimeo Series N. S. 9). We believe the suggestions contained in the report deserve careful study and possible adoption. We are fully aware that there are no final answers to questions in policies and programs designed to control supply and price. But we do think that such programs should consider the effect they have on the marketing system and on consumption of the product.

The essential features of suggested revisions of the Peanut Price Support Program are provisions for farmers to exchange allotments of one controlled crop for another, and for peanut allotments to be based on the history of production by individual farms rather than on historical acreage. Farmers would be allowed all the acreage desired, but supports would be granted only on alloted pounds of sound mature kernels. Buyers of peanuts would also have a dealers' base, or quota, which would be equal to the amount of quota peanuts purchased. All purchases in excess of quotas would go for oil uses. The quota and non-quota peanuts could be co-mingled. More flexibility in support prices would enable peanuts to compete with other food crops in the end uses. Price support levels would be based on consideration of prices of competing commodities as well as the parity concept.

Peanuts acquired by the Government would be systematically disposed of throughout the year, and carryover stocks would be limited.

It is also suggested in the report that peanuts be cleaned and sampled automatically and that the grades be determined from samples larger than the current four ounces.

Advantages claimed for these suggestions are: (1) greater flexibility to permit farmers to attain more efficient production, (2) sale of best peanuts on quota and poor quality peanuts as oil stock, (3) highest quality peanuts would go for edible uses and lower quality for oil uses, (4) more accurate grading and value determination, (5) a more orderly system of handling farmers' stock peanuts, and (6) increased consumption of peanuts and peanut products.

Actually, sampling and grading do not affect quality, but are the means of determining quality. However, if sampling and grading procedures do not give sufficiently accurate results, advantages to be gained by segregation in storage are nullified to some extent.

As a general premise quality in any item costs money. An end-user can get high quality peanuts now if he is willing to pay the price. The question is whether he can afford them, for to make such demands may be impractical from an economic standpoint if the added quality cannot be sold to advantage. In other words, the consumer must know of the added quality and be willing to pay for it.

Some improvement iu quality of end products might be gained by regulations enforced by government agencies such as the Food and Drug Administration. However, it should be pointed out that this could result in expensive additions to the final cost of peanut products to the consumer. Adding to the cost of the end prodnct without doing something to lower costs of processing at the same time the higher quality is obtained could have an adverse effect on the peanut industry. It seems unlikely that the industry can stand adding costs to consumer products and hope to maintain even the present market.

For additional research that is needed it is obvions that a small mechanical sheller to handle samples rapidly and satisfactorily must be perfected. Also a machine is needed that will split the kernels automatically and face them up for rapid inspection to determine concealed damage.

Undoubtedly there is enough engineering and technical know-how to perfect a cleaniug machine that will do the job more efficiently than it is done at present.

We believe that a machine could be developed that would clean, shell, and sort peannts according to sizes in a continuous flow operation and in a completely encased machine. This would eliminate dnst and contamination. The removal of foreign matter from farmers' stock peanuts should be accomplished prior to sampling, grading, selling, and storing. Judgment of some individuals has it that this should be accomplished during the harvesting operation. While this might be more nearly ideal, due to the large number of peanut farmers and the variation in the degree to which cleaning might be accomplished, even with satisfactory equipment, one should have reservations about this approach to obtaining cleaned peanuts. The most practical place for complete cleaning is the buying point. This could develop in one of several ways.

(1) Facilities could be established for cleaning, sampling, and grading by the Federal-State Inspection Service and operated by the Service or leased by the Service to other operators. In any event, a charge would be made for cleaning, sampling, and grading.

(2) These facilities or grading stations could be established by private individuals other than buyers and shellers with Federal-State Inspectors doing the sampling and grading.

(3) They could be established by the present peanut shellers with Federal-State agencies doing the sampling and grading, or buyers could perform these functions and services.

The peanut industry should have a peanut research laboratory located on the campus of an experiment station. Moreover, in my opinion, the peanut industry should be willing to underwrite part of the cost of its establishment and maintenance. Its staff might be part USDA personnel, part State experiment station personnel, and part industry personnel. The most advantageous place for such a laboratory would be the Georgia Experiment Station because of the amount of work already underway in several subject matter fields such as engineering, agronomy, food processing, chemistry, and economics. A laboratory of the sort visnalized wonld have the advantage of closeness to the personnel of these departments who have specialized knowledge of peanuts.

The laboratory should be complete and prepared to do continuous specialized work on developing peanut grading, shelling, sorting, and storing facilities for marketing and processing peanuts. It shonld be equipped with processing equipment; and work should go forward on new or improved methods of blanching, roasting, and processing of end prodncts. New and improved methods of packaging and preserving peanuts and peanut products should be sought. Creation of new products should be a part of the program of work, aud special efforts should be made to find practical ways of establishing peanut products as a regular part of the daily diet.

A large outlay would be required initially to provide such a laboratory, but the annual cost should be nominal after its establishment. The amount of additioual peanut research that should be done is so great that experiment stations cannot afford it now because the additional work plus that now underway would amount to a disproportionately large share of the total research budget.

Such a laboratory would have the advantage of being able to conduct much applied research and development work that is needed now but might be difficult to justify on research projects. Also, the laboratory would not be hampered by projects that cut across subject matter fields.

We have learned in our associations with the people at Georgia Tech that it takes time for workers from the various fields of engineering, economics, and other specialized subject matter fields to come to terms relative to research problems related to a commodity such as peanuts. However, when through associations and experiences with problems, a considerable wealth of information resides with the research workers, they are progressively better prepared to go immediately to the core of a problem and are more likely to come to terms quickly on what is needed and how to go about it most efficiently.

In time the personnel of such a laboratory, working closely with personnel of the various subject matter departments, should contribute many accomplishments.

MARKETING RESEARCH BY U. S. DEPARTMENT OF AGRICULTURE, PERTAINING TO STORAGE, SAMPLING, AND GRADING OF FARMERS' STOCK PEANUTS

By C. B. GILLILAND, *Head, Special Crops Section, Marketing Research Division, AMS, USDA*

Since the passage of the Agricultural Marketing Act of 1946, the U. S. Department of Agriculture has given continuous research attention to the storage, sampling, and grading of farmers' stock peanuts. Some of the results of this research have been made available in research publications listed at the end of this report. This research is in addition to the investigatory work of the Fruit and Vegetable Division in the promulgation and administration of Federal grades and standards for peanuts.

The Agricultural Marketing Service and the Commodity Credit Corportation, in cooperation with certain State agricultural experiment stations, Federal-State Inspection Service, and growers cooperative associations, made available for research purposes certain storage facilities, including peanut cleaning and sampling equipment at Bainbridge, Ga.; and storage bins and peanuts at Headland, Ala.; Stephenville, Tex.; Tifton, Ga.; and Holland, Va.

SAMPLING AND GRADING

In research at Bainbridge designed to evaluate the probe and automatic methods of sampling, using uniform size samples and methods of grading, tentative results from 100 loads of 1955-crop peanuts indicated that no clearly significant differences were revealed by the data between the results from probed samples and results from automatically taken samples in total foreign material in uncleaned peanuts, or in damaged kernels and sound mature kernels in either uncleaned or cleaned peanuts. Estimated loan value based on the results of probed samples from both uncleaned and cleaned peanuts did not differ significantly from comparable estimates based on automatically taken samples.

On the average, probed sample results were slightly higher than automatically taken samples in percentage of foreign material for both uncleaned and cleaned peanuts. This result was not significant for the uncleaned peanuts, however, due to the wide scatter within both the probed and automatically taken sample. The probed sample showed significantly higher results than the automatically taken one in the percentage of loose shelled kernels for both uncleaned and cleaned peanuts. There was some, though not conclusive, evidence that automatically taken samples may provide a better basis for estimating the reduction in gross weight during the cleaning process.

In some instances, wide differences occurred in the loan value of a load estimated on the basis of comparison of a probe sample with an automatic sample. However, these differences were not consistently in the direction of either type of sample and the average difference between probed and automatically taken samples was not significant in respect to either uncleaned or cleaned peanuts. This work did indicate a need for further research in this area.

In the study of sampling and grading of farmers' stock peanuts, comparative tests were made in the 1955-56 season on two small peanut shellers to determine the value of these units for shelling of samples in the grading process. One machine was developed at the Georgia Institute of Technology and the other was developed at the Georgia Agricultural Experiment Station. Although neither of these machines proved to be fully satisfactory, the tests indicated that they do have possibilities.

A field station has been set up by AMS at Raleigh, N. Car., in cooperation with the North Carolina Experiment Station, for work on the development of methods and equipment for grading peanuts. Work on the development of an improved automatic sampling device for peanuts also has been started and will be contiuued. This includes the evaluation of an automatic sampler developed by a commercial sheller in Georgia.

STORAGE OF FARMERS' STOCK PEANUTS

Marketing significance of changes iu farmers' stock peanuts in storage is a joint research project of the USDA aud four State agricultural experiment Stations. This is the fifth year that this project has been in operation. The experimental phases of this study are being conducted at four sites represeutative of the different peanut types and climatic couditions iu the priucipal peanut-producing areas. The major experiment is at Headland, Ala., using Runuer type peanuts, with smaller-scale experiments at Tifton, Ga., with S. E. Spanish; Stephenville, Tex., with S. W. Spanish; aud Holland, Va., with Virginia-type peanuts. At the four sites there are 47 bins of various types of construction, ranging in capacity from 2 to 30 tons.

Following are some tentative conclusions regarding quality and quantity changes of peanuts in storage based on the data developed to date. Analysis thus far indicates that it does not pay, becanse of deterioration, to store farmers' stock peanuts in ordinary storage warehouses for more than 6 months after harvesting. Quantity of sound mature kernels tends to decrease with length of storage, the decrease being more evident dnring the warm summer months. The amount of damaged kernels also tends to increase with length of storage. Withont frequent fumigation, insect infestation can develop to serious proportions almost over night dnring the summer. At Holland, Va., samples drawn dnring the latter part of May 1955 showed no indication of insect damage. On June 7, 1955, because of a little almond moth activity, one bin was fumigated; however, the other three bins at the site were not fumigated. During the first week of July when the peanuts were offered for sale by the CCC, they were examined by prospective buyers, who reported extensive moth and larva activity throughout the three untreated bins. In those bins where insect infestation was not controlled, total damage increased as much as 8 percent over a 6-week period.

Sound mature kernels: The 1952, 1953, and 1955 crops showed in general a fairly consistent maintenance of sound mature kernels during the storage period, but a decrease in the composite sample drawn as the peanuts were moved out of the bins. The percentage of sound mature kernels for the 1954 crop showed more fluctuations than for the previous years, with a small decrease in the percentage of sound mature kernels during storage prior to the hot summer months, but with a decrease in the composite sample drawn during the summer, and as the peanuts were moved out of the bins. As indicated above, at Holland, Va., peanuts stored became heavily infested with insects and the percentage of sound mature kernels decreased as much as 10 percent in some lots from the last of May to mid-July. The following figures give a summary of changes in quality, on a very broad basis, for the 1955 crop.

TABLE 1. Sound mature kernels—1955 crop.

Site	At purchase	First sample from bins	Last sample from bins	Composite sample when loaded out
Alabama	70.5	70.5	68.8	67.6
Georgia	71.5	72.1	70.8	70.8
Texas	65.5	63.3	64.2	62.1
Virginia	65.8	65.2	63.5	63.5

Damaged kernels: There was a slight tendency toward increasing damage as the period of storage increased. During each of the past four storage periods, the average was less than one percent for the season; except in Virginia, where the 1954 crop peanuts stored became heavily infested with insects. The following table shows the results for the most recent year.

TABLE 2. Damaged kernels—1955 crop.

Site	At purchase	First sample from bins	Last sample from bins	Composite sample when loaded out
Alabama	0.8	0.8	1.4	0.7
Georgia	2.5	2.2	2.8	2.8
Texas	1.0	1.1	1.3	1.2
Virginia	0	1.3	1.2	1.2

Other kernels: The percentage of other kernels, including shrivels, for 1954 and 1955 crops showed more fluctuations than for the previons years. The large increase in Alabama from 1.9 to 6.2 percent appeared only between the last sample drawn from the bin and the outgrade sample which was probably dne in part to mnltiple sampling and in part to sampling error and does not give the total picture of the data throughout the periods of storage.

TABLE 3. Other kernels including shrivels—1955 crop.

Site	At purchase	First sample from bins	Last sample from bins	Composite sample when loaded out
Alabama	1.9	1.9	5.0	6.2
Georgia	4.4	4.0	4.5	4.5
Texas	6.7	7.2	7.2	7.5
Virginia	5.3	5.5	6.3	6.3

Foreign material: While there is a wide variation in foreign material between samples, no significant trend has been noted. Of more significance than change in foreign material is the apparent effect of increased foreign material upon insect infestation and upon accuracy in sampling. The higher the foreigh material content, the greater the insect infestation and the wider the variation in samples.

TABLE 4. Foreign material—1955 crop.

Site	At purchase	First sample from bins	Last sample from bins	Composite sample when loaded out
Alabama	4.0	4.0	3.2	2.2
Georgia	6.4	6.4	5.8	5.8
Texas	6.4	7.9	10.2	6.8
Virginia	3.5	6.8	9.4	9.4

Moisture: A definite, continuous downward trend in initial moisture content was noted, and all lots of peanuts placed in storage dried down to safe moisture levels in a relatively short period of time (1 to 3 weeks). Comparison of lots placed in storage at high moisture levels with those of lower levels does not indicate any appreciable effect of initial moisture upon other grade factors. This would indicate that the maximum safe moisture content for peanuts in storage has not been reached in these experiments. Apparently storage houses with adequate ventilation can be used to store peanuts up to 14 percent initial moisture without appreciable damage due to the high moisture except in germination.

TABLE 5. Moisture (Grade)—1955 crop.

Site	At purchase	First sample from bins	Last sample from bins	Composite sample when loaded out
Alabama	10.7	10.7	5.1	6.2
Georgia	8.3	6.3	5.7	5.7
Texas	7.4	4.9	3.9	3.8
Virginia	11.0	9.8	7.2	7.2

Research on the Prevention of Insect Attack on Stored Farmers' Stock Peanuts

Research on the control or prevention of insect infestations in stored farmers' stock peanuts has been under way since 1952 at the Tifton, Georgia, station of the Stored-Product Insects Section, AMS. The studies have been directed principally towards problems of concern to CCC, since producers do not generally store farmers' stock peanuts except in relation of price support programs. The research program has been steadily expanding and at the present time 1½ man-years of professional and 1½ man-years of sub-professional time are spent on it.

The studies have established that there are two general classes of insects that attack stored peanuts—one consisting of several species of moths that feed in the surface layers and are readily observed when the adults fly, and the second group consisting of a number of beetles that work deep in the pile and may not be observed until very heavy infestations are present. It has also been established that injury to the nut meats occurs only where the shell is split or ruptured. Therefore, the degree of insect damage is closely related to the amount of shell damage. It has been observed in most years that infestation does not start in the field while the peanuts are drying following digging, but takes place by insects invading the storage from near-by sources in trash or spilled nuts. However, observations in 1955 indicate that there may be years when infestation does occur in the field.

The current research program is divided into three phases. The first is an exploration of whether or not protective sprays or dusts can be applied directly to farmers' stock peanuts when they are placed in storage. The key factor here is whether or not an undesirable insecticidal residue will remain on the peanuts when they are shelled.

The second is the control or prevention of insect infestation in warehouses storing bulk or bagged farmers' stock peanuts. This includes a study of the value of thorough cleanup in and around the warehouse, the use of residual sprays on the walls and floors of the warehouse before the crop is stored, the use of sprays applied to the surface of bulk piles or aerosols applied periodically in the head space of filled warehouses, and the possibility of using fumigation treatments. The location, degree, and persistence of residues from each treatment under study must be determined.

The third is the source of infestation in stored peanuts. Studies are continuing to determine where and at what time infestation occurs. Many lots of peanuts are periodically sampled in this study from the time they are dug until they are finally shelled.

The control of insects in stored peanuts is complicated at this time by the problem of insecticidal residues. Some control measures long in use can no longer be used because residues resulting from them are not permitted, or are excessive, or a tolerance for them has not been established. The Stored-Product Insects Section is in constant touch with the Commodity Credit Corporation, the Food and Drug Administration, and the manufacturers of insecticides to help solve certain temporary problems resulting during this readjustment period, and to help plan actions or research which will permanently answer them.

The Department plans to continue its work in the storage, sampling, and grading of farmers' stock peanuts, with expansion of work in the mechanized sampling and grading of farmers' stock peanuts and their protection from insect attack.

The following individuals contribnted to the above report:

Golumbic, Calvin—Head, Qnality Evalnation Section, Biological Sciences Branch, Marketing Research Division, AMS, USDA—Research studies in mechanical sampling and grading of farmers' stock peannts.

Latta, Randall—Head, Stored Product Insects Section, Biological Sciences Branch, Marketing Research Division, AMS, USDA—Protection of farmers' stock peanuts from insect attack.

Yeager, J. H.—Agricultural Economist, Alabama Polytechnic Institnte, Aubnrn, Ala.—Project leader of Alabama project pertaining to storage of farmers' stock peannts.

Langley, B. C.—Snperintendent, West Cross Timbers Experiment Station, Stephenville, Tex.—Project leader of Texas project pertaining to storage of farmers' stock peanuts.

King, Frank P.—Resident Director, Coastal Plain Experiment Station, Tifton, Ga.—Project leader of Georgia project pertaining to storage of farmers' stock peanuts.

Clark, H. Marshall—Snperintendent, Tidewater Field Station, Holland, Va. —Project leader of Virginia project pertaining to storage of farmers' stock peanuts.

Publications and Reports Relating to Peanuts

"An Analysis of the Peannt Shelling Indnstry, 1950-53,"
By C. B. Gilliland and T. B. Smith
MR Report No. 134, Agricnltural Marketing Service

"Storage in Marketing Farmers' Stock Peanuts,"
by D. B. Agnew and D. Jackson
MR Report No. 134, Agricultural Marketing Service

"Better Storage Practices Cut Peanut Marketing Costs,"
by C. B. Gilliland
Reprint from Marketing Activities, Feb. 1956.

RECOMMENDATIONS OF PHASE "A"

DR. V. R. BOSWELL, *Head, Div. of Vegetable Crops, USDA*

I This group recommends that the Peanut Council give consideration to the establishment of a central peanut evaluation facility with two major objectives:

(1) The development of specifications of desired qualities in raw peannts for specific end nses.

(2) To conduct advanced or semi-final evalnations of strains and products from specific agronomic treatments.

II That research agencies increase breeding work to develop improved varieties that will meet indnstry standards and grower requirements.

III Increase research on methods of control of insects, diseases, nematodes and weeds in relation to peanut quality.

IV Increase research on the relation of soil management fertility and water supply to the quality.

REPORT OF INFORMAL GROUP DISCUSSION ON PHASE "B"—"FACTORS AFFECTING QUALITY AS INFLUENCED BY HARVESTING, CURING AND FARM PROCESSING

By G. W. GILES, *Head, Agricultural Engineering Department, N. C. State College*

Group B developed a classification, inventory and methods of attack on the quality problems as affected by harvesting, curing and farm processing.

It is, of course, realized that within a matter of two and one-half hours all the problems could not be adequately resolved and defined. Substantial progress was made, however, and this report should form a foundation for continuation at some future date.

Five objective areas, each of which will encompass the quality problems, are listed below. Although the specific charge was to deal with the problems of harvesting and curing and processing that affect quality, it will be noted that two other end objectives were injected, lowering cost and increasing efficiency. They are important and we considered it difficult and objectionable to separate them from quality.

1. Determination of a criteria for quality.

2. Improvements and the development of new concepts in harvesting that provide: (a) better control over the quality, (b) lower cost of cnring and (c) greater labor efficiency.

3. Improvements and the development of new concepts in curing that provide: (a) better control over the quality, (b) lower cost of curing and (c) greater labor efficiency.

4. Improvements and the development of new concepts in processing from curing to marketing that will provide a product of a higher aud more consistent quality for the trade.

5. Method of attack.

The listing of the important problems according to these five objective areas are as follows:

1. *Determination of a criteria for quality.*
   a) In cooperation with other researchers, work out the composition of the nut for varying degree of maturity aud treatment in terms of chemical coustituents and physical properties.
   b) Move ahead with defining and utilizing subjective measurements based upon needs of industry and consumer acceptance. Some of the more importaut criteria presently known are:

      Free from foreign material
      Free from insects, insect damage
      Free from certain pathological elements such as molds, disease and rotten nuts
      Free from discoloration
      Free from shrivels, small or otherwise undesirable nuts
      Good blanching characteristics without splitting
      Good flavor
      Adaptable to processiug to a uniform color
      Free of hard peanuts.

2. *Improvements and the development of new concepts in harvesting that provide:* (a) *better control over the quality,* (b) *lower cost of harvesting and* (c) *greater labor efficiency.*
   a. Define the state of maturity to secure optimum quality.
   b. Investigate possibilities of bringing the mass of peanuts in the ground to uniform maturity at the same time for harvesting.
   c. Determine optimum treatments (tillage, row pattern, clipping top, etc.), in preparation for harvestiug.
   d. Determine optimum methods, equipment and techniques in digging, shaking and picking operation of harvesting.

3. *Improvements and the development of new concepts in curing that provide:* (a) *better control over the quality,* (b) *lower cost of curing and* (c) *greater labor efficiency.*
   a. Determine optimum moisture content for harvesting aud curiug operations.

b. Determine optimum moisture content for safe storage.
c. Determine specification for curing and curing methods (before and after picking) by field curing and artificial means in terms of environmental factors.
NOTE: Curiug implies more than moisture removal.
d. Determine specification for a storage system in terms of environmental factors.
e. Study weather effects, patterns and forecasting as related to harvesting and curing.

4. *Improvements and the development of new concepts in processing from curing to marketing, that will provide a product of a higher and more consistent quality for the trade.*

a. Improvement and development of handling and storage facilities on the farm.
b. Improvement and development of means for removal of foreign material, if any, after curing.
c. Minimize loose shelled kernels and damaged hulls during the processing operations.

5. *Method of attack.*

a. Devote more of onr effort towards fundamental research. While we must do some of the day-to-day improvements, or follow the more obvious approaches, it is essential that we devote much effort to bring to light new knowledge as a basis for stimulating creativeness and the development of new concepts.
It is only through the latter that great strides can be made with resulting benefits to both the farming business and the industries that utilize its products.
b. Incorporate the use of statistics in the planning of experiments and in the analysis of the data in order to ascertain the validity of results. For example, in one study, the variability in damage to peanuts by mechanical pickers was measured and fonnd to be greater from day to day than within a day. This points up the importance of collecting a few samples each day over a period of several days rather than many samples in one or two days for secnring valid results.

Two general recommendations were made by Group B. They are as follows:

1. Researchers involved in the problems of production, harvesting and curing and those who are involved with the physical and chemical problem coordinate all efforts related to quality and the end product. The cooperation of industry is needed in this endeavor.
2. In order to define more adequately the problems and implement more effective cooperation and coordination of effort towards the solution of these problems, it is recommended that committee actions similar to the group discnssion leading up to this report, but perhaps smaller in size for efficiency, be continned. For this purpose, it is recommended that considerations be given to the formation of a regional technical committee, the composition of which is to be developed following considered thought. It is also recommended that we explore the opportunities and make recommendations for effectuating a close cooperation between public research and industry. In giving further consideration to this, the thinking of all leaders in both pnblic agencies and private indnstries, who are interested in peanuts, should be solicited.

RECOMMENDATIONS OF PHASE "C"
FACTORS AFFECTING QUALITY AS INFLUENCED BY SAMPLING, GRADING, STORING AND SHELLING PEANUTS:

By Mr. E. J. Young, *Executive Vice President, Stevens Industries*

1. That research for developing methods of obtaining fair and accurate samples of Farmers' Stock Peannts be continned and expanded on a belt-wide basis.
2. A full program of research be initiated or expanded to develop rapid and accurate methods of grading peanuts for factors affecting the qnality of edible products. (Mannfactnrers finding characteristics that are satisfactory are reqnested to report to researchers.)
3. Initiate and expand research on the effects and the elimination, control or improved handling techniques of the following factors that affect the qnality of Farmers' Stock Peanuts in storage and the products produced therefrom:
    1. Foreign material
    2. Loose shelled kernels
    3. Insects and Rodents
    4. The handling in and ont of storage.
    5. Type of storage.
    6. Segregation according to quality.

The committee, recognizing the serious problems involved in the control or elimination of insects and rodents in stored Farmers' Stock Peanuts, recommends this work be given top priority.

4. Group C recognizes the need for research on the effects of shelling on the qnality of peanuts and the need for improved shelling facilities. We therefore recommend that an investigation be made to determine the feasibility of establishing a pilot shelling plant for the evaluation of existing machinery and the development of new machinery for shelling peanuts on a belt-wide basis and that consideration be given to the proposal for a complete belt-wide peanut laboratory.

CONFERENCE SUMMARY

Glenn W. Burton, *Chairman, Division of Agronomy, University of Georgia Coastal Plain Experiment Station, Tifton, Georgia*

The expense of this Conference, including the time required to assemble and prepare the excellent reports that we have heard, represents an investment for government and industry in excess of $50,000. As we look back on this Conference that soon will be history and lay plans for another, we will do well, I think, to ask ourselves two questions:

1. What have I learned?
2. What difference will it make to me?

Permit me to begin by sharing with you some of the things that this Conference has taught me.

1. I have learned that quality—"CONSISTENT QUALITY," as Bob Canby chose to call it—is important. The frequency with which the word appeared in large type in your program would have cansed any reader to conclude that this is true. After listening to A. S. Yohalem's address, however, I know that quality is important because we cannot have increased consnmption of peanut products without it. Quality is usually an ambiguous term having different meanings for different people. Mr. Yohalem helped me to understand the meaning of quality in peanuts with his statements, "Undesirables must be entirely eliminated" and "A larger, better-tasting, and more easily processed peanut must be found."

2. I learned that PRESENT U. S. GRADES AND QUALITY ARE NOT PERFECTLY CORRELATED, that there is still much ART associated with quality appraisal and that much research is needed at this point.

3. I learned that EVERY MAN FROM THE BREEDER TO THE CONSUMER CAN CONTRIBUTE TO OR DETRACT FROM THIS THING CALLED QUALITY. The manner in which they can contribute is still poorly understood. I was interested to hear C. B. Gilliland say that the large field from the first buyer to the consumer, the field into which well over half of my consnmer dollar goes, has hardly been touched researchwise and that funds available for such research can be had for little more than the asking.

4. I learned that we know far less than we need to know about how to get quality and how to keep it.

5. I was not surprised to learn that the end user of peanuts can get quality now if he is willing to pay for it. As in all other fields for one reason or another, we are not using the know-how we now have. It seems to me that J. L. Shepherd was very right when he said, "The major problems cnrrently and in the futnre consist of establishing the proper incentive to make growers use the optimum methods we now have for producing a quality raw prodnct." Qnality costs money. It must be paid for.

6. I learned that this is ONE INDUSTRY and that the breeder, the research worker, the grower, the grader, the buyer, the processor, the wholesaler, and the retailer are each but links in a chain that can be no stronger than its weakest link. If I am a part of this chain and think I am the pot, I must be very sure that I am bright before I call the kettle black. I feel certain that our association here with the other links in the chain will help each of us to avoid the serious error of calling the kettle black.

7. I learned, again from your program, and your speakers, that this indnstry is BELTWIDE. We have inherited state lines. Most of us must live and work within them. They can, and do, contribute much to onr way of life. They should never be allowed to act as barriers and stnmbling blocks to progress.

What difference will it make to me?

Unless this Conference brings about some change in me—in my attitude, my understanding and particularly my activity—it will be time and money wasted so far as I am concerned.

Too many times, I fear, we imagine that conferences will furnish all of the answers. If our ignorance can be removed by an integration of existing, but widely scattered, facts then conferences can help. But the facts must come from research, hard work back home.

Certainly, all of us now know if we did not know hefore that we must have more facts. How can we get them? THROUGH RESEARCH.

Every man engaged in research has a full program now. He can do no more withaut adding more hands or discontinuing a part of what he now is doing. If I were in peanut research, I think I wonld want to re-evaluate my program in light of what has transpired here. If I did, I think I would find some changes that could be made—changes that would make my program more meaningfnl and more useful to the industry, changes that would strengthen my link, that would polish up my kettle. This adjustment can make a stronger program but cannot supply all of the facts we need.

We must find new support for research. Taxpayers and legislators, indutry, and the public believe in research. Additional support can be found when tbe need is real and is properly presented. Twenty years ago, we built a house. Since then, we've been trying to make of it a home. Several years ago, the hiuges on one of the doors that we use a great deal began to squeak. At first, I ignored them but I soon learned that I could find no peace in that way. Finally, I made a special trip to town, bought a can of oil, came home, and oiled those hinges. To my knowledge, they are the only hinges in my house that have been oiled. You, and particularly your organization, the National Peanut Council, can be those hinges.

Any new research that will most certainly be BELTWIDE in its significance must be located in some state. Naturally, I would like to see it come to Georgia because it would strengthen our agricultural research program. To locate the work in Georgia would probably give Georgia farmers a slight advantage over those in other states. I hope, however, that when new funds do become available that I shall be big enough to say, "Locate the research where it will best serve the PEANUT BELT." I say this because I believe that it is the only attitude that we can afford to have.

Finally, we must snrely realize that there is no substitute for hard work and cooperative effort. For maximnm progress, there mnst be a free interchange of findings and ideas. There must also be a willingness to help one another without too much concern for credit. Many years ago, Alexander Dumas wrote a fascinating tale about Three Musketeers, who accomplished the impossible with a simple little slogan, "All for one and one for all." We would do well, I think, to make it our slogan, too.

REPORT OF RESOLUTION COMMITTEE

H. L. WINGATE, *Pres., Georgia Farm Bureau*

RESOLUTION

Section One

The progress, the proper expansion, in fact the entire future of the peanut indnstry, will be determined by the progress and success of research and research promotion relating to peanuts and peanut products.

As we review the work of this conference, and of similar conferences in the past, we cannot escape the conclusion that we are not now receiving the full benefit of the peanut research programs heretofore and now being carried on.

We believe that this is due, in good part at least, to the lack of integration or coordination of the activities of the numerous research agencies and the lack of liaison among those now conducting research on peannts in its many phases, Federal, State and private.

We, therefore, recommend the adoption of the following resolution by the members of this Conference:

Be it resolved, by the Peanut Research Conference, held here in Atlanta, February 21 and 22, 1957.

1. That a well qualified and experienced person be engaged to serve as the coordinator of all research and research information relating to peanuts and peanut products in all its phases, from the breeding of the peanut to its consumption;

2. That the Research Committee of the National Peanut Council and the Resolntions Committee of this conference, he requested to give the fore-

going recommendation their earliest convenient attention and prepare plans and recommendations for its activation for consideration of the 17th Annual Convention of the National Peanut Council at the Fontainebleau Hotel, Miami Beach, April 28, 29 and 30.

Section Two

We have reviewed the recommendatious submitted by the Chairman of each of the groups. We believe these recommendations are very worthwhile and the successful completion of the projects recommended will make a splendid contribution toward progress in the "breeding, planting, cultivation, harvesting, curing, picking, sampling, grading, storing, and shelling of peanuts", and we express the earnest hope that our research agencies will press forward in their efforts to bring these projects to an early and successful conclusion and that channels will be strengthened and maintained for the interchange of information on research results and research needs between the research agencies and the several segments of the peanut industry.

RESOLUTION

Be it Resolved:

1. That we hereby express our admiration and deep appreciation of the splendid program arranged and carried out at this Conference. We have a feeling that it may mark the beginning of a new day in the history of the peanut and its use. We believe that the discussions carried on with respect to each of the phases set forth in the program and the recommendations made by each of those groups can resnlt in great benefit to all segments of the peanut industry;

2. That we feel a deep debt of gratitnde toward John T. Phillips, Jr., who inspired this Conference, to the members of his Steering Committee, and to the Chairman of the Research Committee of the National Peanut Council, Mr. Robert C. Canby, all of whom have worked nntiringly on the arrangements and the program for this Conference, and who are entitled in good measure to full credit for its success.

RESOLUTION

Be it Resolved:

That we are most grateful to the Citizens and Sonthern National Bank, and to its officers and employees, for the delightful and most enjoyable reception Thursday evening.

This great banking institution has always cooperated most generously with all segments of the peanut industry in promoting the production, harvesting, marketing and processing of peanuts. We appreciate their continued interest in the peanut industry and its expansion.

RESOLUTION

Be it Resolved:

That we express to the management of the Biltmore Hotel our sincere appreciation for the uniform courtesy, accommodations and splendid service rendered this Conference and all of those attending.

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